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The Effect of Mathematics Realistic Education Aided by Mathematics Software towards the Process of Solving Mathematical Communication Problems of Junior High School Students

Marwan Marpaung[1], Ani Minarni[2], Togi Panjaitan[3]
[1,2,3] *Mathematics Department, State University of Medan, Indonesia*
marwanmarpaung04@gmail.com

Abstract

One factor that has a big influence on mathematics learning outcomes and how students provide solutions to mathematical problems, among others, is the learning factor as well as initial mathematical knowledge (IMK). So, the objectives of the research are to find out: (1) the influence of the Realistic Mathematics Education (RME) Approach aided by Microsoft Mathematics software on students' mathematical communication ability (MCA), (2) an interaction between IMK and RME approach to mathematical communication ability, (3) the students' completion process in solving mathematical communication problems. The third objective is very important because it can reveal whether horizontal and vertical mathematization as the ideas of RME benefit the students. The results of the research show that: (1) there is a significant effect of the RME Approach aided by Mathematics software on students' mathematical communication ability, (2) there is no significant interaction between the initial mathematical knowledge and the learning approach to students' mathematical communication ability, (3) the students' completion process in solving mathematical communication problems attain the "good" category.

Keywords
realistic mathematics education approach (rme); conventional learning approach; mathematical communication ability (MCA), Mathematics

I. Introduction

Mathematics with its various role make it as a very important science. One important role of mathematics is as a tool of thought that deliver students understand mathematical concepts being studied. Throughout the history of mathematics learning, the problems encountered in the learning mathematics becomes more and more complicated so that it requires the improvement continuously. Besides, mathematics is often regarded as one of the most difficult lessons for students. The negative effect of this perception is that there are many students who already feel anti-mathematics. Moreover, complaints about the low mathematics learning outcomes of students from the lowest level of primary school education to college never disappear.

One of the efforts to improve the low mathematics learning outcomes of students should be viewed from five aspects of general mathematics learning formulated by the *National Council of Teachers of Mathematics* (NCTM: 2000) as follows.

> "Students must learn mathematics through understanding and actively build on their prior knowledge. To make this happen, mathematics learning is formulated with five general objectives: (1) learning to communicate, (2) learning to think, (3) solving

mathematical problems, (4) learn interrelated ideas; and (5) promoting a positive attitude towards mathematics.

This is consistent with Turmudi (2011; 55) that says, "Aspects of mathematical communication ability and reasoning should be an important aspect in learning mathematics. The communication aspect trains students to be able to communicate their ideas, both written and oral communication. In addition, according to Saragih (2007: 7), mathematical communication ability in learning mathematics need to be considered due to it can organize and consolidate students' mathematical thinking. According to Baroody (1993) there are at least 2 important reasons that make communication in learning mathematics need to be the focus of attention, namely (1) mathematics as language; mathematics is not just a tool for thinking (a tool to aid thinking), a tool for finding patterns, or solving problems but mathematics is also "an invaluable tool for communicating a variety of ideas clearly, precisely, and succintly," and (2) mathematics learning as social activity; as a social activity, in mathematics learning, interaction between students, as well as student communication is an important part of "nurturing children's mathematical potential".

Improving mathematical communication ability need to use appropriate learning approaches such as the Realistic Mathematical Education (RME). According to Gravemeijer (1994), there are three principles in designing mathematics learning with a realistic approach, namely: (a) guided reinvention, (b) didactical phenomenology, and (c) self-developed model. Guided Re-invention or rediscovering is the first principle of RME. In addition, mathematical communication skills can be also improved by involving software. One of the supporting software that can be used in learning mathematics is *Microsoft Mathematics*. The use of this software can increase speed and accuracy in various calculations in mathematics so that the time needed to solve mathematical problems could be more efficient and the results obtained are more accurate. During the process of RME approach, students will be more easily involved in mathematical problem solving if learning is combined with the use of computer and communication technology (ICT). The use of ICT is one of the six principles of learning mathematics; technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and improves students' learning"; or application in class, the use of ICT can be integrated to several learning approach (Roima R, Mulyono & Ani M. : 2018).

Based on the problems and facts mentioned above, the researchers thought that learning using the Realistic Mathematics Approach aided by Microsoft Mathematics software can be used as a way to improve students' mathematical communication ability. To follow up on these thoughts, a study with the following titles was carried out: The Effect of Mathematics Realistic Education Aided by Mathematics Software towards the Process of Solving Mathematical Communication Problems of Junior High School Students.

