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MATHEMATICAL COMMUNICATION AND PROBLEM SOLVING ABILITY OF 8TH GRADE STUDENTS AFTER INVOLVING MODEL ELICITING ACTIVITIES (MEAS) STRATEGY

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Abstract

The practitioners of mathematics education believed that problem-solving ability is the core of the learning mathematics. In the problem-solving process, students are challenged to explore their mathematical concepts and capabilities. Students must identify the adequacy of the data contained in the problem. More than this, the student must ensure that the data at issue is relevant and logical to answer questions. Students also need to understand the relationships that exist between the data and the questions, and it should be reflected in the model made the students. Students should make sure that the model that has been created is a model that can be used to solve the problem. In solving the problem, students use concepts and mathematical representations to express their mathematical ability and reasoning. All the activities in the process of mathematical problem solving has the potential to maximize the mathematical ability of students if students are given the opportunity to discuss with their peers. One of the capabilities that can be developed through discussion is mathematical communication skills. Habituation to the students to communicate mathematically through ongoing discussions will strengthen the ability of solving mathematical problems. Strategy of teaching-learning that has the potential to build simultaneously problem solving skills and mathematical communication is Model Eliciting Activities (MEAs). There are six principles of MEAs that allow the establishment of problem-solving ability and mathematical communication simultaneously, namely the principle of : using a real problem , creating a mathematical model, presenting their mathematical thinking to other students, judging the truth of their solution, documenting the results of his work , and the principle that the resulted model is an effective prototype models. This study, which involved 69 students of 8th grade and aimed to determine the ability of communication and solving mathematical problems students after the students engaged in learning mathematics through MEAs strategy, provide results that: the ability of communication and solving mathematical problems of students that engaged in learning mathematics through MEAs strategy better than students engaged in learning mathematics through conventional strategies. The results of this study also indicate that there is a positive association between mathematical problem solving skills and mathematical communication skills.

Keywords: association, mathematical communication, mathematical problem solving, the model-eliciting activities (MEAs)

INTRODUCTION

National Council of Teachers of Mathematics (Van de Walle, 2007) set a standard of a teaching-learning process of mathematics that is to enable students: (i) build new mathematical knowledge through problem solving, (ii) solve problems that arise in mathematics and in other fields, (iii) implement and customize a variety of suitable strategies to solve the problem, and (iv) observe and develop a mathematical problem-solving process.

Problem-solving process allows students to gain an understanding of new mathematical concept contained in problems. Van de Walle (2007) argues that the new mathematical understanding will be gained by students when they actively seeking a relationship, analyzing patterns, find whether the methods are appropriate or not appropriate, test a result, judging or criticizing their thoughts. Student engagement in reflective thinking to the ideas of mathematics will optimize their mathematical ability.

Sumarmo (2008) stated that one type of problem solving is a problem solving as an activity. Problem-solving as an activity includes: (i) identifying the adequacy of the data for solving the problem, (ii) creating a mathematical model of a situation or everyday problems, (iii) selecting and apply strategies to solve problems, (iv) explaining or interpret the results related to the origin of the problem, and verify the results, and (v) applying mathematics significantly. The characteristics of problem solving that involve a non-routine problem, mathematical reasoning and higher level thinking skills, makes it classified as a higher-level thinking skill. Solving the problem does not easily and automatically load the settlement procedure. NCTM (2000) recommends that a novelty of problem is a necessary component in problem solving.

Specific investment objectives of problem solving in a teaching-learning process of mathematics (NCTM, 1989) are to: (i) increase the willingness of students to try solving problems and improve student’s persistence when solving problems, (ii) improve students' independence in understanding of the concept which led to increase of student confidence about his ability to solve problems, (iii) help students aware of strategies in solving problems, (iv) make students aware of that the problem has a settlement value through a systematic manner, (v) to make students aware of that many of the problems can be solved in various ways, (vi) improve students' skills in choosing the right settlement strategy, (vii) improve the students’ ability to apply accurately solving strategies, and (viii) increase the students’ ability to obtain the more correct answers to a problem.

The process of mathematical problem solving (Polya, 1973) namely (i) understanding the problem, (ii) making a plan and design how to solve problem, (iii) carrying out the plan, and the final step (iv) looking back, done by students would be more effective if carried out through discussion. The discussion became a forum for students to speak up about mathematical thinking and learn to understand mathematical thinking of other friends.

