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The Implementation of Problem Solving Strategy with Making Drawing Process to Increase Mathematical Thinking Ability of Grade 9 'Students, When Learning Geometry

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Abstract: *Problem solving is essential in mathematics teaching and learning. Beside the problem solving can help students to solve mathematics problem systematically and completely, it can also increasethe students' mathematical thinking ability. Problem solving strategy consists of some heuristic strategies, and one of those is making drawing process. The purpose of this paper is to investigate how students' mathematical thinking increased when they use problem solving strategy including making drawing process to solve some mathematical problems, in particular when they solve geometry problems. For this purpose, a research has been made in two cycles of learning process. The analysis then describedthrough these following aspects, in which problem solving strategy consists of four main steps, (1) understanding the problems, (2) making plans to solve the problems, (3) solving the problem by using the previous plan, and (4) looking back, in which in step three making drawing process happen.*
Keywords: *problem solving strategy, making drawing process, mathematical thinking, geometry problems.*

I. Introduction

Problem in the simple meaning is a discrepancy between a pretension and reality. Hudojo (2003) said that something is a problem if someone doesn't have a rule or a law that can be used to find the answer of the problem. Schoenfeld (1985) stated that a problem in mathematics is a difficult matter for a pupil that attempted to solve the problem. Moreover, that difficulty should be an intellectual impasse rather than a computational one. In order to find the solution of the problem, pupils have to use their previous knowledge, and during the process they form a new understanding (NCTM, 2000 : 68).

Lenchner (1983:8) pointed out his idea about the differences between an exercise and a problem in mathematical term. He said that an exercise is a task for which a procedure for solving is already known; frequently an exercise can be solved by the direct application of one or more computational algorithms. On the other hand, a problem is more complex because the strategy for solving is not immediately apparent; solving a problem requires some degree of creativity or originality on the part of the problem solver. Musser (2011:4) stated that to solve a problem, one has to pause, reflect, and perhaps take some original step that is never taken before to arrive at a solution.

Problem solving becomes essential thing in mathematics learning process because it has a close connection to real life. Indeed, Greenes, Ginsburg and Balfanz (2004) said that young children have been noted to show an interest in investigation and solution of mathematical problems (Angela, 2014). From the statement, we can conclude that their mathematical thinking have evolved since an early aged. Mathematical thinking ability then becomes an important thing. By using their mathematical thinking ability, pupils can form a process to solve a problem, which includes problem's identification processing, using some strategies to solve the problem, using previous knowledge and skill, representing the problem and reasoning the whole process.

From the observation conducted by the researcher, some information have been obtained, such as; pupils tend to solve the problem by jumping immediately into calculations with the numbers mentioned in the problem and give the answers without initially trying to identify the information about the problem. Furthermore, when the pupils are given the questions about the reason behind their solving steps, some of them do not know the answer, while the other give the illogical and not mathematical answer. By the analysis through the observation process, the researcher concluded that students' mathematical thinking and problem solving ability are still low. In order to improve those abilities, the researcher uses the problem solving strategy which includes the use of drawing in the learning process.

Problem solving can improve mathematical thinking ability (NCTM, 2000). In this research, problem solving is a strategy to solve a problem that included four main steps, that are understanding the problems, making plan to solve the problems, solving the problems by using the previous plan, and looking back. Polyaas the originated of problem solving strategy define problem solving as a process whichinclude various activities, such as understanding the problem, planning a solution process, solving the problem, and looking back (Polya,

1945). Another idea pointed by Krulik and Rudnik, in which they define problem solving as a thinking process when students using their knowledge, skill and understanding that have been learned to solve unfamiliar problem. From what those experts says, it can be concluded that problem solving is a thinking process in order to solve an unfamiliar problem, in which the solver using their previous knowledge and skill, that contained in process of understanding the problems, making plan to solve the problems, solving the problems, and looking back the process.

To solve mathematical problem by using problem solving strategy, there are some heuristic strategies that can be used, and one of those is the use of drawing. In this case, drawing that be used is drawing which represent and reflect the problem situation, consist of some information that helpful for solver to solve the problem. Larkin and Simon (1987) in Nunokawa (2006) explained thatone of the merit of use of drawings in solving problems is the fact that it can group together all information that is used together and enable the solver to avoid large amount of search for the element needed to make problem solving inference. It means that, by the use of drawings students can be aimed to grouping all information and can help them to identify the unneeded information. Diezman and English also stated that in order to solve mathematics problem, students interpret the information they get to the drawing that they made. It can change students understanding about the problem.