This research was carried out at SMP Negeri 30 Medan. The objectives of the research are to find out: (1) the influence of the Realistic Mathematics Education (RME) Approach aided by Microsoft Mathematics software on students' mathematical communication ability (MCA), (2) an interaction between IMK and RME approach to mathematical communication ability, (3) the students' completion process in solving mathematical communication problems. The most important objective of this study is to investigate the process of solving mathematical problems proposed by students because this can show whether the mathematical ideas horizontally or vertically benefit the mathematical communication ability of students who learn mathematics in RME classes assisted by Mathematics software.

Furthermore, because there is a suspicion that IMK also influences MCS, the researchers are also interested in examining the effect of interactions between learning approach and IMK on MCA achievements. Data from this study will be analyzed using Analysis of Variance (ANOVA) at a 95% confidence interval. This research will also investigate the process of solving mathematical problems raised by students after they are taught through a Mathematics software-assisted RME approach.

II. Review of Literatures

2.1 Realistic Mathematics Education Approach

According to Freudenthal (Gravemeijer, 1994), Realistic Mathematics Education (RME) has characteristics, namely: (1) starting mathematics learning with real problems (related to students' daily lives or can be imagined by students), (2) using problem solving models constructed by students through teacher guidance, (3) using student contributions through "various answers" and "various ways", (4) maximizing interaction between student-student, student-teacher, and student-learning resources, and (5) linking mathematical material with mathematical topics others (intertwinement).

The learning process through RME consists of learning to solve realistic problems informally, namely by using problem representations in the form of images or other representations such as graphics. This process is called horizontal mathematization or model of process; then problem solving continues to the stage of the activity of formulating images and other forms of representation into the process of making mathematical models or mathematical equations. This process is called the vertical mathematization or the process or model for (Gravemeijer. 1994).

RME has succeeded in enhancing mathematical procedural fluency (Nuraida, Kusumah, & Kartasasmita, 2019); increasing understanding of mathematical concepts and self-efficacy of junior high school students in Medan City (Pratama, Minarni, Saragih, 2015); students reflective thinking skills (Junaedi & Wahyudin, 2020). On the other side, mathematical communication ability could be increased through learning approaches (Perawansa & Minarni, 2019; Minarni & Napitupulu, 2020).

2.2 Mathematical Communication Ability

On the other hand, Greenes and Schulman (1996: 168) who said that mathematical communication is: (I) the central strength for students in formulating mathematical concepts and strategies, (2) capital success for students towards approaches and solutions in mathematical exploration and investigation, (3) a place for students to communicate with their friends to get information, share their thoughts and findings, brainstorm, evaluate and sharpen ideas to convince others. In line with NCTM, Lestari & Yudhanegara (2015) is the ability of mathematical communication is the ability to convey mathematical ideas both verbally and in writing as well as the ability to understand and accept mathematical ideas of others carefully, analytically, critically and evaluatively to sharpen understanding.

To create a conducive learning situation that can optimize students' ability in mathematical communication, students should be organized in small groups, besides, the teacher should familiarize multi-directional communication even student-centered rather than teacher-centered. Meanwhile, to make students master communication ability can infer to the standard processes set forth in NCTM 2000, namely as often as possible the teacher engages students in solving mathematical problems that require students to use mathematical

communication tools such as mathematical symbols, tables, graphs , diagrams, mathematical equations (models).

In addition, Baroody (1993) argues that there are five aspects to mathematical communication skills, namely:

1. Representation
2. Listening
3. Reading
4. Discussion
5. Writing

The aspect of representation becomes the foundation for the need to measure mathematical communication ability through mathematical problem solving tests.

Meanwhile, the steps to solve mathematical problems can be referred to the ideas of Polya (1987) by combining them with the standard process of doing mathematics (NCTM, 2000).

2.3 Microsoft Mathematics Software

For three decades, Microsoft Mathematica has defined the state of the art in technical computing-and provided the principal computation environment for millions of innovators, educators, students, and others around the world, widely admired for both its technical computing-and seamlessly available in the cloud through any web as well as natively on all modern desktop systems (Wolfram, 2003). Wolfram further stated that this software is software that is easy to understand and easy to use because it is designed in accordance with a very simple program syntax. An example of using this software is shown in Figure 1

