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The Effect of Metacognitive Learning Strategies on Heuristic Ability in Mathematical Reasoning and Self Efficacy Reviewed from Students' Initial Mathematical Abilities

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***Abstract*—The use of Metacognitive Learning Strategies to help students understanding the way of learning, is an important thing that teachers need to pay attention to. This Research aims to examine differences between the Mathematical Heuristic Reasoning Ability and Mathematical Self Efficacy students who obtain the Metacognitive Learning Strategies and students who received conventional learning based on Initial Mathematical Ability (high, medium, low). This research is a quasi-experimental in the form of Non-Equivalent Control Group Design on 66 students in a junior high school in Bandung. The statistical test this study was conducted on students initial mathematical ability data, pretest data, and posttest data through normality test, homogeneity test, t-test, and Mann-Whitney U test on the data of students' ability of Heuristic in Mathematical Reasoning and Mathematical Self Efficacy. Based on the results of the study, it is concluded that there are significant differences in the ability of Heuristics in Mathematical reasoning between the experimental class and the control class viewed reviewed from each aspect or all of the high, medium and low Initial Mathematics Ability categories.**

Keywords— metacognitive learning strategies, mathematical heuristic reasoning ability, mathematical self efficacy

I. INTRODUCTION

Mathematics is one of the most important subjects that given to students at school. In order to support the success of students academically, it required good skills in Mathematics [1]. Although Mathematics is a very important material in schools, yet the lesson learned in school less favored students less. Besides, students have opinion that Mathematics is a difficult subject [2]. As a result students have difficulty in learning mathematics especially about problem solving [3-4]. It is estimated that 25% to 35% of students have difficulty in mathematics [5], including students in Indonesia. Therefore it is necessary to improve the way students learn so that they succeed [6]. In this case the teacher's role is very necessary. They have an important role in school, and are expected to take the initiative to help students overcome the difficulties. Thus the teacher needs to understand student's potential and obstacles for them give lessons and an effective strategy [7]. One of the possible interventions by the teacher are using metacognitive strategies.

Knowledge of metacognitive refers to the psychology of cognition [8]. The term of metacognitive was first introduced by Flavell in 1976 [9]. He explains that metagonitive is cognition of cognition. Another definition, metacognitive is thinking about thinking [10]. Khun and Dean [11] explained that metacognitive are things that can enable students to do the same thing as previously described, but with different contexts. Furthermore Flavell [9] states that metacognition consists of metacognitive knowledge and metacognitive or regulatory experience. Metacognitive knowledge refers to the acquisition of knowledge about cognitive processes, that can be used to control cognitive processes. While metacognitive experiences are processes that can be applied to control cognitive activities to achieve cognitive goals.

Teachers who apply metacognitive strategies will give a positive impact on students. The application of metacognitive strategies can assist students in learning various subject matter such as biology, economics, social including mathematics. Pintrinch [12] states that metacognitive strategies have a very important role to help students in learn. Metacognitive strategies refer to the methods used by teachers in helping students to understand the way they learn. In other words, the teacher becomes the main actor in designing the learning process so that students succeed well with metacognitive strategy. Students realize how they learn, they will use this process efficiently to get information and new knowledge. Ultimately and gradually they become students who independently develop their intellectual abilities and have a good reasoning.

To build students' intellectual abilities, it cannot be separated from how they can solve problems. So that students have reasoning and are able to solve problems properly they need to be given a problem solving strategy. A more in-depth study of improving the quality of students in the reasoning process is an important thing that is becoming a focus in the world of Mathematics education. Mathematics Reasoning is one aspect of the problem-solving process components to develop efforts to obtain solutions to problems by applying knowledge of mathematics and involves thinking and reasoning skills of students [13]. Furthermore, every person who reason and think analytically tends to pay attention to patterns, structures or rules both in daily life situations or in the form of symbolic [14].

