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ENHANCING MATHEMATICAL COMMUNICATION SKILLS FOR STUDENTS OF ISLAMIC SENIOR HIGH SCHOOL WITH RME APPROACH

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Abstract

The research intended to compare the differences of mathematical communication skills between the students who are taught with RME and students who are taught with conventional learning approaches in terms of the school's level and Mathematical Prior Knowledge (MPK). The research populations are all Islamic Senior High School (MA) students in Jakarta consist of 4 National Standard Schools (NSS) and 72 Regular Schools (RS). From two categories of schools level will be selected one of the school randomly. The research instruments used in this research are teaching materials on probability which is designed based on RME approach, MPK test, and mathematical communication skill test. The data will be analyzed by using the Mann-Whitney test and t-test. According to the data analysis, it was found that: (1) there are differences in mathematical communication skill between the students who are taught with RME approach and students who are taught with conventional learning approaches, as generally, or even

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both schools level and three categories of MPK, the RME learning approach given a better enhancement, (2) there are no significant interaction between learning approach and school level to the improvement of the students' mathematical communication skills, (3) there are significant interaction between learning approaches and students' MPK to the improvement of mathematical communication skills, RME approach contributed to better enhancement for low MPK students.

Background

Basic Education Curriculum in Indonesia stated that Mathematics lesson at Senior High School or Sekolah Menengah Atas (SMA) and Islamic Senior High School or Madrasah Aliyah (MA) has purposes to encourage students to be able to have several skills as follows:

1. Understanding mathematical concepts, explaining the relationship between concepts and applying concepts or algorithms, flexibly, accurately, efficiently, and appropriately, in solving problems.
2. Solving problems that included the ability to understand the problem, design a mathematical model, solve the model and interpret the obtaining solution.
3. Communicating ideas with symbols, tables, diagrams, or other media to clarify the situation or problem.
4. Having respect on the usefulness of mathematics in daily life, such as, the curiosity, attention, and interest in studying mathematics, as well as a tenacious attitude and confidence in problem solving. (Department Education of Government [5].)

The four objectives are closely related to mathematical problem solving skills. To master problem solving skills, students require a mathematical communication skill, because it can assist the students to connect mathematical problems in everyday life as well as problems in other disciplines with the existing rules in mathematics. Mathematical communication skill consists of: (1) the ability to express mathematical ideas by writing, demonstrating, and creating a model of problems, and (2) the

ability to understand, interpret, and evaluate mathematical ideas presented in written, verbal, or visual form.

Mathematical communication skill is vital to be developed, as Pugalee [19], communication is an essential part of teaching and learning mathematics. Kusumah [15] also said that by communicating mathematical ideas, it can be exploited in a variety of perspectives and students can sharpen the way of thinking. Furthermore Jacob (in Setiawan [23]) expressed that mathematical communication is essential in the learning process and accessing mathematics.

To enhance students' mathematical communication skills, mathematics learning with Realistic Mathematics Education (RME) approach offers a solution. The three principles and the five characteristics of RME support on the enhancement of students' mathematical communication skills, particularly on modeling and interaction.

Learning with RME approach has been applied in several elementary and junior high schools, such as research Fauzan et al. [8], Armanto [1], Saragih [21], Uzel and Uyangor [25], and Lecturer Manchester Metropolitan University [6]. All the studies have shown that the RME approach could improve student's motivation and students' learning achievement in both elementary and junior high schools. Moreover, Zulkardi et al. [26] research has shown that RME teaching approach makes students enjoying mathematics learning process.

By observing several studies above, RME approach probably can also be used to improve students' mathematical communication skills for Senior High School (SMA) and Islamic Senior High School (MA) students. However, it is still questionable, as the characteristics of primary and junior school students are different from Senior High School, however RME learning approach can also be applied in Senior High School, because realistic perspectives are not only interpreted with the connection of the real world, but also with related to the clear imagination students. RME approach has not been implemented on Senior High School in Jakarta, so MA in Jakarta are chosen to be a research place so that teachers in MA can obtain a new knowledge.

Each student has a different skill to understand mathematics. As Gabon (cited by Ruseffendi [20]) stated that the students who are chosen randomly from the population, there are always consisted of the high, the middle, and the low level skill. This caused students skill shared normally distributive. Different abilities measured by Mathematical Prior Knowledge (MPK) tests. From MPK test, the students grouped on 3 categories of MPK are high, medium and low. Does learning by RME approach can give contribution better towards increasing communication mathematical ability on third category of students' ability or only upon students who has high ability or reverse also need to be observed. On the other hand, according to Ruseffendi [20], "the different of ability whose students can be influenced by environment factor", learning environment in National Standard School (NSS) and School Standard (SS) also different. One of example of different as supplying LCD in every class on NSS, whereas in Standard School not yet all classes are completed LCD. Does learning by RME approach just give contribution on increasing students' ability in National School Standard or reverse or both school level needs to be observed. Therefore, it might be suggested to implement and do research more on the realistic mathematics hereby approach in two school levels (NSS and SS) along with three categories of mathematical prior knowledge.

Formulation of Research Problem

Based on the background above, the issue will be focused on whether there are differences in mathematical communication skills between the students who are taught with RME and students who are taught with conventional learning approaches. The research question will be formulated as follows:

1. Are there any differences in mathematical communication skill between students who are taught with the RME approach and those who are taught with conventional learning approach:

   a. In general.

   b. Subject to school level.

c. Subject to mathematical prior knowledge.