The indicator of mathematical problems solving ability Sumarmo (2008) include: (i) the students can identify the elements that are known, (ii) the student can formulate a mathematical problem or develop a mathematical model, (iii) the student can apply strategies to solve a variety of problems (similar and new problems) within or outside of mathematics, (iv) the student can explain and interpret the results as the origin of the problem, and (v) the students can use math significantly.

The indicator shows the mathematical communication skills (Sumarmo, 2004) are: (i) link real objects, drawings, and diagrams into mathematical ideas, (ii) explain the ideas, situations and mathematical relationships, orally or in writing with real objects, images, and graphs; (iii) declare everyday problems with mathematical language or symbols, (iv) listen, discuss, and write about mathematics; (v) read with understanding a written mathematical presentation; (vi) make conjectures, formulate arguments, formulate definitions, and generalizations, and (vii) a description or paraphrasing a paragraph in the language of mathematics itself. However, this study only tested the students' mathematical communication ability in writing.

MEAs strategy is the process of teaching and learning potential for students to explore mathematical ability in solving mathematical problems and communicate mathematically. Lesh , et al . (2000) have designed and tested MEAs step process to develop mathematical understanding ability of students based on six principles of MEAs (Shuman, 2008). The principle of constructing the model, the reality principle problem to be meaningful and relevant to the real experience of the students, the principle of self-assessment that requires students to assess or measure the usefulness of their solutions, the principle of the model documenting the results of their thought process, the principle of sharing and reuse of models, the principle of principle prototype effectively ensures that the resulting model will be as simple as possible, but still mathematically significant. Lesh , et al. (2000) have found that MEAs can be designed such that the activities carried out lead to significant learning builds communication skills and mathematical problem solving.

MEAs implemented in several steps (Chamberlin, 2002). Learning begins with the presentation of a problem or situation that is contextual. In presenting problems of students with teacher guidance through the discuss process studying the problem context. Once teachers know that each group had to understand the problems, the activities continued with solving the problem. The discussion groups provide opportunities for students to discover concepts / principles of mathematics. After making several iterations of the solution and revise if necessary, the students present their models to the class.

Eric (2008) examined the use of MEAs in the teaching-learning process of mathematics in primary schools. Mathematics teaching-learning process considered takes place contextually by modeling activity as a catalyst to bring mathematical reasoning and make the lessons meaningful. MEAs gives students the opportunity to resolve the really contextual issues. In addition, students gain the opportunity to develop mathematical thinking in the modeling process.

METHODOLOGY

This research is a quasi-experiment used one Junior High Schools in Depok, West Java. This research involved 69 of 8^{th} - grade students from two classes. One class was used as experiment class and the other one was used as control class. Students in experiment class received MEAs teaching-learning, while students in control class received conventional teaching-learning. Research implementation in both classes is done directly by the researcher. Before the treatment, all students are tested for their prior knowledge of mathematics. After treatment of experiment, all of students are given the test of mathematical problem-solving ability and mathematical communication ability.

The teaching-learning process in this study used a teaching-learning process design (RPP) and student worksheet (LKS). RPP and LKS are designed to develop students' ability in solving a mathematical problem about linear equations and communicate their thinking into writing mathematically.

Scoring to each item test of mathematical problem-solving ability given in a scale of 10 which is a modification of the Scale for Problem Solving (Szetela etc., 1992) in Mathematical Problem Solving Rubric Scale Chicago. The numbers of questions used to test the ability of mathematical problem solving are five questions. While, scoring to each item test of mathematical communication ability given in a scale of zero to four which is a modification of Maryland State Department of Education (1991): "Sample activities, student responses and Maryland teachers' comments on a sample task: Mathematics Grade 8". The lowest possible scores achieved by students is zero, and the highest score that can be achieved by students is four. The numbers of questions used to test the ability of mathematical communication are five questions.

