Problem Solving Learning With Drawing A Diagram Strategy To Improve Mathematical Reflective Thinking Skills

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Abstract. *The purpose of this research was to analyze the increase of mathematical reflective thinking skills among students taught by problem-solving learning with drawing a diagram strategy from students who are taught by conventional learning with an expository method. The research method used is a quasi-experiment with a randomized posttest given to the control group design. To take samples, the researcher used cluster random sampling by taking two of the eight classes, one class as a class experiment and the other class as a control class. The result of this research showed that students' mathematical reflective thinking skills who are taught problem-solving learning with drawing a diagram strategy overall are higher than students who are taught by conventional learning with an expository method. Specifically, this research showed that problem-solving learning with drawing a diagram strategy indicated a huge increase on the evaluation indicator compared with the other indicators.*

Keywords: problem solving, learning, thinking skills

1. INTRODUCTION

A good education is an education that aimed at humanizing. Humanizing means to form and build human characters, as mentioned in the national education system, so that they are independent and responsible human beings. Independence and responsibility can be formed through various learning activities. Independence gained in the study raises awareness as a goal to achieve. Through consciousness, a person will monitor and control the thinking process. Thus, the thinking capacity will be increased and continuously trained.

One high-level thinking skill that is currently being pursued maximumly in mathematics learning is the ability to think reflectively. This is consistent with the statement that: "the ability to think mathematically is one measure achievement of mathematics learning goals, especially the ability to think in a high level (high order thinking skills), such as critical thinking, creative, logical, analytical and reflective" (Moore and Aziz , 2012). Reflection in mathematics is a tool to develop the students' ability to use the concept - the concept of mathematics to solve practical problems and participate in a deeper thought about the topic. Furthermore, in the context of mathematics, reflection involves examining procedural knowledge used in everyday practice - the way that applications can be extended beyond the immediate circumstances (Betne, 2009). Students may be aware of and able to control their own thinking processes while doing math activities. Therefore, it is important to develop reflective thinking skills in mathematics, particularly in the problem-solving process.

There are a number of teachers teaching without training the students on how to get the concept. A research on classroom observation VIII at MTs in South Jakarta found that, overall, the teacher only explained and asked the students to take a note on the teacher's explanation. Then, the students are instructed to work on the common problems with similar type of questions. Other results are shown from preliminary studies and review of students' work regarding the ability in mathematical reflective thinking. Results of pre-study in class VIII indicated that out of 36 students, there are only three students who received grades above KKM with value – less than 50 for the average grade. Therefore, only 8.33% of the students were able to resolve the problem. Specifically, the results of previous studies conducted by Fadhila's daughter in one of the junior high schools located in South Tangerang City, Banten concluded that the average ability of the students using metacognitive approach in reflective thinking is higher than the average of those who use

conventional learning. In other words, this finding proves that the ability to think reflectively in mathematics are not developed in the conventional learning.

Based on the problems mentioned above, teachers should be able to choose the learning strategies that can stimulate reflective thinking in learning math and improve learning outcomes. Suyitno stated that problem-solving model learning models improved higher-level thinking (HOT) skills. A problem-solving model with higher-order thinking allows the students to experience maximum use of knowledge and skills. As a result, the significance of learning is tasted (Sri Widodo, 2013). Learning the problem-solving approach potentially trains learners in facing personal and group problems together. The students learn how to identify the causes and the alternatives to solve the problems. The orientation of the investigation and discovery of learning is based on problems solved together. Learners must conduct an investigation to seek, analyze and define problems, develop hypotheses, collect and analyze data, and draw conclusions (Ridwan, 2013). Thus, it can be concluded that learning problem-solving teaches students how to overcome barriers through learning experiences by conducting discovery and investigation so that they can construct their knowledge.

One method that can help teachers teach problem-solving learning is a method of drawing a diagram which is by combining the use of a diagram to represent a problem. The diagram can establish a connection between the fixers and the problem. Sybilla Backmann (2004) supported this by saying that the diagram is designed to help children understand the issues and use strategies to provide appropriate solutions that can be justified on the basis of the concept. Diagrams are used for various purposes such as a line to symbolize the object, a line in spacing and timing, a scale, a map or directions, connecting objects, and a sketch.