2. Is there interaction between learning approach with school level for enhancing communication of mathematical competence?
3. Is there interaction between students' learning approach with MPK for enhancing communication of mathematical competence?

Review of Literature

Mathematical communication skills

According to Brenner [4], there are three aspects of mathematical communication, viz., communication about mathematics, communication in mathematics, and communication with the mathematics.

As a guide to measure students' mathematical communication skill, NCTM [18] provides some indicators that can be used are: (1) the ability to express mathematical ideas by speaking, writing, demonstrating, and describing the ideas into visual form, (2) the ability to understand, interpret, and assess the mathematical ideas presented in writing, verbal, or visual form, (3) the ability to use vocabulary/language, notation and mathematical structures to present ideas, draw relationships, and make a model.

In this study, mathematical communication skills that will be examined are:

a. The ability to express mathematical ideas in the form of pictures.
b. The ability to understand, interpret, and evaluate mathematical ideas presented in the pictures form.

The ability to express mathematical ideas in the pictures forms consists of: (1) the students' ability to sketch problems associated with a permutation towards a mathematical model, (2) the students' ability to sketch problems related to a combination form from an event towards a mathematical model, (3) the students' ability to sketch problems related to a combination of sample space towards a mathematical model, (4) the students' ability to sketch problems in probability form that is related to combination and

multiplication rules, and (5) the students' ability to sketch problems associated with permutation and cyclic permutations.

On the other hand, the ability to understand, interpret, and evaluate mathematical ideas presented in the pictures form includes: (1) the students' ability to make a permutation form from the problem containing pictures sketch, (2) the students' ability to make a combination form to count the number of ways of an event based on the pictures, (3) the students' ability to make a combination form to cut the numbers of sample spaces based on their created drawing sketch, (4) the students' ability to find probability from created drawing sketch, (5) the student's ability to solve a probability problem that is associated with combination from created drawing sketches, and (6) the students' ability to solve problems related with permutations and cyclic permutation through pictures sketch.

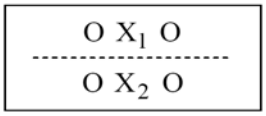
RME approach

RME approach is a mathematical learning approach that started from the real word or something that can be visualized by students. This approach is initially developed in 1971 by the Freudenthal Institute in The Netherlands, which is based on Freudenthal's view that mathematics as a human activity (in Heuvel [13]). Based on these views, three basic principles of RME are developed, namely: (a) Guided Reinvention through Progressive Mathematizating, (b) didactical phenomenology, and (c) emergent models (Gravemeijer [9]). Based on three principles above, the process of mathematics learning, Van Reeuwijk (in Drijver [7]) provides the following characteristics of Realistic Mathematics Education: the 'real' world, free productions and constructions, mathematization, interaction and integrated learning strands. In Indonesia, the mathematics learning with RME approach developed by a team of Pendidikan Matematika Realistik Indonesia (PMRI) since the 1990's by some lectures from: ITB, UPI, UNJ, UNESA, UNY and USD (Sembiring [22]).

Methods and Procedure

This research is a quasi experimental design with pretest-posttest control

group design as follows:



(Ruseffendi [20]),

where X_1 is teaching with RME approach, X_2 is conventional learning approaches, and O is the mathematical communication skills on the pretest and posttest.

There are three research variables such as: independent variable, dependent variable and control variable. The independent variable is a learning approach that consists of the RME approach and conventional learning approaches. Dependent variable is a students' mathematical communication skill, and the control variable is the school level and students MPK. School level comprised of National Standard School (NSS) and the Regular School (RS), while MPK students will be categorized like high, medium and low. The research populations are sophomore of MA in Jakarta, academic year 2011/2012, consisting of 4 National Standard Schools (NSS) and 72 Regular Schools (RS). This test instruments used in this research are Mathematical Prior Knowledge (MPK), and mathematical communication skills.

Analysis of the Data

The analyses used in this study are the analysis of qualitative data and quantitative data analysis. Qualitative data analysis is used to analyze the students' answer sheets at pretest and posttest. From this analysis, students' mathematical communication skills will be obtained on the pretest and posttest. The results qualitative analysis will be followed by quantitative analysis to compare the average enhancing students' mathematical communication skills from experiments class and the control class. Enhancing mathematical communication skills will be measured by mathematical formula:

$$g = \frac{\text{posttest score} - \text{pretest score}}{\text{maximum possible score} - \text{pretest score}}$$ (Meltzer [16], Hake [12]).

The differences of students' mathematical communication skills will be measured by the Mann-Whitney and t-test.

On the other hand, the interaction between learning approach with school level and MPK will be based on Minium [17] said that in general, the question of interaction between two treatments may be phrased this way: "Whatever the difference among the several levels of one treatment, is it the same for each of the levels of the other treatments?"

Results

Enhancing communications of mathematical competence

There are differences in mathematical communication skills between the students who are taught with RME approach and students who are taught by conventional learning approaches, both in general (see Table 1), or even on the second level of the school (see Table 2) and three categories of MPK (see Table 3).

