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Realistic Mathematics Education Toward Mathematical Communication Skills of Students using Hypothetical Learning Trajectory

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Abstract. This research is motivated by the indispensability of learning that is able to bridge the students to understand a concept in mathematics. The difficulty of students to understanding the concept of fractions is still a problem in elementary school, so there is an assumption that learning mathematics is very difficult. Use of the learning trajectory or Hypothetical Learning Trajectory (HLT) became one of the alternatives for students to understand the concept of fractions in mathematics. The research is aimed to describe and analyze the existence of significant differences in improvement of students' mathematical communication skills who learned and not learned used Realistic Mathematics Education (RME) with HLT. This research method is quasi-experimental with the pretest-postest nonequivalent design. The data collection instrument used was a mathematical communication skills test. The population of this research is all fourth grade students in one elementary school located in the district of Tawang, Tasikmalaya. The results of this research showed that based on data analysis N-gain scores, the value of Sig. (2-tailed) Equal Variances Assumed by 0,024 less than the significance level (a = 0.05), H_0 is rejected and H_a accepted. Therefore, it can be concluded that the improvement of students' mathematical communication skills in the RME class (experimental class) is higher than the control class. Thus, there is a significant difference in improvement of students' mathematical communication skills who learned and not learned used RME with HLT. The recommendation of this research is to conduct further research that can develop RME-based Learning Trajectory in mathematics.

Keywords: Realistics Mathematics Education, Communication skills, Mathematics, Elementary education, Fraction.

INTRODUCTION ~ Mathematics lessons in schools are still considered difficult for most elementary students in Indonesia. To change these assumptions, it is necessary to make effective and fun learning designs. One of effective and fun learning by making a design in accordance with the pattern of natural levels of student thinking. Materials from mathematical concept will be mastered well if students are able to understand the material that is between the prerequisite material and the final material of the concept. Mathematical communication skills are very important possessed by students, especially elementary school students. Abstract concept form of mathematics to be taught to students. Elementary students must be able to communicate mathematical material as a form of understanding in learning mathematics. It is appropriate in Peraturan Menteri Pendidikan Nasional No. 20 of 2006 concerning Content Standards concerning the objectives of mathematics learning and the *National Council of Teachers of Mathematics* (NCTM, 1989) regarding the standard processes in mathematics learning, which include: Communicating ideas with symbols, tables, or other media to clarify the situation or problem. Based on the Permendiknas and NCTM, students Elementary schools must be able to communicate mathematical material both orally and in writing.

Based on exploratory studies by conducting observations to class IV in one elementary school in Tasikmalaya City, students' mathematical communication skills regarding fractions are not optimal. That is because the diverse abilities of students , there are students who can be fast and there are students who are slow in receiving information and understanding a concept and communicating it. However, the learning design provided is still lacking in facilitating students who are slow in understanding a concept. In connection with the above, we need an effective learning design that can be applied by the teacher to optimize students' mathematical communication skills. One learning design that is thought to be able to improve students' mathematical communication skills is *Realistic Mathematics Education* (RME) using *Hypothetical Learning Trajectory* (HLT).

Based on the research results by Winarti, D. F. , Geri, S . R., Riza, Z . F. (2019) that the increase in problem solving skills and mathematical communication between students who learn used RME is higher than those who use direct instruction. According to Treffers (in Hadi, 2010) a realistic approach is an approach that uses realistic problems as a base for learning. According to Van den Heuvel Panhuizen & Drijvers (2014, p. 521), "... in RME, problems are presented to students can come from the real world but also from the fantasy world or the formal world of mathematics, as long as the problems are experientially real in the student's mind. " Freudenthal also explained that the word 'realistic' refers not only to connections with the real world, but also refers to real problem situations in students' minds (Uzel & Uyangor, 2006, p. 1952). In addition, Lizarraga, Baquedano, & Oliver (2010, p. 132) cite the opinion of Ritchhart and Perkins that mathematical skills can be better learned if students' believe that they will be useful in many real-life situations .

From some of the opinions of the experts above, it can be concluded that "realistic" in RME, is not only a real situation in life, but can come from the formal world of mathematics, as long as the problems experienced are real in the minds of students . The RME steps are 1. giving realistic problems to students ; 2. Resolve realistic problems. Students can describe realistic problems and find the problem solving strategies using the model of- and for- model designed on instructional task sets or HLT; 3. Student interactivity in groups; 4. Summing up the results of the discussion; 5. Reaffirming the answers to the problems raised and giving individual tasks.

RME emphasizes two important things in learning planning, namely *Hypothetical Learning Trajectory* (HLT) and model development (Wijaya, 2010). *Hypothetical Learning Trajectory* (HLT) is used to help students understand mathematical concepts, especially in fractions . According to Gravemeijer (2004) on learning a mathematical concept, the hypothesis is based on the prerequisite

abilities that students already have and their learning experiences. At a later stage, the hypothesis is elaborated on a special plan called the *Hypothetical Learning Trajectory* (HLT). HLT Development was formulated in three parts, according to Sarama & Clements (2009) states that *goals* or learning objectives to be achieved; *levels of teaching* or levels of thinking from easy to complex; and *Instructional Task* or set of instructional tasks that can help students understand a concept from one level to the next. HLT is expected to improve elementary students' mathematical communication skills .