In mathematical reasoning, some aspects play an important role in achieving the success of Mathematics assignment, namely heuristic ability in Mathematical Reasoning in terms of cognitive aspects and Mathematical Self Efficacy in terms of affective aspects. Cognitive and affective aspects are two aspects that interrelated and interact with each other. The ability of heuristics in Mathematical Words relates to the stages of work performed in problem solving [15]. It can be said that when problem solvers implement heuristics, it can lead them to finding solutions. heuristic thinking is about general strategies that must be obeyed and manifest as explained by Polya. To increase understanding in problem solving tasks that are described through certain stages, students need good Self Efficacy. Self Efficacy contributes greatly in terms of support from within that affects decision making and influences the actions to be taken. When someone has a high Self Efficacy he will certainly survive and not easily give up on activities before they can solve the problem, and Self Efficacy greatly affects the decisions they make. Both of these important aspects must be developed within students and integrated in the learning process at school.

But the reality on the ground shows the mismatch between reality and what should be achieved. The reality in the field, the learning process in schools emphasized in the aspect of 'doing' but not on the aspect of 'thinking' [16]. What is taught in the classroom has more to do with manipulative skills or concerning how to do things but less to do with why and what the implications are. In other words learning is only in the form of memorization, not reasoning, problem solving or the ability to think as a basis for understanding. As a result, the development of students' mathematical reasoning and problem solving abilities is hampered. Realizing the importance of developing a learning strategy to improve the ability of heuristics in Mathematical reasoning to support student success in problem solving, it is necessary to have a typical learning that can more actively involve students in developing their thinking skills.

At present, what is the center of attention is typical learning as what can contribute to the students' ability of heuristics in mathematical reasoning and Mathematical Self Efficacy. Besides having to provide a learning environment that is able to motivate students to be able to explore heuristic abilities in their reasoning and Mathematical Self Efficacy, teachers must be creative in developing learning patterns that are able to direct students towards success in the use of heuristics in Mathematical reasoning which at first did not guarantee successful in solving the problems towards achieving success in solving Mathematical problems. The teacher is possible to move towards a different pedagogical type which in this case is a learning model to instill the effectiveness of heuristic and metacognitive strategies in problem solving which will easily assist students in finding solutions to various problems. It also concerns the type of learning in which the teacher encourages students to solve problems frequently, instills free thinking and asks for different approaches to solutions that will make students rich in problem solving experiences.

This research is a development carried out from several studies that have been done before. Most of the previous research focused on heuristics in problem solving. Here the researcher wants to specialize in the ability of heuristics in mathematical reasoning. Mathematical Reasoning is an aspect that is in the process of students solving problems. Heuristics play an important role in the process of mathematical reasoning as a stage of thinking in the process of reasoning. Research that examines the effect of Metacognitive learning strategies on the ability of heuristics in Mathematical reasoning and Self Efficacy is a research that is rarely done, so researchers intend to develop it.

II. METHOD

This research is a quasi-experimental research in the form of Non-Equivalent Control Group Design with the subject of class VIII students in one of the junior high schools in Bandung, namely SMP N 15 Bandung. In this case in chosing the school is a school with a cluster being in accordance with the categorization district of the city of Bandung. The study involved two classes comprised of 66 students, which is first class with a learning of Metacognitive Strategy while the second class without a strategy Metacognitive Learning Strategy. In this study, each research group, namely the experimental group and the control group, will be grouped based on their abilities into three levels, namely : high, medium, and low ability group. This ability grouping is obtained from the results of the Initial Mathematics Ability test regarding subject matter that has been studied previously. The time of this research is 1 month, with 8 meetings, each meeting with a duration of 2x40 minutes.

III. RESULT AND DISCUSSION

Ministry of National Education [17] explains that in the world of education learning strategies can be interpreted as a plan that contains a series of activities designed to achieve certain educational goals. The phases that are applied in this metacognitive learning are: (1) Provision of problems; (2) information gathering; (3) Planning; (4) monintoring; and (5) Reflection.

Fig. 1. Picture of group discussion activities and group presentations.