Table 1. Enhancing mathematical communication skills

Statistic	Pretest		Posttest		N-Gain		N-Gain difference
	Exp	Control	Exp	Control	Exp	Control	
n	53	55	53	55	53	55	Significant
Average	3.357	3.367	92.448	57.374	0.922	0.559	
Std	0.978	0.961	10.635	11.317	0.110	0.118	

Table 2. Enhancing mathematical communication skills viewed from school level

School level	Statistic	Pretest		Posttest		N-Gain		N-Gain difference
		Exp	Control	Exp	Control	Exp	Control	
NSS	n	30	31	30	31	30	31	Significant
	Average	3.394	3.402	95.515	61.290	0.953	0.599	
	Std	0.923	0.908	8.710	10.136	0.090	0.105	
RS	n	23	24	23	24	23	24	Significant
	Average	3.320	3.333	88.775	52.273	0.884	0.506	
	Std	1.048	1.027	11.740	10.646	0.122	0.111	

Table 3. Enhancing mathematical communication skills viewed from MPK category

MPK category	Statistic	Pretest		Posttest		N-Gain		N-Gain difference
		Exp	Control	Exp	Control	Exp	Control	
High	n	4	4	4	4	4	4	Significant
	Average	3.636	3.636	95.455	77.273	0.953	0.764	
	Std	0.000	0.000	9.091	1.818	0.094	0.019	
Medium	n	39	40	39	40	39	40	Significant
	Average	3.263	3.455	92.960	57.636	0.927	0.561	
	Std	1.118	0.803	10.354	9.909	0.107	0.103	
Low	n	10	11	10	11	10	11	Significant
	Average	3.636	2.975	90.000	49.091	0.896	0.475	
	Std	0.000	1.471	12.457	7.799	0.129	0.081	

The interaction between learning approach with school level and MPK category for improvement on mathematical communication

Interaction between learning approach to school level by comparing the effect of different learning approaches at both the school level. Interaction between the learning approach and the school level can be conducted by observing the following graph in Figure 1. Since the graph tends to parallel, this suggests that the interaction between learning approach to school level is not significant.

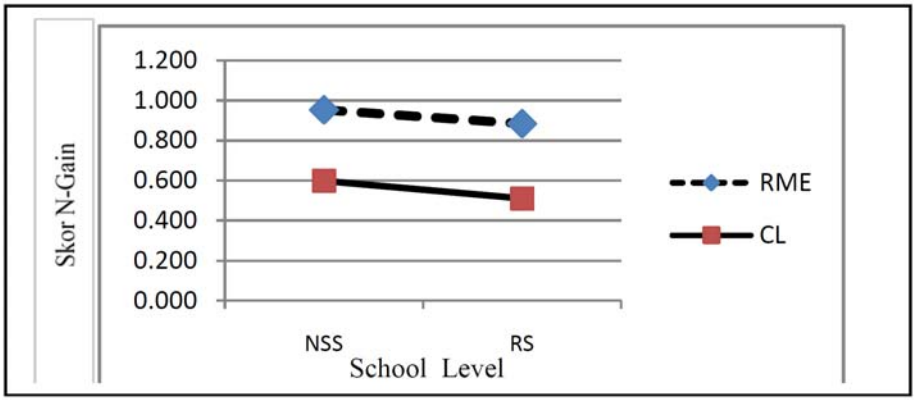


Figure 1. Interaction between learning approach with school level for enhancing communication of mathematical competence.

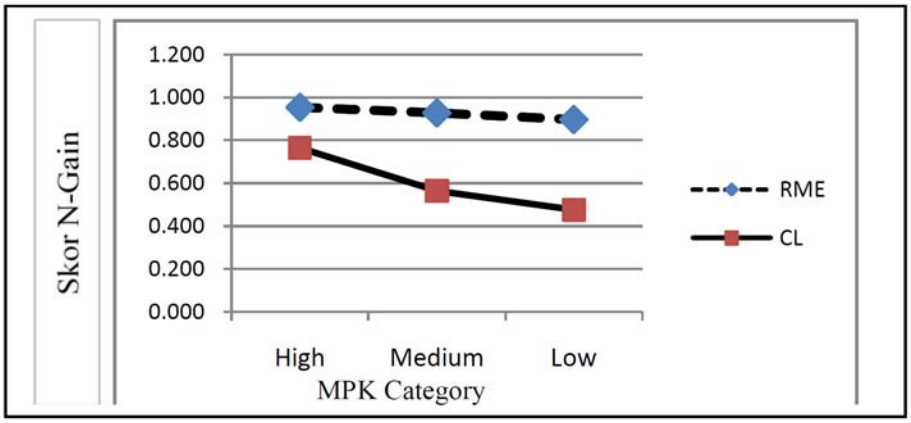


Figure 2. Interaction between learning approach with MPK students for enhancing communication of mathematical competence.

Interaction between students' learning approaches with MPK seen by comparing the effect of different learning approaches in three categories of MPK. To see whether this interaction is significant, it can use graph in Figure 2. Since the graph tends to intersect, this suggests that the interaction between the MPK approaches to student learning is significant.

Discussion

The fundamental difference between RME approaches and conventional learning lies in the Guided Reinvention through Progressive Mathematizating and emergent models. In conventional learning, the teacher explains the mathematical concepts and their application to several problems, so that students can solve problems that involve only one mathematical concept, but the difficulty in solving problem that involves several concepts such as the following problem below:

A dinner at the round table was attended by four families. Each family consists of husband, wife and a child. So all in all there are 12 people.

a. If it is agreed that each family member should sit side by side, make a sketch to find many ways their sitting arrangement.

b. Based on the sketches that you create so many ways determine the composition of their seats.