The process uses a diagram called translation. During the translation process, there is potential to acquire knowledge through information reorganization and make further conclusions. The knowledge gained depends on three components: information processing, selective combining, and selective comparison (Carmel, 2000). Information processing means connecting the relevant information to be presented. Selective combination refers to how the new information is incorporated as a discrete form. It focuses on the relationship that compares new knowledge with prior knowledge of the diagram. The component focuses on the importance of knowledge about the type of diagram that plays a role in solving the problems. Thus, we can conclude that the method of drawing a diagram is a method used by students when they are solving problems. This diagram helps students build connections with the problem so that they can be understood easily. This is because the diagram can describe the connection of the information in the issues.

Shermis said that the most complete list of reflective skills can be found on Weast namely: identifying the authors' conclusion; identifying the reasons and evidence; identifying the language ambiguous and vague; identifying assumptions and conflicts of value; identifying assumptions descriptive; evaluating statistical reasoning; evaluate sampling and measurement; evaluate logical reasoning; identify information removed; pronounce its values with understanding, without prejudice (Noer, 2008). Thus, Shermis said reflective skills in general have identification and evaluation skills. This was confirmed by the definition of the ability to think math reflectively presented by Abdul Muin, Yayah Kusumah, and Utari Sumarmo that this ability in the learning of mathematics is named through the thinking process of describing, identifying, interpreting, evaluating, predicting, and make inferences in mathematical situations.

Jansen and Spitzer identified the reflective thinking ability with two or four phases in the cycle of Rodger's reflection. One is the description phase. The description phase illustrates how students think. It also describes how to distinguish students into individuals or groups (Muin, 2011). Criteria for assessing the depth of reflective thinking were expressed by Lee as follows: (1) Level 1 Recall (R1) which considers the facts, covering the following aspects: describe what is experienced, interpret the situation based on the memory of the experience without providing an explanation, trying to find another similar way (imitation) which has been observed and thought; (2) Level 2 rationalization (R2), is the rationalization of the relationship, covering the following aspects: find the relationship between the parts of the experience, interpret with explanations (rationalizations), seeking the information as to why it happened and to generalize the experience gained; (3) Level 3 reflectivity (R3) is the reflectivity, covering the following aspects: to approach the experience to predict, analyze the experience of a different view, make a decision of experience gained (Muin, 2012). Through the three levels above proposed by Lee, the depth of reflective thinking can be seen from description, through the generalization of experience, to the stage of decision-making. Based on the mathematical definition of reflective thinking skills described, in this study, the ability of reflective thinking can be defined as the ability to think in describing a situation or a mathematical

problem, identifying situations or mathematical problems, evaluating, and making conclusions (generalizations).

The problem-solving method of drawing a diagram consists of four stages: (1) understand the problem, (2) plan the making of drawing a diagram as a solution, (3) run the solution by drawing a diagram, and (4) review (Shapiro, 2014). The learning phase is very supportive of each other. The first stage is to understand the problem in which the students identify the problems such as relevant information as initial capital in problem-solving. After the students were asked to explain what is required or completed on the issues presented, this initial stage is to facilitate the students in improving their reflective thinking ability on indicators to describe and identify math problems. The second stage is planning to draw a diagram as a solution. In this stage, the students were asked to identify the mathematical concepts involved and the charts that will be used following the concepts related to the problem. This stage can facilitate students to improve their math reflective thinking ability.

The next stage is to run the solution by drawing a diagram. In this stage, the students visualize the problem by drawing a diagram selected following the relevant math concepts. After that, students perform mathematical calculations if needed to get the final results. This stage can enhance students' mathematical ability in reflective thinking on indicators to describe and identify problems. The final stage is to revisit in which the students were asked to review the answers following the request. Furthermore, students are asked to make a decision or conclusion. The final stage is to improve students' mathematical reflective thinking on indicators to evaluate and make conclusions. The stages of problem-solving learning with drawing a diagram method described previously concluded that problem solving learning improves students' mathematical abilities of reflective thinking.

2. METHODS

The method used in this study is a randomized quasi-experimental with a posttest conducted only on the control group. The sampling method uses cluster random sampling by taking two of the eight classes, one class as the experimental class and the other class as the control class. The experimental class was treated by using the methods of problem-solving learning by drawing a diagram, while the control class was given conventional learning with an expository method. The second class was given reflective thinking ability tests at the end of learning. If there was a significant difference between the results of the experimental class with grade control, the treatment accorded significant influence. The study design was described as follows:

Research Design

Group	Treatment	Posttest
E	X	O
C	-	O

The target population in this study was all students at one of the MTs in South Jakarta. The population of inaccessibility was the entire eighth-grade students in the MTsN. The sample selected is grade VIII with the detailed information as follows; VIII - 6 as the experimental class and grade VIII - 5 as the control class.