THE RESULT OF STUDY

Statistics of the prior mathematical knowledge (PAM) students described in Table 1. below.
Table 1. *Statistics of PAM Scores*

Statistics	Experiment Class	Control Class
The number of students	34	35
Maximum Score	20	19
Minimum Score	6	7
Average Score	13.79	13.26
Standard Deviation	2.76	2.57

PAM students at experiment class have an average of mathematical prior knowledge almost same with PAM students at control class. The standard deviation of PAM students at the experiment class higher (2.76 > 2.57) than the standard deviation of PAM students at the control class. Size standard deviation obtained explains that the PAM of students at the experiment class is more heterogenic than PAM of students at control class.

Analysis of the mean difference test aimed to determine the differences of mathematical prior knowledge between students in the experimental and control classes. The results of the normality test data with the Shapiro-Wilk test gives the Sig. higher than $\alpha = 0.05$. The data are normally distributed. The result of Levene's Test was 0.071 with the Sig. higher than 0.05 explained that the variance of mathematical prior knowledge of students in the experimental and control classes are homogeneous.

Table 2. *The Average Difference Test of Prior Mathematical Knowledge*

df	*t-test for Equality of Means*	*Sig. (2-tailed)*
67	0,836	0,406

The results of the t-test of two independent samples of the two sides as shown in Table 2. shows that students who receive MEAs learning have mathematical prior knowledge same with students who received conventional learning.
Results of prior mathematical knowledge tests classify students in the group with criteria of high, medium, low as in the following Table 3.

Table 3. *Distribution of the number of students for Each Categories based on Prior Mathematical Knowledge*

Categories	Experiment	Control
Top	13	12
Moderate	16	15
Low	5	8
Total	34	35

Statistics are used to describe the mathematical problem-solving ability of students described into a table that contains data about the number of students, on average, and standard deviation of the test results by category PAM and classes as in Table 4.

Table 4. *Statistics of the Mathematical Problem-Solving Ability*

Statistics	Experiment class				Control class			
	Up	Moderate	Low	Total	High	Moderate	Low	Total
The Number of Students	13	16	5	34	12	15	8	35
Average	37.54	25.87	25.83	30.32	30.67	21	21.88	24.29
Standard Deviation	7.05	7.88	8.98	9.45	8,68	8,31	8,74	9,51
The ideal score is 50								

Test to determine differences of students' mathematical problem solving abilities between students who received learning MEAs with students who received conventional learning gave the results is as described in Table 5.

Table 5. *The Average Different Test of Mathematical Problem Solving Ability*

df	*t-test for Equality of Means*	*Sig. (2-tailed)*
67	2,645	0,010

Sig. value smaller than $\alpha = 0.05$ led to conclude that the average of mathematical problem solving ability of students who received the MEAs learning is higher learning than students who received conventional learning.

Statistics of the mathematical communication ability of students are described into Table 6. The highest total score that can be achieved by students for mathematical communication ability is 20.

Table 6. *Statistics of the Mathematical Communication Ability*

Statistics	Experiment class				Control class			
	Up	Moderate	Low	Total	High	Moderate	Low	Total
The Number of Students	13	16	5	34	12	15	8	35
Average	15.15	10.67	10.67	12.38	12.75	8.33	6.88	9.51
Standard Deviation	2.79	3.72	3.56	3.98	5.51	4.08	2.59	4.90
The ideal score is 20								

Test to determine differences of students' mathematical communication abilities between students who received learning MEAs with students who received conventional learning gave the results is as described in Table 7.

Table 7. *The Average Different Test of Mathematical Communication Ability*

	Statistics
Mann-Whitney U	364,000
Wilcoxon W	994,000
Z	-2,780
Asymp. Sig. (2-tailed)	0,005

Sig. value smaller than $\alpha = 0.05$ led to conclude that the average of mathematical communication ability of students who received the MEAs learning is higher learning than students who received conventional learning.

DISCUSSION

MEAs are mathematical learning strategies that involve students in activities led to a mathematical model of a mathematical problem. Explore mathematical problem and elicit a mathematical model in the process of learning mathematics was a relatively new learning activities for students in the experimental class.

The majority of students showed enthusiasm to engage in MEAs teaching-learning process and to find out what it is learning MEAs. Enthusiastic that appears at the beginning of learning among students in both classes is relatively the same. While enthusiastic of control class more on students' attracted to engage in learning activities through LKS. This phenomenon coincided with the beginning of the learning activities in the study.