To solve the above problem, it required communication skills such as, the ability to express mathematical ideas in a problem by using a picture and interpreting the images that have been created in mathematical form. In this case, the learning process through Progressive Mathematizating Guided Reinvention and posing models help students to solve problems that involve multiple concepts, compare answers on student learning RME approaches and conventional learning.

For 57 students follow learn RME approaches, 28 students (17 from NSS and 11 from RS) answered as Figure 3a, 20 students (12 from NSS and 8 from RS) answered as Figure 3b, 3 students (2 from NSS and 1 from RS) answered as Figure 3c. Answers as Figure 3a and Figure 3b show the ability of students to sketch (model) of the problems associated with the combination of permutations and a cyclic permutation, while the students' answers on Figure 3c show students understand the problems associated with this form cyclic permutation and permutations, but not able to integrate the form cyclic permutation and permutations of the problem. The ability of the students has an impact on problem solving, students who answered the question (4a) as in Figure 3a and Figure 3b answer question (4b) as in Figure 4a and 4b, while students who answered the question (4a) as in Figure 3c to answer question (4b) as Figure 4c.

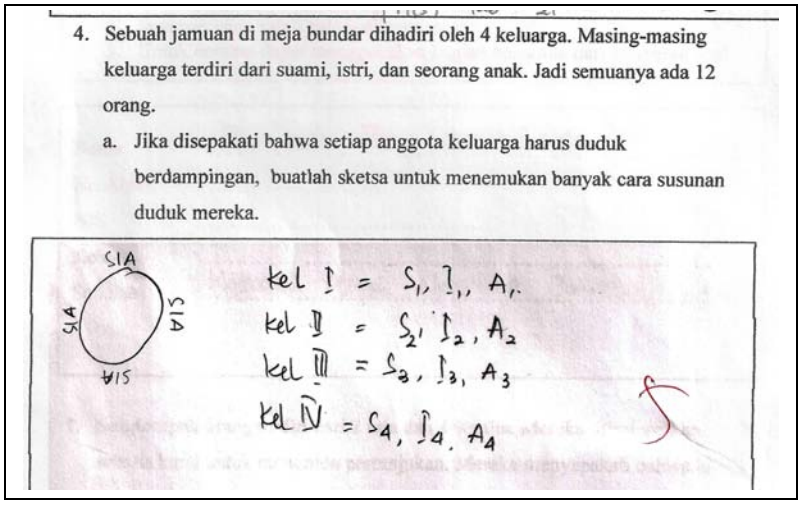


Figure 3a. Answer Type A for experiment class on problem number 4a.

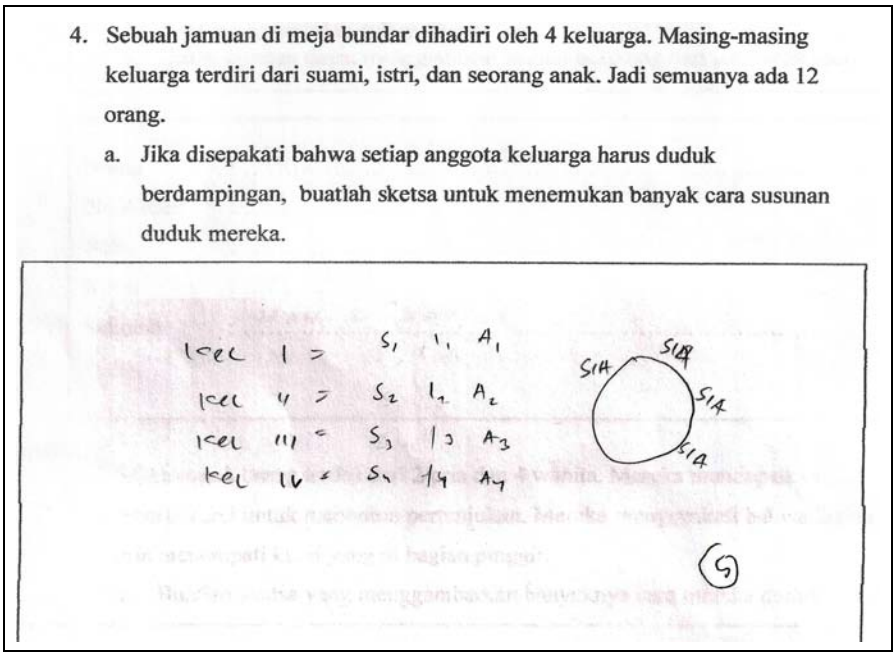


Figure 3b. Answer Type B for experiment class on problem number 4a.