The instrument used in this study was in the form of test capabilities of mathematic reflective thinking. Arranged in the form of test item description and it was given after learning is complete. Data analysis of the data used is descriptive statistics and quantitative analysis. The hypothesis is tested by using the t test.

3. RESULTS AND DISCUSSION

The results of reflective thinking ability test showed that each student's maximum score was 24. the highest score for the experimental class was 23 and the lowest was 6, while the highest score for the control class was 14 and the lowest was 1. The result of the test on reflective thinking in the experimental class and control class were presented in the following table:

Tabel 3. The *Posttest* Result of Reflective Thinking Mathematically

No	Indicator	Ideal Score 36 Students	Experimental Class			Control Class		
			Score 36 students	Mean	Mean (%)	Score 36 students	Mean	Mean (%)
1	*Describe*	288	157	4.36	54.52	105	2.92	36.46
2	*Identify*	144	112	3.11	77.78	72	2.00	50.00
3	*Evaluate*	288	156	4.34	54.17	48	1.33	16.67
4	*Make Conclusions*	144	81	2.25	56.25	55	1.53	38.20
	Total	864	506	14.06	58.56	280	7.78	32.40

Table 3 above shows the distribution of data from 36 students in the experimental class and 36 students in the control class after learning problem-solving by drawing a diagram in the experimental class. The average ability to think reflectively in mathematical problem-solving learning with drawing a diagram method was equal to 14.06 or 58.56%, while the reflective thinking ability taught with conventional learning using the expository method was equal to 7.78 or 32.40 %.

Data on test results showed that the aspect of reflective thinking with the highest percentage obtained by the two classes was on identifying aspect, 77.78% of the experimental class and 50% of the control class. Aspects of reflective thinking with the lowest percentage in the two classes were evaluating aspects, the experimental class was at 54.17% and 16.67% was in the control class.

The percentage gained by the second grade on the ability to evaluate was equal to 37.50%. It can be seen from the aspect of evaluating the achievement scores obtained in the second class. The maximum score was 288. The experimental class obtained a score of 156, while the control class obtained a significantly lower which was only 48. The percentage difference between the two classes in evaluating the aspects was far different from the reflective thinking which has a difference of 18.06%, the aspect of identifying with a difference of 27.78%, and the aspects of concluding by a margin of 18.05%.

When viewed from some indicators of the ability to think reflectively, generally students who use the problem-solving learning method of drawing a diagram state that they make better results than those who use conventional learning. The differences in percentage on each indicator measured was presented in Figure 4.1 below.

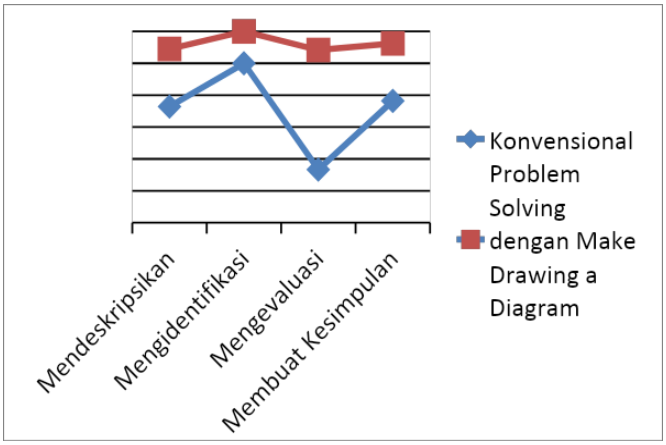

Figure 4.1 Comparison of Indicator Percentage Achievement of Reflective Thinking Ability Between Convensional Class with Experiment Class

4. DISCUSSION

The result of comparison of indicator percentage describes the result of every indicators and we can see from the figure that for indicator of make conclusions on the experimental class and the control class has a difference that is not much, even almost the same between indicator of describe with making inferences at 18.06% and 18.05%. This means that the difference in improvement achieved for both aspects between the experimental class and control class was not far different. However, the difference in the percentage was strong enough at identifying and evaluating aspects. The percentage difference between the experimental class and control class in the aspects of identifying the results was 27.78%, while 37.5% was the evaluating aspect. These results imply that the aspects of identifying, among students experimental class and control class, experienced an increased achievement which was quite large, even larger and more significant in evaluating aspects.