All students are grouped into groups. Each group of students consist of student with a variety of mathematical prior knowledge of high, moderate and low. During teaching-learning process, the grouping students show its potentials effectively motivate students to actively engage in discuss. Concentration of students involving in discuss process provoke and broaden student' understanding of mathematics by providing arguments, asking questions and paying attention to mathematical thinking of other friends.

Teachers monitor mathematical activities of in working groups, and gave feedback as reinforcement, ask questions or give some examples and non-examples. Involvement of students and the teacher's role trained students to model a problem, solve problems and communicate mathematical ideas. Modeling (Blomh 2004, in Eric 2008) gives students experience in to understand and describe the relationship between mathematical and their daily lives so that their motivation to learn mathematics increased. Phenomena that appear in this study in accordance with the result study of Dux & Salim (2009), which also showed that the MEAs teaching-learning process provide opportunities for students to make changes to their work, and leads to a mathematical model completely.

CONCLUSION

Implementation of MEAs stages in teaching-learning process by applying principles problems reality, modeling, self-assessment, sharing, documenting, and prototype model is potentially building mathematical ability of students to solve mathematical problems and to communicate it mathematically. The results of this study indicate that students who received teaching-learning with MEAs strategy had mathematical problem-solving ability and mathematical communication ability better than students who received conventional teaching-learning.

REFERENCES

Chamberlin, S. A. (2002). Analysis of interest during and after Model-eliciting Activities: A comparison of gifted and general population students. Unpublished doctoral dissertation. Retrieved 27 August, 2012 from:

http://www.cimt.plymouth.ac.uk/journal/chamberlin.pdf

Eric, C.C.M. (2008). Using Model Eliciting Activities for Primary Mathematics Classrooms. Association of Mathematics Educators. The Mathematics Educator, Vol. 11No. 1/2, 47-66. Retrieved 11 August, 2011 from:

http://repository.nie.edu.sg/jspui/bitstream/10497/135/1/ME-11-1-47.pdf

Lesh, R., Hoover,M., Hole, B., Kelly, A., Post, T. (2000). Principles for developing thought-revealing activities for students and teachers. In A. Kelly & R. Lesh (Eds.), Handbook of research design in mathematics and science education (pp.591-645). Mahwah, N.J.: Lawrence Erlbaum and Associates, Inc. Retrieved 19 May, 2011 from: http://www.cehd.umn.edu/ci/rationalnumberproject/00_2.html

National Council of Teachers of Mathematics, (2000). Principles and Standards for School Mathematics. Reston, VA: NCTM. Retrieved 13 December, 2010 from: http://www.fayar.net/east/teacher.web/Math/Standards/index.htm

National Council of Teachers of Mathematics, (1991). Principles and Standards for School Mathematics. Professional Standards . Reston, VA: Author. Retrieved 25 December, 2011 from: http://www.fayar.net/east/teacher.web/Math/Standards/index.html

National Council of Teachers of Mathematics, (1989). Principles and Standards for School Mathematics. Curriculum and evaluation standards for school mathematics . Reston, VA: Author. Retrieved 15 January, 2011 from: http://www.fayar.net/east/teacher.web/Math/Standards/index.htm

Polya G., (1973). How to Solve It. A New Aspect of Mathematical Method. Second Edition. New Jersey: Princeton Press University.

Sumarmo, U., (2008). Berpikir matematik: Apa, Mengapa, dan Bagaimana cara mempelajarinya. Universitas Pendidikan Indonesia, Bandung: not published.

Sumarmo, U., (2004). Proses mengajar-belajar Matematika untuk Mendukung Pelaksanaan Kurikulum Berbasis Kompetensi. Paper presented at the Pelatihan Guru Matematika di Jurusan Matematika ITB. April 2004. Retrieved 11 June, 2011 from: www.ekofeum.or.id/artikel.php?cid=51

Szetela, W. and Nicole, C., (1992). Evaluating Problem Solving in Mathematics. Educational Leadership., May 1992, pp. 42-45.

Retrieved 18 June, 2012 from: http://web.njit.edu/~ronkowit/teaching/rubrics/samples/math_probsolv_chicago.pdf

Van de Walle, J.A. (2007). Elementary and Middle School Mathematics. Pearson Education, Inc.