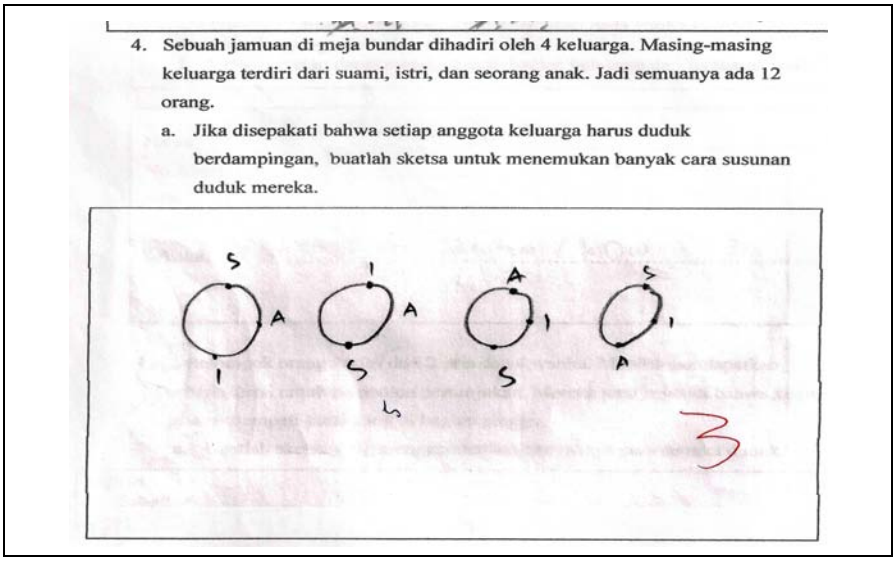


Figure 3c. Answer Type C for experiment class on problem number 4a.

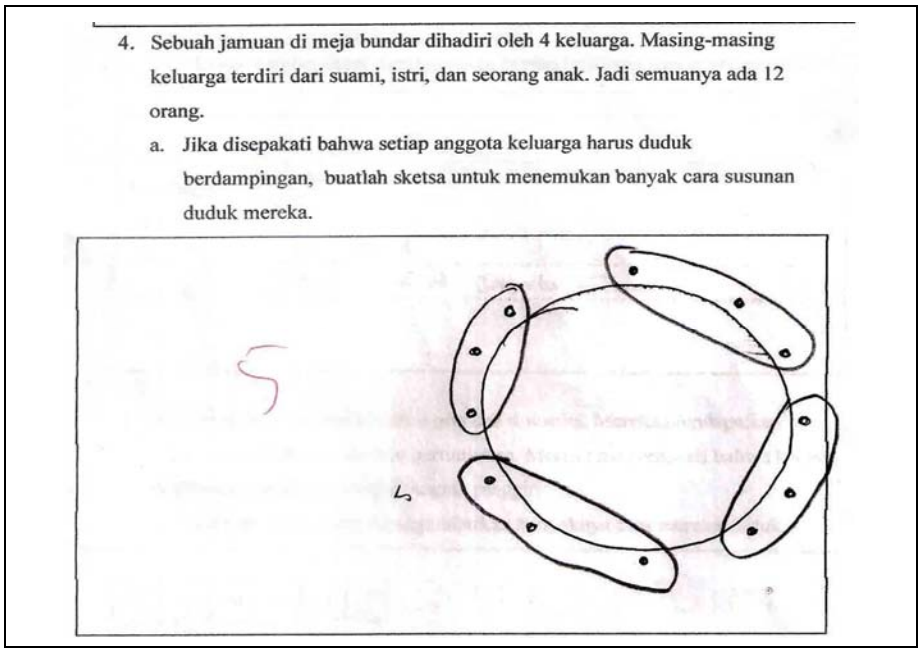


Figure 3d. Answer Type A for control class on problem number 4a.

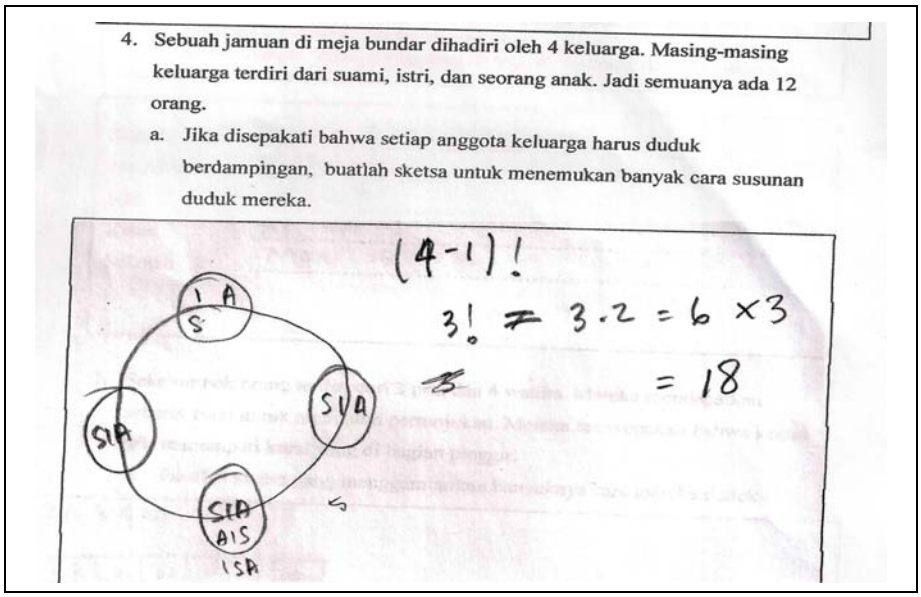


Figure 3e. Answer Type B for control class on problem number 4a.