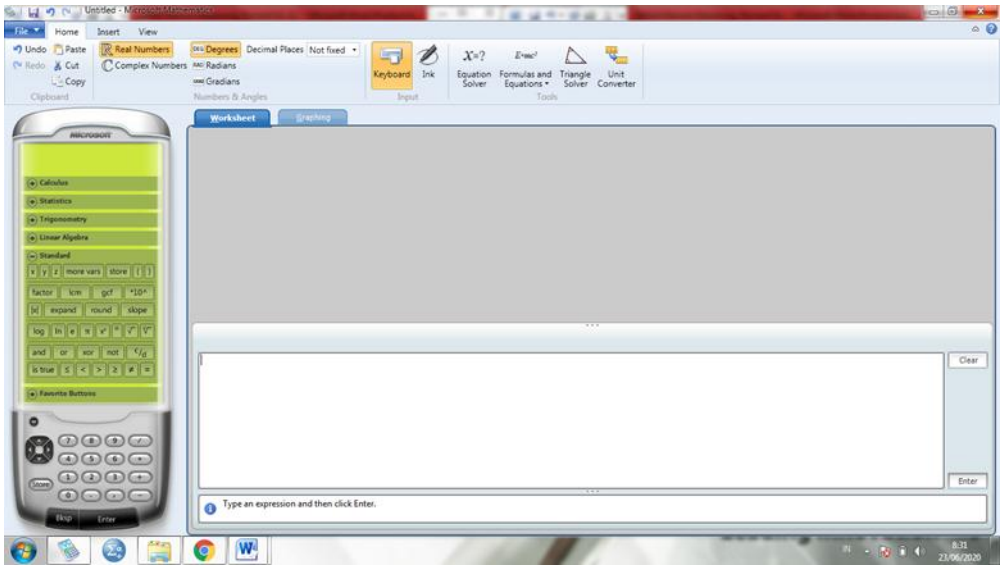

Figure 1. Example of Microsoft Mathematica Performance

III. Research Methods

3.1 Research Type

This research is quasi-experimental that aims in investigating by comparing the similarities or differences behavior patterns of the subjects (Glass & Hopkin, 1979).

3.2 Sample and Population

The sample of this research is the students at grade 7 SMP Negeri 30 Medan. There are 31 students at experiment classroom and 35 students at control classroom. The population is all of the students at that school, around 300 students.

3.3 Research Design

The research design used here is a pretest posttest design by applying the RME approach assisted with Mathematical software in the experimental class, while in the control class the teacher continues to use the conventional approach. There are 31 students in experiment classroom and 35 students in conventional classroom. Research design can be described as follows:

Experiment classroom	O1	X	O2
Control classroom	O1	-	O2

Note:
O1 = IMK tes
X = RME approach Aided Mathematics Software
O2 = MCA tes

3.4 Data Collection Techniques

Data to be collected in this study includes data on initial mathematical kowledge (IMK) to be measured through the IMK test, data on mathematical communication ability to be measured through MCA test scores, and data on mathematical problem solving processes that can be obtained by analyzing student work papers in solving mathematical problems that given by the teacher. The IMK test is designed based on the mathematical knowledge students have before they are taught through the RME approach. The MCA test is a test that is designed based on aspects of mathematical communication ability. MCA test is held after the implementation of RME assisted with Mathematics software is completed.

3.5 Validity of the Instrument

According to Minarni (2020) The validation of learning tools and instruments aims to obtain valid learning instruments and research instruments that are suitable for use in research. Learning tools and research instruments were validated by 5 experts. Based on the results of the learning device validation it was found that the learning device is good for use in learning. The validation of the research instruments was carried out statistical tests (empirically) to see the validity, reliability so that the validity of the research instruments was getting better. Content validity was tested through *expert judgment* , while item validity was done by correlating item scores with total scores.

3.6 Data Analysis

Data analysis technique of the research is descriptive statistics and inferential statistics. Descriptive statistics include the calculation of the mean, standard deviation, variance, maximum value and minimum value of sample data and the presentation of data in tabular or graphical form. Inferential statistics are statistics used to analyze sample data and the results are applied to the population. The purpose of data analysis conducted with inferential statistics is to test the research hypothesis. The research will use Analysis of Variance (ANOVA) at a 95% confidence interval, because the analysis will include to testing interaction between learning approach and initial mathematical knowledge on MCA of the students.

IV. Discussion

4.1 Results

The following description are the results of the research.

a. Mathematical Communication Ability

Table 1 shows the results of mathematical communication ability test both from the experimental class and the control.

Table 1. Description of the Mathematical Communication Ability (MCA)

Statistics	Learning approaches				Posttest Score Difference
	PMR		Conventional		
	IMK	Postes	IMK	Postes	
N	31	31	35	35	
Average	55.08	76.16	55.17	68.34	7.82
Standard Deviation	21.15	13.43	16.02	11.83	

In Table 1 above, it can be seen that the average mathematical communication ability of students has increased after being given effect, both the experimental class and the control class.

b. Data of the Interaction between Mathematical Initial Knowledge and the Learning Approach to Students' Mathematical Communication Ability

Description of Mathematical Communication Ability based on IMK and RME Approach is displayed in Table 2.