The use of drawings plays some roles in problem solving process. In Nunokawa (2013), Van Essen and Hamaker (1990) explain that as follows, (1) drawings relieve working memory, (2) by generating drawings, solvers make problems more concrete, (3) problem information can be reorganized more efficiently (Larkin and Simon, 1987), and (4) some problems characteristics are more easily inferred from drawings, correlation between the elements in the problem can be more explicit in drawings Gutsteinand Romberg, 1995). Before making a drawing, students have to understand the problem well. Nunokawa (2013) also explain that students understanding will be reflect in the drawing they've been made, so students need to understand the problem enough to construct the helpful drawings.

The use of problem solving strategy to solve mathematical problem needs students' higher mathematical thinking ability (Fuch& Bayer, 1998 in Abdullah, 2014). In this case, mathematical thinking is students thinking process in order to solve the problems, in which it related to how students identify the problems, use the right strategy to solve the problem, use their previous knowledge and skill, represent the problem and justification of mathematical reasoning. Formally, Burton (1984) defined mathematical thinking as thinking style which related to mathematical operations and symbols, and by using the mathematical concept, problems can be solved easily. Moreover, Iannone (2006) also pointed out that mathematical thinking is an activity when a solver solve the problem by combining some elements, such as, (1) choosing right and effective way, (2) using previous strategy in order to solve the problem, (3) generalization, (4) flexible with the mental process, and (5) understanding the formal structure.

Mason (2010) pointed out that mathematical thinking is a dynamic process which extended the understanding by increase the complexity of the problems that want to be solved. This process can be done by the use of mathematical thinking phase, whichare entry, attack and review. Entry phase is a base before the solution be founded. In this phase, problems understanding process occur. Understanding the problem can be done by identifying, classifying, ordering and organizing information. Some question that can be used as guiding, "*What do I know?", "What do I want?", or "What can I introduce?"*.This questions not only to identify the problem's information, but also as a preparation stage to solve the problem, and there are some conjectures that will be proved in the next stage. Some strategies can be form due to help students find the solution.

On attack phase, solving process be done by using the strategies based on the preparation, and also proving the conjectures. On the other hand, the review phase, looking back process is done. This phase can improve and extended thinking ability by trying to make the generalization of the solution.

In this research, students will solve some geometry problems, in particular about the congruence of flat shape. Consequently, students' thinking ability can be captured through the process to find the solution, in which their solution will reflect the third phase of mathematical thinking. During the process, students will solve the problems by using the fourth of problem solving steps which included with making drawing process. The problem solving steps match with mathematical thinking phase, so students' thinking ability can be seen by analyzing their solution process.

II. Method

This research was made by qualitative approach that conducted in Class Action Research (CAR). The data next will described verbally. The research was made in two cycles which contain planning, acting, observing, and reflecting processes. During the research, the researcher act as teacher and also as the planner, data collector, data analyst, and informer of the research. The research was held in 'SMPN 10' Malang Junior High School, Indonesia, with 30 students of grade 9 as the subject.

In this research, the data was get from the validation process through the learning instrument, test result, which consist of initial test and final test in every cycle, and the observation through the learning process. The validation result across the learning instrument showed that the instrument was valid and can be used in learning process. Moreover, to identify students' mathematical thinking ability, the researcher uses this following rubric;

Table 1.1 Rubric of Mathematical Thinking Ability

Mathematical Thinking Phases	Description	Score
Entry	Do not write the information obtained after reading the problem, do not make plan to solve the question, do not make a suitable representation of the problem	0
	Write down the information but incomplete, do not make plan to solve the question, make representation but incorrect.	1
	Write down the information but incomplete, make incorrect plan, make suitable representation.	2
	Write down the information, the information is complete, make plan to solve the problem, make a suitable drawing which represent the problem.	3
Attack	Do not solve the problem by using the plan that have been made, do not give the reason for the solution process, wrong solution process	0
	Solving the problem by using the previous plan but incorrect, do not give the reason, and incorrect solution process	1
	Solving problem by using the previous plan, but the reason is ambiguous, the solution process is correct.	2
	Solving the problem by using the previous plan, solution process is correct and the reason in the process is correct and clear.	3
Review	Do not check the suitability of a question and solution process, do not write hard part for the problem solving process, gave no other way to resolve the problem, do not make generalization solution to the broader context	0
	check the suitability of a question and solution process, write down the hard part of problem solving process, gave no other way to resolve the problem, do not generalize the solution to the broader context.	1
	check the suitability of a question and solution process, write down the hard part of problem solving process, gave alternative way to resolve the problem but incorrect, generalize the solution to the broader context but incorrect.	2
	check the suitability of a question and solution process, write down the hard part of problem solving process, gave right alternative way to resolve the problem, generalize the solution to the broader context.	3

The score counting processes as follows;
Maximum score = 9
Final score was counted as follows;

$$Score = \frac{Score\ from\ each\ problem}{n\ \times maximum\ score} \times 100$$

Note:
Score of every problem = total value on each phase at each number and then be accumulated.
Maximum Score = Maximum score from each (E + A + R)
n = number of problem
After the assessment was made, students' mathematical thinking ability will be grouped into several categories according the score they get.