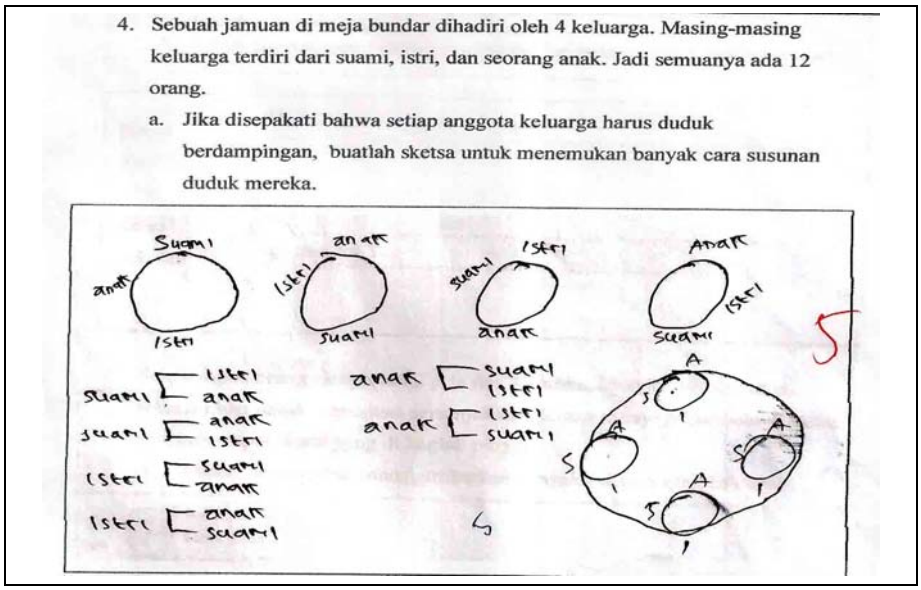


Figure 3f. Answer Type C for control class on problem number 4a.

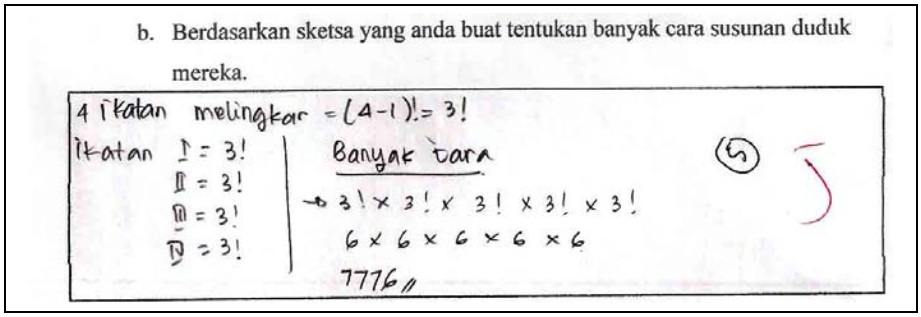


Figure 4a. Answer Type A for experiment class on problem number 4b.

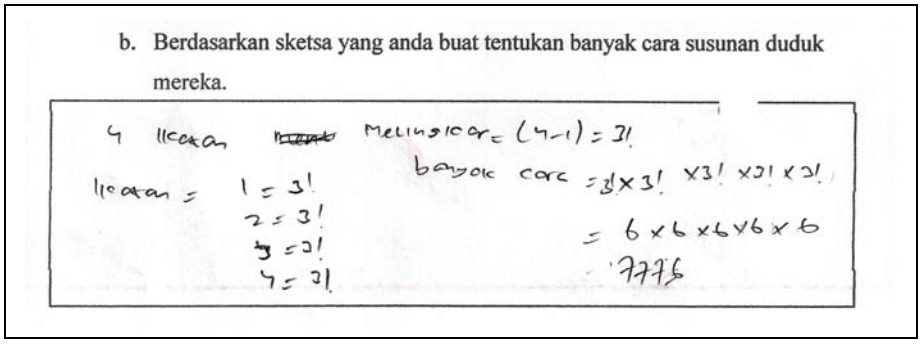


Figure 4b. Answer Type B for experiment class on problem number 4b.