Table 2. Description Mathematical Communication Ability based on Learning Approach and IMK

Test of Between-Subjects Effects

Dependent Variable: Mathematical Communication Ability

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1745.102 [a]	5	349.020	2.221	. 064
Intercept	223748.028	1	223748.028	1423.653	. 000
Approach	990.636	1	990.636	6.303	. 015
IMK	706.812	2	353.406	2.249	. 114
* IMK approach	93.127	2	46.564	. 296	. 745

Error	9429.883	60	157.165		
Total	353463.000	66			
Corrected Total	11174.985	65			

Based on Table 2 above, it appears that significant value to the approach of 0.01 5 (sig . < .05), so the testing hypothesis is significant. It means there is the effect of learning approach towards mathematical communication ability of the students. Also, testing hypothesis of the effect of Learning Approach and IMK is significant.

c. Description of Students Performance in MCA Test

We begin this section by showing one example of an MCA test question and the process of answering that question by showing the worksheet of the student whose get high score (Figure 1).

Example of an MCA test:
"*For the 30th Junior High School reunion party, the consumption committee bought 4 kg of fish and one kg chicken for a total of sixty thousand rupiahs, and 1 kg of fish and 2 kg of chicken for a total price of 50 thousand rupiahs. If they have to buy additional 2 kg of fish and 2 kg of chicken as well, how much rupiah do they have to provide to pay for it?*"