Table1.2 The Categories of Students' Mathematical Thinking Ability

The interval category of Students' Mathematical Thinking Ability	The category of Students' mathematical thinking ability
$85 \leq total\ score \leq 100$	Very High
$75 \leq total\ score < 85$	High
$55 \leq total\ score < 75$	Average
$total\ score < 55$	Low

From the score of each student, then the classical average score was calculated to determine the ability of students' mathematical thinking as a whole. The average is determined by dividing the total value of students score with the number of students that is 30 students.

Analysis of the data in this study is to see the increase of students' ability to think mathematically from the initial tests before treatment is given until the end of the test cycle 1 and cycle 2 after the action is. Thus, the successful criteria of this research are when 80% of students have achieved the high or very high level of mathematical thinking ability.

III. Result And Discussion

The Implementation of Problem Solving Strategy which Contain Making Drawing Process in Geometry Lesson

Learning process in the classroom is a process which use problem solving strategy that contained the use of drawings. The implementation of those strategies is explained as follows;

At the beginning of the lesson, teacher prepares the students physically and mentally for the learning process. Teacher gives apperception by asking the students about the learning materials that have been given in the previous lesson. The aim of giving students the apperception is to identify whether students have controlled the prerequisite materials and also have had enough knowledge and skill to solve the following problems (Hudojo, 2003; Krulik&Rudnik, 1995). Moreover, teacher pointed out the benefit of learning activities that can be seen in real life activity. It was believed that it can encourage students to learn mathematics enthusiastically. Besides giving apperception and motivation, teacher also explains the learning objectives that will be accomplished.

In the main activities of learning process, in cycle 1 and cycle 2, the students firstly explored the pictures on students' activities sheet to find the main concept of flat figure congruence. It was based by cognitive theory, in which the process to understand a concept was begun with developing students' ability to construct the meaning of the lesson, both orally or written. Students identify the concept then using it to solve the problem (Subanji, 2013).

When students have found and understood the concept of congruence, teacher gives some problems related to congruence concept to be solved by the students. Teacher guides students to solve the problem by using problem solving steps which concluded with making drawing process.

The solution process was begun by teacher guides students to understand the congruence problemthen identify what information presents in the problem. Besides understanding the information, students also identify what has been questioned in the problem.

Furthermore, teacher teaches students to make plan or conjecture in order to find the problem solution. This process be done by students make a drawing which suitable with the problem and represent the problem. The drawing which be made by the students showing their understanding about the problems. Students then put the information. By picturing the problem, students can find new information which helpful for their solution process. Moreover, students explain how the problem will be solved, or they can make a conjecture of the problem. The conjecture then be proved in the next stage. Both of the process above was based on the entry phase of mathematical thinking. Students prepare anything they need to solve the problem, formulate and reconstruct the question of the problem, absorb, classify, and organize information, planning solution process, drawing the problem, and put the information on it (Mason, 2010).

The next step is solving the problem by using the information that have been identified and plan that have been made. While students solve the problems, they have to give some logical and mathematical reason which relevant to the solution process. Reasoning in mathematical problem solving is an essential process, which positively influence the advance of mathematical thinking. This term included some things like collecting evidence, making inferences, and justifying conclusions. NCTM (2000) suggested that the study of mathematics should emphasize reasoning, so that students can justify their answer and solution processes as well as make and evaluate mathematical conjectures and arguments.

The conjecture from the previous phase will be proved in this stage. This process is based on the attack phase, in which students have understood the problem well, or in the other words the entry phase was doing well. Students choose the information they needed to solve the problem, use the plan they made, and then solve the problem (Mason, 2010).

The last step is looking back process. This process is to identify whether the solution process have come with the right answer, which is suitable with the question of the initial problem. Besides, it is also a process to correct the wrong concept or solution process that has been made. Moreover, this stage can be done by giving the alternative solution for the same problem. This process was review phase, which purposed to improve and extend thinking ability and make the solution more general (Mason, 2010). The process was made, reflected and extended to the general form.

The last process of the lesson is teacher helps students to make a conclusion for the whole learning process.

During the learning process happen, it can be seen that the students' mathematical thinking ability was developed and improved. Students are able to solve the congruence problem systematically and give the logical and mathematical reasoning along the solution process. The drawing made by students in second step is also appropriate with the problem situation. It can be concluded that students have understood the problem well before they make a drawing and solve the problem. The looking back process was made by students to verify the solution process they made. Thus, the process of students to solve the problem was suitable with the mathematical thinking phase.