According to Greenes & Sculman in (Armiati, 2009, p. 3) the importance of communication among them is to express ideas through conversation, writing, demonstration, and portraying visually in different types. Meanwhile, according to NCTM in (Van de Walle, 2008, p. 48) that without communication in mathematics, teachers will have little information, data, and facts about students' understanding in doing mathematical processes and applications. Of the two opinions above, in addition to the ability to understand mathematical concepts, mathematical communication skills are also important for students to have . So students are expected to understand a concept in mathematics learning and be able to communicate understanding of a concept well.

Indicators of student ability in mathematical communication in mathematics learning according to NCTM (1989) can be seen from:

1. The ability to express mathematical ideas through oral, written, and demonstrate and visualize them.
2. The ability to understand, interpret, and evaluate Math ideas both verbally and in other visual forms.
3. The ability to use terms, mathematical notations and structures to present ideas, describe relationships and models of situations.

Therefore, objective of this study is to describe and analyze in detail the differences significant increase communication capabilities mathematical students SD using *Hypothetical Learning Trajectory* (HLT) with those not using *Hypothetical Learning Trajectory* (HLT) in learning *Realistic Mathematics Education* (RME). The research hypothesis is "There is a difference in the improvement of mathematical communication skills between students who take and those who do not take the *Realistic Mathematics Education* (RME) *learning* using *Hypothetical Learning Trajectory* (HLT)."

METHOD

The research approach used is a quantitative research approach using a quasi-experimental method. The research design used was *the pretest-posttest non-equivalent design* (Cohen, 2007, p. 283), with the following pattern:

Kelas 1 : O_1 _ _ X_1 _ _ O_2 _

Kelas 2 : O_3 (-) O_4

Keterangan:

O_1 dan O_3 : *Pre-test*

O_2 dan O_4 : *Post-test*

X_1 : Pembelajaran *Realistic Mathematics Education* (RME) menggunakan HLT

(-) : Tidak ada perlakuan

_·_·_·_·_·_·_·_·_ : Subjek tidak dikelompokkan secara acak

The subjects in this study were IVA and IVB grade students at SDN Dadaha located on Dadaha street, Tasikmalaya City. The IVA class at SDN Dadaha as an experimental class and treated with *Realistic Mathematics Education* (RME) *learning* uses the *Hypothetical Learning Trajectory* (HLT), while all IVB class students are the control class with direct learning. Learning Instruments in the form of RME-based Learning Implementation Plans (RPPs); set of instructional assignments or *Hypothetical Learning Trajectory* (HLT). Instruments that used is instrument test the ability of understanding mathematical concepts and mathematical communication ability tests; observation instrument; and, documentation.

Data collection techniques used were test techniques of pretest and posttest tests for the ability to understand mathematical concepts and tests of mathematical communication skills; non-test techniques in the form of observation to determine the process during the treatment carried out; and, documentation in the form of supporting documents for evidence of research implementation.

Data processing was carried out with the help *of* SPSS 21 and *Microsoft Excel 2007*. *Software* processing and analysis of the results of this research data are as follows:

calculate student pretest and posttest scores according to the scoring rubric used; minimum score; maximum score; average, and, standard deviation.

calculate the magnitude of the score increase in the ability to understand concepts and mathematical communication with the formula Meltzer (2002), namely:

$$N\text{-}gain\ (g) = \frac{(\boldsymbol{postest\ score}) - (\boldsymbol{pretest\ score})}{(\boldsymbol{max.score}) - (\boldsymbol{pretest\ score})}$$

Conduct normality tests and homogeneity tests on research data in the form of scores increasing the ability to understand concepts and mathematical communication.

Conduct a difference test of two averages using the *Independent t-Test* to prove the hypothesis of this study.

Make conclusions and generalizations from the results of the hypothesis test of this research.

RESULTS

The results of data acquisition pretest mathematical communication skills of students in the experimental class (RME) and the control class. Pretest data analysis was conducted to determine differences in the acquisition of mathematical

communication skills among students in two classes before receiving treatment (*treatment*). The following are the results of the normality test scores of students' mathematical communication ability tests between the experimental class and the control class can be seen in Table 1 below.

Table 1. Normality Test

Pretes Kemampuan Komunikasi Matematis	Kelas	Kolmogorov - Smirnov		
		Statistic	df	Sig.
	Eksperimen	.148	28	.115
	Kontrol	.228	30	.000

From table 1 above, it can be seen that the normality test with the *Kolmogorov-Smirnov test* at the significance level (α = 0.05), the experimental class (RME) obtained the significance value of the calculation results of 0.116 and the control class obtained a significance value of 0.000. It can be concluded that the data is normally distributed. Then the test continued with the independent test sample t-test to see the difference in mathematical communication skills between the experimental class (RME) with the control class before receiving treatment. The results of the t-test are as follows.