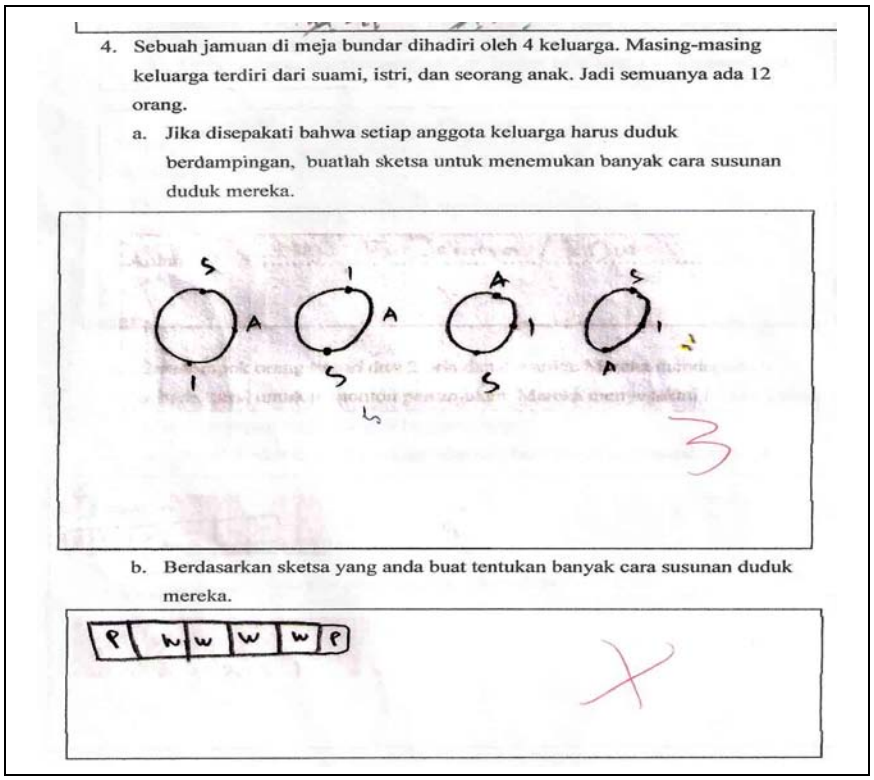


Figure 4c. Answer Type C for experiment class on problem number 4b.

For the 55 students who join conventional process, 17 students (9 of NSS and 8 from RS) answered as Figure 3d, 14 students (8 of NSS and 6 from RS) answered as Figure 3e, 13 students (7 from NSS and 6 from RS) answered as Figure 4f, and only 13 students who did not answer, but this capability is not followed by solving related problems with the combination of permutations forms a cyclic permutation from the sketch of image as shown in Figure 4d, Figure 4e and Figure 4f. The students who answered the question (4a) as Figure 3d answer question (4b) as Figure 4d, students who answered the question (4a) as Figure 3e answer question (4b) as Figure 4e, and the students who answered the question (4a) as Figure 3f answer matter (4b) as Figure 4f.

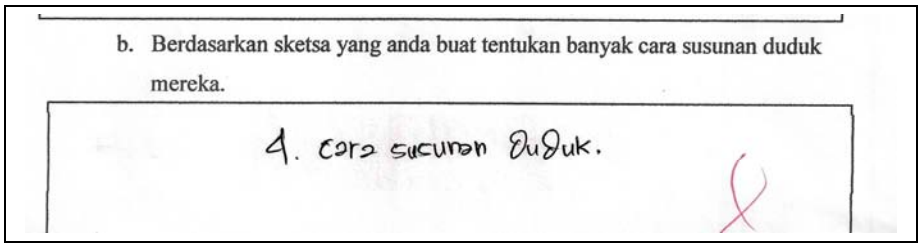


Figure 4d. Answer Type A for control class on problem number 4b.

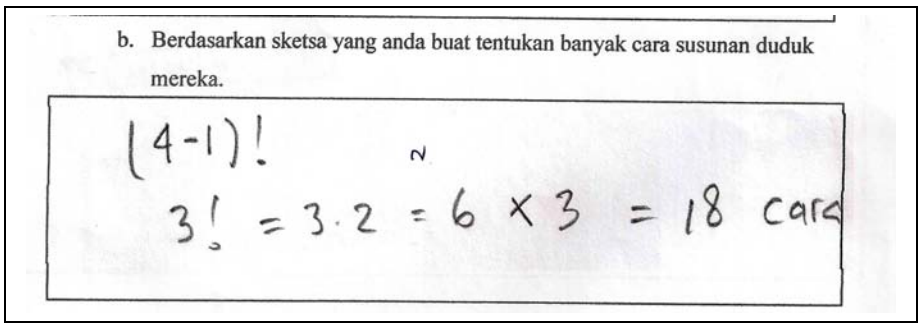


Figure 4e. Answer Type B for control class on problem number 4b.

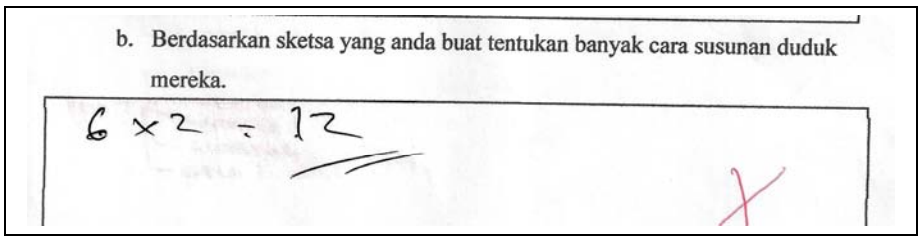


Figure 4f. Answer Type C for control class on problem number 4b.

Conclusion

Based on the findings and the discussion that has been discussed previously, some conclusions are obtained as follows:

1. There are significant differences between the students who are taught with the RME approach and the students who are taught with conventional learning (CL) to enhancing mathematical communication skill both in general and in second level schools and third categories of MPK. Learning the RME approach provides a better improvement of mathematical communication skills.

2. There are no significant interaction between learning approach and the improvement of school level mathematical communication skills.
3. There are significant interactions between learning approach with MPK students to communication of mathematical competence. RME learning approach contributes to better low MPK students.

Implication

Based on the data, discussion and conclusions, the RME learning approach can be used to enhance mathematical communication skills in MA.

Recommendation

If the RME approach is used to enhance the mathematical communication skills for MA's student in counting rule and probability topic, then RME approach probably can also be used for other topics in Madrasah Aliyah. As mathematics curriculum in MA is relatively same with Senior High School, then RME learning approach can also be applied to enhance the mathematical communication skills in Senior High School.