Students' Mathematical Thinking Ability After The Learning Process By Using Problem Solving Strategy Which Included Making Drawing Process

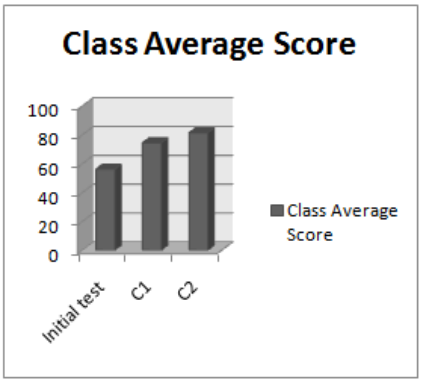
Students' mathematical thinking ability was seen from the result of the final test in every cycle, whether the students' solution process have conducted mathematical thinking phases, that is entry, attack, and review. Nevertheless, researcher at first gives students the initial test to analyze students' mathematical thinking ability before they are introduced with problem solving strategy which concluded with making drawing process.

The result of initial test is 43,33 % students are in low level of mathematical thinking ability (13 students), 43,33 % are in average level (13 students), and 13,33 % are in high level. In this research, the successful criteria is if 80 % students are in high or very high level of mathematical thinking ability, with the value range is 75-100.

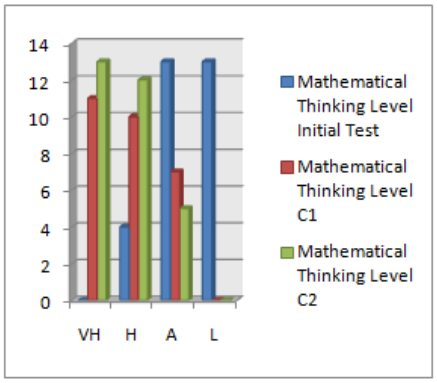
Based on the result of final test obtained during the research, it can be concluded that students' mathematical thinking ability is increasing. It can be explained as follows;

a. The result of the final test of cycle 1 shown that there have been no students who have low level of mathematical thinking ability. It means that there are percentage reduction by 43,33 % for students which in low level of mathematical thinking. Meanwhile, there are 7 students from 28 students who took the tests (25%), which still have the average level of mathematical thinking ability. However, this percentage decreased by 18.33% compared with the result of initial tests. In addition, there are 35.71% of students with a high level of mathematical thinking, in which the value is increase 22.38% from the initial tests, and 39.28% of students are in very high level, which increased by 39.38% compared to the initial test.
b. The result of the final test in cycle 2 shows that there has been no student with the low level of mathematical thinking ability (the same as at the end of cycle 1). While there are still 5 students (16.67%) who had average levels of ability to think mathematically. Nonetheless, there is a decrease in the percentage of students in this category, which amounted to 8.33%, when compared with the results at the end of cycle 1. In addition, there are 12 students with high-level of mathematical thinking ability, or approximately 40%, which is an increase of 4, 29% compared with the results at the end of cycle 1, and there are 13 students with mathematical thinking ability level is very high, with a percentage of 43.33%, where the value is increased by 4,05% of a percentage in cycle 1. Although there is still a students with the ability to think mathematically moderate, but the amounts mentioned above meets the criteria of success established researchers. Thus, it can be concluded that the entire process, there is an increased level of students' mathematical thinking skills.

Overall, the increasing of students' mathematical thinking can be shown in the figure below;



Picture 1.1 Charts of the increasing of Students' mathematical thinking Ability in average



Picture 1.2 Chart of the increasing of number of students at each level of mathematical thinking ability.

Note :
C1 = Cycle 1 of Learning Process
C2 = Cycle 2 of Learning Process
VH = Very High Level of Mathematical Thinking Ability
H= High Level of Mathematical Thinking Ability
A= Average Level of Mathematical Thinking Ability
L= Low Level of Mathematical Thinking Ability

IV. Conclusion And Suggestion

Conclusion

The analysis on this research focusing in the learning process by using the problem solving strategy which combining with making drawing process that can improve students' mathematical thinking ability. Learning process occur by using fourth steps of problem solving strategy, that is understanding the problem, planning the problem solution, solving the problem, and looking back solution process. Making drawing process which represent problem situation was executed in second step of problem solving strategies. By using this strategy, students' mathematical thinking ability is improved and students also can solve problem better.

Suggestion

Based on the conclusion, advice or recommendation that can be given is in learning process, teacher can use problem solving strategy in order to increase students' mathematical thinking ability. Besides can improve mathematical thinking ability, the teacher can add the drawing process when solving problem can also help students to get new information that helpful for them to understand the problem well and to find the right solution of the problem.

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