The existence of a considerable margin on the evaluated aspects can be indicated in the learning process using problem-solving methods in drawing a diagram. This was accustomed to checking the truth of the answers, especially in the process of drawing, whether the image created is sufficient and appropriate to answer the problems. The activity is displayed in the Student Discussion Sheet (LDS) through activities such as the assignment and reconsidering the work that has been done to resolve the problem. However, these evaluation activities never appeared on conventional learning, because conventional learning students merely exercise without revisiting the answer. Discussion Sheet Students (LDS) used did not include questions that train students to revisit their answers, merely conclude at the end of the activity. It provides an opportunity to evaluate the activity that occurred more frequently in the problem-solving learning method of drawing a diagram.

The high ability to evaluate problem-solving learning with drawing the diagram method was strengthened by the translation process in the use of the diagram. The process was not limited to accessing and connecting previous knowledge with new learning as an excuse to give an answer (Delinda, 2015). The process makes it easy to associate students' existing concepts to give reasons when checking the truth. This is consistent with the statement that in mathematics learning and teaching, the image plays an important role as a tool to support reflection and the means to communicate ideas (Iliada and George, 2004).

The results of this research are similar to Sawati's research on "The Effects of Problem Solving Strategy Implementation Draw a Picture Of Problem Solving Ability Story". The study showed that students who learned by using problem-solving strategies draw a better picture than those using conventional learning. Students learning problem-solving can draw a picture in systematic thinking and reasoning in solving. Similarly, the learning problem solving by drawing a diagram method also focuses on the process of thinking to solve the problem. Specifically, it identifies the problem and reason with the help of a drawing sketch to facilitate understanding in solving problem

5. CONCLUSION

Based on the analysis and discussion described in the previous chapter, the conclusions of this study are as follows: (1) ability to think reflectively using learning problem-solving methods by drawing a diagram is overall higher than those using conventional learning. This difference can occur because of the differences in treatment during the learning process;

(2) Learning problem solving by drawing a diagram method is specifically well applied to enhance the students' abilities in reflective thinking on evaluating indicators. The results obtained from the percentage were the difference between the two indicators in evaluating a larger class than the other indicators.

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REFERENCES

1. Arikunto, Suharsimi. *Dasar – Dasar Evaluasi Pendidikan*. Jakarta : Bumi Aksara, 2012. Ed. 2.
2. Backmann, Sybilla, "Solving Algebra and Other Story Problems with Simple Diagrams: a Methode Demonstranted in Grade 4-6 Texts Used in Singapore", *The Mathematics Educator Vol. 14, No.1, 42 – 46*, 2004.
3. Betne, Prabha, "Reflection As a Learning Tool In Mathematics", *The Laguardia Journal* On Teaching and Learning, In Transit, 2009.
4. Cresswell, John W, *Educational Research Planning, Conducting, and Evaluating Quantitative and Qualitative Research*. Boston : Pearson Education, Inc., 2008. Third Edition.
5. Departemen Agama Republik Indonesia, "Undang – Undang Republik Indonesia Nomor 20 Tahun 2003 Tentang Sistem Pendidikan Nasional", http://kemenag.go.id/file/dokumen/UU2003.pdf, 11 September 2015.
6. Diezmann, Carmel M, "Evaluating the Effectiveness of the Strategy Draw a Diagram as a Cognitive Tool for Problem solving", *Proceedings* of the 18th Annual Conference of Mathematics Education Research Group of Australasia, Darwin, 1995.
7. Diezmann, Carmel M, "The Difficulties Students Experience In Generating Diagrams For Novel Problems", *Proceedings* of the 25th Annual Conference of International Group for the Psychology of Mathematics Education, Hiroshima, 2000.
8. Dimyati dan Mudjiono. *Belajar dan Pembelajaran*. Jakarta : Rineka Cipta, 2009. Cet. IV.
9. Elia, Iliada., and Phillipau, George., "The Functions of Pictures In Problem Solving", *Proceedings* of the 28th Conference of the International Group for the Psychology of Mathematics Education, Vol 2, 2004.
10. Garderen, Delinda Van., *et al.*, "TEACHING Exceptional Children Vol 47", (http://www.tcx.sagepub.com), 2015.
11. Gonzales, Fany M., and Martines, Enrique Castro, "Diagrams Produced by Secondary Students In Multiplicative Comparison Word Problems", *Journal* of Mathematic and System Science 4, 25 February, Spain : University of Granada, 2014.
12. Hudojo, Herman. *Pengembangan Kurikulum Dan Pembelajaran Matematika*. Surabaya: Universitas Negeri Malang, 2005.
13. Kurniawati, Lia. *Pendekatan Baru dalam Pembelajaran Sains dan Matematika Dasar*. Jakarta: PIC dan IISEP UIN Jakarta, 2007.
14. Kusumaningrum, Maya., dan Saefudin, Abdul Azis, "Mengoptimalkan Kemampuan Berpikir Matematika Melalui Pemecahan Masalah Matematika", *Prosiding* Disampaikan pada Seminar Nasional Matematika dan Pendidikan Matematika Kontribusi Pendidikan Matematika dan Matematika dalam Membangun Karakter Guru dan Siswa, 10 November, Yogyakarta: FMIPA UNY, 2012.
15. Kuswana, Wowo Sunaryo. *Taksonomi Berpikir*. Bandung : PT Remaja Rosdakarya, 2011.