References

[1] D. Armanto, Conventional vs. realistic mathematics in the division, Bulletin PMRI, KPPMT ITB, Bandung, 2003.

[2] E. Azhar, Counting rule learning approach RME, Proceedings of the SNM-2010, Vol. 1, Department of Mathematics, University Indonesia, Depok, February 6, 2010.

[3] E. Azhar, Contribution RME approach to implementation lessons math in curriculum Indonesia, Journal PradikMa, Vol. 3, 1 edition June 2010. Medan: Prodi P. Matematika State University Graduate Program in Medan, 2010.

[4] M. E. Brenner, Development of mathematical communications in problem solving groups by language minority students, Bilingual Research Journal 22(2, 3 & 4) (1998), 103-128.

[5] Department Education of Government, Curriculum Content Standards Unit Level, Departement Education of Government, Jakarta, 2006.

[6] Lecturer Manchester University, Realistic Mathematics Education, 2007. http://www.mei.org.uk/files/gcse2010/Realistic_Mathematics_Education_final_ .pdf.

[7] P. Drijver, Students encountering obstacles using a CAS, Standards for Mathematics Education, Freudenthal Institute, The Netherlands, 1995.

[8] A. Fauzan, Dick Slettenhaar and T. Plomp, Traditional Mathematics Education vs. Realistic Mathematics Education: Hoping for Changes, Centre for Research in Learning Mathematics, 2002, pp. 1-4. http://mes3.learning.aau.dk/Projects/Fauzan.pdf.

[9] K. Gravemeijer, Developmental Research: Fostering a Dialectic Relation between Theory and Practice, Standards for Mathematics Education, Freudenthal Institute, The Netherlands, 1995.

[10] S. Hadi, Plomp and Suryanto, Introducing realistic mathematics education to junior high school mathematics teacher in Indonesia, Proceedings of the 3rd International Mathematics Education and Society Conference, Centre for Research in Learning Mathematics, Copenhagen, 2002, pp. 5-16. http://doc.utwente.nl/58708.

[11] S. Hadi, PMRI, Seed Quality Learning Mathematics, PMRI Magazine, Vol. No. IV. 3, October 2006, Bandung: IP-PMRI Faculty ITB, 2006.

[12] R. Hake, Interactive-engagement vs traditional methods: a six thousand-students survey of mechanics test data for introductory physics course, Department of Physics, Indiana University, Bloomington, Indiana 47405, Tersedia, 1999. http://www.physics.indiana.edu/~sdi/ [15 Mei 2012].

[13] P. M. Heuvel, Mathematics Education in the Netherlands: A Guided Tour, Freudenthal Institute CD-ROM for ICME9, Utrecht University, Utrecht, 2000. http://www.fi.uu.nl/en/rme/TOURdef+ref.pdf.

[14] P. M. Heuvel, Realistic mathematics education as work in progress, F. L. Lin, ed., Common Sense in Mathematics Education, pp. 1-43, Proceedings of 2001 The Netherlands and Taiwan Conference on Mathematics Education, Taipei, 2001. http://www.fi.uu.nl/publicaties/literatuur/4966.pdf.

[15] Y. S. Kusumah, Concept, Development, and Implementation of Computer-based Learning in Developing Capabilities High-order Mathematical Thinking, Inauguration Speech Professors, UPI, Bandung, 2008.

[16] D. E. Meltzer, Normalized Learning Gain: A Key Measure of Student Learning, Department of Physics and Astronomy, Iowa State University, Iowa, 2002. http://ajp.aapt.org/resource/1/ajpias/v70/i12/p1259_s1.

[17] E. W. Minium, Statistical Reasoning in Psychology and Education, John Wiley & Sons, New York, 1978.

[18] NCTM, Curriculum and Evaluation Standard for School Mathematics, Reston, Virginia, 1989.

[19] D. K. Pugalee, The treatment of mathematical communications in mainstream algebra text, Proceedings of the International Conference, The Decidable and the Undecidable in Mathematics Education, Brno, Czech Republic, September 2003. http://math.unipa.it/~grim/21_project/21_brno03_Pugalee.pdf.

[20] Ruseffendi, Fundamentals of Educational Research and Field Other Non-exact. Tarsito, Bandung, 2005.

[21] S. Saragih, Developing logical thinking skills and communication mathematics secondary school students with mathematics realistic approach, Doctoral Dissertation at UPI PPS: Not Published, 2007.

[22] R. K. Sembiring, What and Why PMRI, PMRI Magazine, Vol. VI 4: 60-61. Bandung: IP-PMRI, 2008.

[23] A. Setiawan, Problem based learning to improve communication skills and problem solving mathematical secondary school students, Unpublished Thesis, New York, 2008.

[24] Tim PMRI Bandung, Measurement with Beads, Bulletin PMRI, London: ITB KPPMT PMRI Bulletin, ITB KPPMT, London, 2003.

[25] D. Üzel and S. M. Uyangör, Attitudes of 7th class students toward mathematics in realistic mathematics education, International Mathematical Forum 39 (2006), 1951-1959.

[26] Zulkardi, N. Nieveen, Jan Van Den Akker and Jan De Lange, Implementing a ‘European’ approach to Mathematics Education in Indonesia through Teacher Education, 2002. http://www.math.uoc.gr/~ictm2/Proceedings/pap81.pdf.