Figure 1 explains some of the processes applied in metacognitive learning strategies, namely the process of group discussion and group presentations. At each meeting, the process of inculcating concepts using Student Worksheets is done through group discussion activities. Student groupings are based on previous Initial Mathematical Ability groupings. Each group consists of students with high, medium, and low Initial Mathematics Ability criteria. This is done so that students with various Initial Mathematics Ability criteria can exchange information and help one another. So it is expected that students with high Initial Mathematics Ability criteria can help students with moderate and low Initial Mathematics Ability criteria

so that the contribution of learning with this Metacognitive strategy can be felt by all students with high, medium, or low Initial Mathematics Ability categories.

Learning with this Metacognitive strategy is applied to students to increase the ability of heuristics in Mathematical reasoning and Mathematical Self Efficacy. Based on the results of the test work that is designed in such a way shall be able to measure the ability of heuristics in Mathematical Reasoning students can be seen that there are differences in responses between the experimental and control classes. It can be observed in Fig. 2.

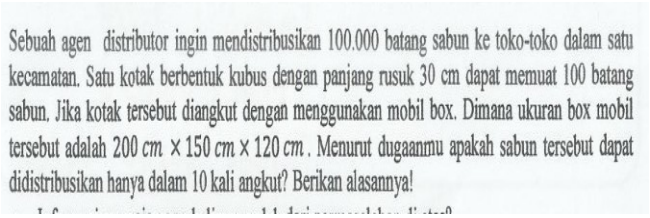
Sebuah agen distributor ingin mendistribusikan 100.000 batang sabun ke toko-toko dalam satu kecamatan. Satu kotak berbentuk kubus dengan panjang rusuk 30 cm dapat memuat 100 batang sabun. Jika kotak tersebut diangkut dengan menggunakan mobil box. Dimana ukuran box mobil tersebut adalah 200 *cm* × 150 *cm* × 120 *cm*. Menurut dugaanmu apakah sabun tersebut dapat didistribusikan hanya dalam 10 kali angkut? Berikan alasannya!

Fig. 2**.** Example of one of the items in the post test.

Figure 2 is one of the items in the post test. This item is used to see the heuristic ability in Mathematical Reasoning. Next will be observed how students from the control class responds to learning conventionally and compared with experimental class learning using learning strategies metacognitive.

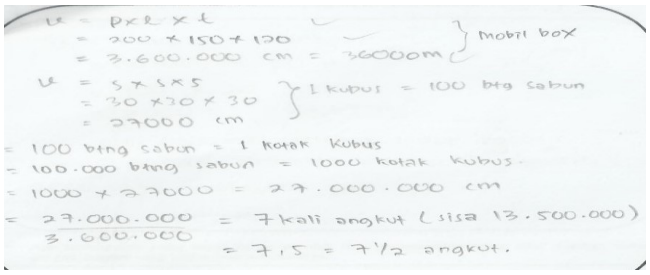

Fig. 3 **.** Examples of solving problems one of the control class students in solving problems in the post test.

In Figure 3, it appears that students are trying to solve problems using the store of knowledge they have. But the work done is not right. These students have not been able to control the thinking processes that they have to be able to consider the various possibilities that can occur from existing problems. In contrast to the results of the work of one of the students in the experimental class who were able to consider various possibilities of the problems presented to them. This can be observed in Fig. 4.

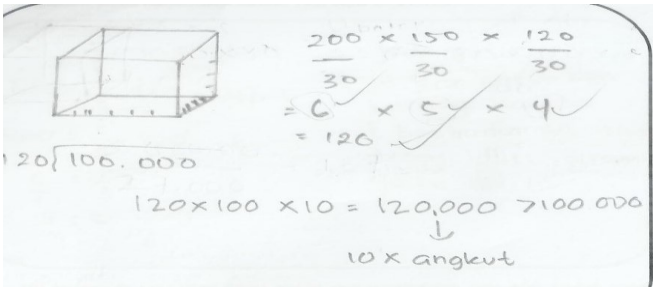

Fig. 4. Examples of solving problems one of the experimental class students in solving problems in the post test.

Figure 4 shows that there is an experimental class, students have solved the problem using the stored knowledge they have appropriately. These students have been able to control their thinking processes through Metacognitive Knowledge to be able to consider the various possibilities that can occur from existing problems. The excerpt from the posttest work above is the result of one of the students in an experimental class with moderate Initial Mathematics Ability criteria.