Table 2. T-test results of mathematical communication skills before treatment

Pretes Kemampuan Komunikasi Matematis		Levene's test equality of variances		t-test Equality of means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
	Equal variances assumed	4.817	.032	1.508	56	.137	4.129	2.737
	Equal variances not assumed			1.487	45.457	.144	4.129	2.777

From table 2 above, the value of *Sig. (2-tailed) Equal Variances Assumed* at 0.137 and 0.144 greater than the significance level (α = 0.05) then H_0 accepted. So it can be concluded that there is no difference in mathematical communication skills between students who take and who do not take learning *Realistic Mathematics Education* (RME) using HLT before receiving treatment (*treatment*).

Analysis of the effect of RME on increasing mathematical communication skills using *N-gain* scores of mathematical communication skills in the experimental class (RME) and in the control class. The mean *N-gain* score illustrates the improvement in mathematical communication skills after learning. This

analysis is to test the second research hypothesis. Before testing the hypothesis, the prerequisite test is performed first, the normality test. The normality test results are as follows.

Table 3 . Normality test

N-gain Kemampuan Komunikasi Matematis	Kelas	Kolmogorov - Smirnov		
		Statistic	df	Sig.
	Eksperimen	.141	28	.162
	Kontrol	.142	30	.125

Based on table 3 above, the N-gain score of the experimental class and the control class is normally distributed, then the hypothesis test step uses the *independent sample t-test* . The results of the hypothesis test are as follows.

Table 4 . Test the research hypothesis

N-gain Kemampuan Komunikasi Matematis		Levene's test equality of variances		t-test Equality of means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
	Equal variances assumed	.104	.748	2.316	56	.024	.18667	.08060
	Equal variances not assumed			2.314	55.531	.024	.18667	.08060

From Table 4 above, the value of *Sig. (2-tailed) Equal Variances Assumed* by 0,024 less than the significance level (α = 0.05) then H_0 is rejected and H_a accepted. It can be concluded that there is an influence on improving mathematical communication skills between students who take part in and who do not take part in Learning *Realistic Mathematics Education* (RME) using *Hypothetical Learning Trajectory* (HLT). So, it can be said that the increase in mathematical communication skills of the experimental class is higher than the control class. Therefore, the conclusion of this study is t erdapat improvement of communication capabilities mathematical difference between students who take those who did not follow the learning *Realistic Mathematics Education* (RME) using *Hypothetical Learning Trajectory* (HLT) .

DISCUSSION

In the implementation of learning to use RME begins with apperception to find out the student's initial knowledge before studying fraction material class 4 semester 1 . Then, communicate the purpose of learning and m e nginformasikan material to be studied. At the core activities, the RME learning steps are carried out. The first step, namely filing a group problem regarding the material fractions . Submitting this group problem , the teacher presents a contextual problem. The use of this contextual problem refers to

the characteristics of RME according to Treffers. The task of the teacher here is as a guide and director. That is, when students have difficulty in solving problems, the teacher provides feedback questions that lead students to find further clues in solving individual problems. This is in line with the results of research by Frangke, *et al* . (2009, p. 391) which states that, *teachers' questions can position the student thinking in relation to mathematics in ways that support student understanding. Our analysis provides evidence that many questions occur after teachers' initial questions asking students to explain how they solved problems.*

Then, the third step, Interactivity: Submitting group problems. In this third step students are grouped 3-5 people in each group to work on the problem problems proposed by the teacher listed in the Student Activity Sheet (LKS) . The LKS is made in the form of HLT that has been previously planned regarding the fractional material. According to Nur and Muclas (in Arnyana, 2006, p. 698), the learning that was carried out was to help children to actively manipulate and interact with their environment that emphasizes children's thought processes and mental processes. Another opinion, namely according to Kozulin that one's interactions with the environment can help learning (Isnurani, Sugiatno, & Yani, 2015, p. 7). Therefore, by grouping, this aspect of interactivity in RME learning helps students to be able to interact, exchange ideas, and discuss with group friends, so they can find ways to solve these problems. Next, in the fourth step, which is concluded. After discussing the group, the student representatives present or communicate the results of the answer questions to the worksheet and each student pays attention and is involved in class discussion. The fifth step, namely the confirmation and assignment of tasks. After students discuss and communicate the results of the answers to problems, the next step is to equalize the perceptions of each student, so students know the essence of the material being studied. And to develop students' thinking skills, given other problem problems and students work individually, to find out whether each student has understood or has understood the material being studied. Conclusion

The conclusion from the study is that there is a difference in the improvement of mathematical communication skills between students who take and those who do not participate in *Realistic Mathematics Education* (RME) *learning* using *Hypothetical Learning Trajectory* (HLT) .

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