16. Muin, Abdul. “The Situations That Can Bring Reflective Thinking Process In Mathematics Learning,” *Makalah* disampaikan pada Seminar Internasional dan Konferensi Nasional Pendidikan Matematika ke IV Building the Nation Character Through Humanistic Mathematics Education, 21 – 23 Juli, Yogyakarta: Departemen Pendidikan Matematika UNY, 2011.
17. Muin, Abdul., dan Kurniawati, Lia, “Problem Based And Metacognitive Learning To Improve Mathematical Reflective Thinking Skills”, *Proceeding* of Conference On Research, Implementation And Education Of Mathematics And Sciences, 18 – 20 May. Yogyakarta : Universitas Negeri Yogyakarta, 2014
18. Noer, Sri Hastuti Noer. “Problem Based Learning dan Kemampuan Berpikir Reflektif dalam Pembelajaran Matematika”, *Makalah* Disampaikan pada Semnas Matematika dan Pendidikan Matematika Vol 2, 2008.
19. Phan, Huy P, “Reflective Thinking, Effort, Persistence, Disorganization, and Academic Performance: A Mediational Approach”, *Electronic Journal* of Research in Educational Psychology 7(3), 9 Juli, Australia : University of New England, Armidale, 2009.
20. Posamentier, Alfred S., and Krulik, Stephen. *Problem solving in Mathematics Grades 3-6*. United States of America: Corwin, 2009.
21. Purwanto, M. Ngalim. *Psikologi Pendidikan*. Bandung : PT Remaja Rosdakarya, 1990.
22. Sani, Ridwan AbdullahSani. *Inovasi Pembelajaran*, Jakarta: Bumi Aksara, 2013. Semerci, Cetin. “Developing A Reflective Thinking Tendency Scala for Teachers and Student”, *Educational Science : Theory and Practice 7(3)*, September, Turkey : Firat University, 2007.
23. Shapiro, Sharon. *Problem solving Drawing a Diagram*. Sydney: Blake Education, 2000.(https://www.blake.com.au/v/vspfiles/downloadables/PT1_ProblemSolving.P df), diakses pada 28 Oktober 2014.
24. Suharna, Hery., dkk., “Berpikir Reflektf Mahasiswa dalam Menyelesaikan Masalah Matematika,” *Makalah* disampaikan pada KNPM V, Juni, Himpunan Matematika Indonesia : Universitas Negeri Malang dan Universitas Khairun, 2013.
25. Uosaka, Yuri., and Manalo, Emmanuel, “The Effects of Peer Communication with Diagrams on Students’ Math Word Problem Solving Processes and Outcomes”, *A Grant-in-Aid for Scientific Research* from the Japan Society for the Promotion of Science, Tokyo.
26. Warti, Rini, “Kecerdasan Intuitif dan Kecerdasan Reflektif”, *Edu-Math;Vol.4*, 2013.
27. Widodo, Tri., dan Kadarwati, Sri, “High Order Thinking Berbasis Pemecahan Masalah Untuk Meningkatkan Hasil Belajar Berorientasi Pembentukan Karakter Siswa”, *Cakrawala Pendidikan*, Februari, Semarang: FMIPA Universitas Negeri Semarang, 2013.