Metacognitive Strategy was given to the students in control and experiment class, homogeneity test of the pretest score between the control class and the experimental class was first tested to ensure that both samples came from populations tha had the same variance (homogeneous). The homogeneity test conducted in this study is using SPSS (Levene Test). The test criteria is used to test homogeneity are:

If Sig. (p-value) < α (α = 0.05), then H0 is rejected
If Sig. (p-value) ≥ α (α = 0.05), then H0 is accepted

Homogeneity test is performed on the pretest score of heuristic ability in Mathematical Reasoning and Mathematical Self Efficacy of the control and experimental class. This test is performed as a prerequisite test in the analysis of independent sample t- test which will then be used to compare the average of the two case groups.

In addition to discussing the results of work on student worksheets, this article also describes the results of statistical tests to see if there is a significant difference between the average heuristic ability in Mathematical Reasoning of students in the experimental class and the control class. Statistical test results can be seen in the following Table I.

TABLE I. SUMMARY OF AVERAGE DIFFERENCE TEST RESULT

Initial Mathematics Ability	Comparison of averages (E: K)	t	t '	*Mann-Whitney U*	Sig. (2 tailed)	Ho
High	69.75: 58.00	2,757	-	-	0.017	Reject
Is	66.00: 51.38	-	-	-4,674	0,000	Reject
Low	60.00: 43.00	4,661	-	-	0.002	Reject
Whole	66.00: 51.31	7,552	-	-	0,000	Reject

H0: *There is no difference in heuristic abilities in mathematical reasoning.*
H1: *There are differences in heuristic abilities in mathematical reasoning.*

With the following test criteria:
If Sig. (p-value) <α (α = 0.05), then H0 is rejected
If Sig. (p-value) ≥ α (α = 0.05), then H0 is accepted

Based on the summary test results of the average difference in the sample groups presented in Table 1 above, it is seen that when viewed as a whole as well as for Initial Mathematics Ability with high, medium and low criteria, a significance value of less than 0.05 is obtained, so H0 is rejected. This means that there are significant differences in the ability of Heuristics in mathematical reasoning between the experimental class and the control class when viewed as a whole and when reviewed between each of the high, medium and low Initial Mathematics Ability categories. In addition to examining the aspects of Heuristic Ability in Mathematical Reasoning, it is also seen how the difference in Mathematical *Self Efficacy* of experimental and control class students. Table II illustrates how the effect of metacognitive learning strategies on students mathematical Self Efficacy.

TABLE II. SUMMARY OF MEAN DIFFERENCE TEST RESULT

Initial Mathematics Ability	Comparison of averages (E: K)	t	t'	*Mann-Whitney U*	Sig. (2 tailed)	H0
High	195.88: 164.50	-	4,975	-	0.004	Reject
Is	183.71: 166.71	-	3,757	-	0.001	Reject
Low	167.00: 152.80	2,406	-	-	0.043	Reject
Whole	184.12: 164.12	-	-	-4,811	0,000	Reject

H0: There is no difference in Mathematical Self Efficacy
H1: There is a difference in Mathematical Self Efficacy

Based on the summary test results of the average difference in the sample groups presented in Table 2 above, it is seen that when viewed as a whole as well as for Initial Mathematics Ability with high, medium and low criteria, a significance value of less than 0.05 is obtained, so H0 is rejected. This shows that there are significant differences in the final Mathematical Self Efficacy between students who obtained the Metacognitive learning strategy and students who get Conventional learning both overall and when reviewed between each Initial Mathematics Ability category (high, medium and low).

IV. CONCLUSION

Based on the research that has been carried out, it can be concluded that there are significant differences in the ability of heuristics in mathematical reasoning and students' Mathematical Self Efficacy between the experimental class and the control class when viewed as a whole or when reviewed between each high, medium and low Initial Mathematics Ability category. In other words, The study result provides information that metacognitive learning strategies capable of giving effect to the ability of heuristic reasoning and Mathematical Self Efficacy students.

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