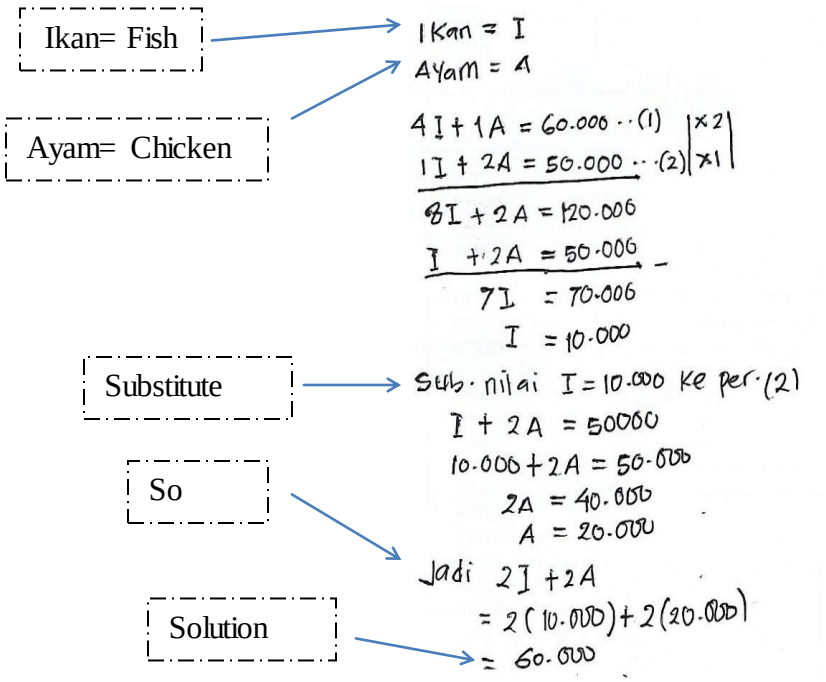

Figure 2. Completion of Example

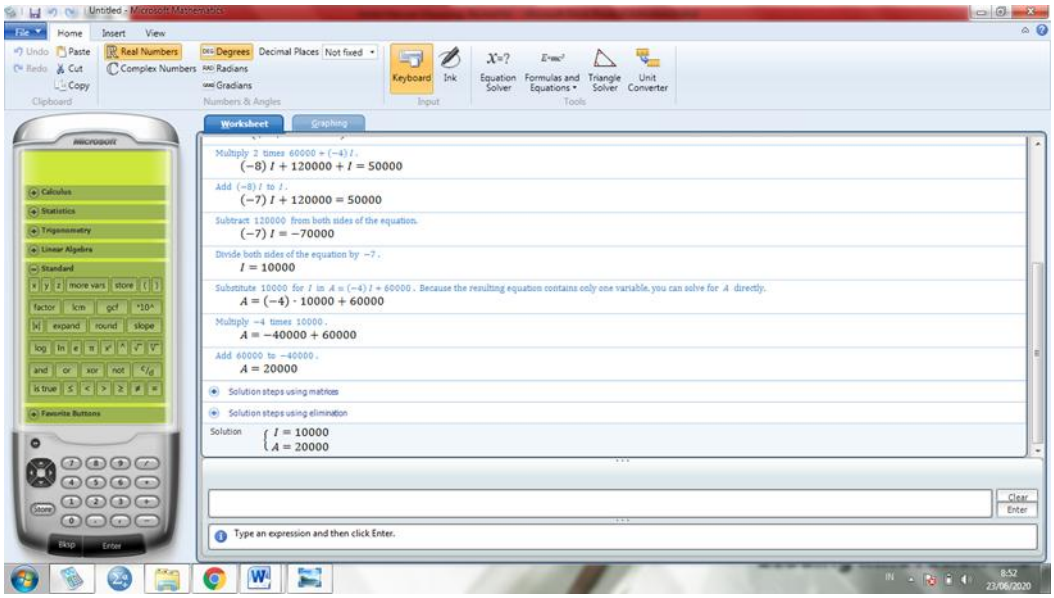

Figure 3. Completion Using the Microsoft Mathematica Application

The data in Table 3 is a research finding related to the number of students in each MCA category in classes, the experimental class and the control class.

Table 3. The Number of Students at Every Category of MCA

Score	Exp.	Control
≥ 75	17	12
60 ≤ X < 75	6	8
< 60	8	15
Total	31	35

4.2 Discussion

a. Students' Mathematical Communication Ability

The results of statistical tests show that the learning approach has a significant influence on the achievement of mathematical communication skills (MCA). This means that the effect of the RME approach assisted by Mathematics software gives a better effect than the effect of conventional learning approaches. The difference in the average MCA score between the experimental class and the conventional class is 7.82 based on ideal score 100. This difference in achievement is indeed not high enough but at least gives hope that the RME approach assisted by Mathematics software can improve the student's MCA achievement.

Researchers have confidence that if this learning approach is implemented in a longer period of time it will provide even better results because the students who take part in learning through the Realistic Mathematical Approach with *software* aided by *Microsoft Mathematics* have become accustomed to being active in solving mathematical problems by thinking individually or in groups. Whereas in the conventional learning approach, while in conventional classes this does not happen.

b. The Effect of Interaction Between Learning Approaches and IMK towards Students' Mathematical Communication Ability

Table 2 shows that there is no interaction between learning factors and mathematical initial knowledge. This means that the learning factor has a significant influence on students' MCAs. In other words, the RME approach aided by Mathematica software gives a better influence on the achievement of MCA compared to the conventional approach. This shows that instilling the habit of solving mathematical problems through 'the model of' and 'model for' initiated by RME has succeeded in increasing students' ability to solve mathematical communication problems (MCA).

This finding happened because the learning activities in the experimental class directed by the teacher so that students represent problems in various forms of representation, as an initial step in learning mathematics in RME-called horizontal mathematical (model of), and activities formulating horizontal mathematical results (model for) turns out can improve mathematical problem solving abilities. This statement is supported by data that there is no interaction effect between learning factors and students' initial mathematical knowledge on the achievement of mathematical communication ability (see Table 2). This means, the RME factor influences the achievement of the MCA, not other factors.

c. The Process of Solving MCA problems

The mathematical communication problem solving process shown by students in their working papers shows that students who study mathematics in the experimental class are better than those who study in conventional classes. The following table shows that more than 75% of students in the experimental class have fulfilled mathematical problem solving steps that include representation of problems in various forms of representation, in accordance with the mathematical communication process standards initiated by NCTM 2000.

Based on Table 3 we can conclude that the number of students who have achieved MCA scores is more than enough, scores above 60 on the ideal score of 100, there are as many as more than 75%; not so in the control class. From a number of students who scored above 60, the mathematical problem solving process was in accordance with the standard mathematics doing process initiated by NCTM 2000.

What reinforces the statement is the result of an analysis of student performance in solving MCA problems. An example can be seen in Figure 1. In the picture, it appears that students in the experimental class have been able to apply the problem solving steps exactly according to the problem solving steps initiated by Polya (1987).

V. Conclusion

Based on the results of the analysis of research data about mathematical communication skills and learning motivation of students who learn through a realistic mathematical approach aided by *Microsoft mathematics* , the following conclusions are obtained:

1. There is a significant effect of the Realistic Mathematics Education Approach aided by *Microsoft Mathematics software* on students' mathematical communication ability.
2. There is no significant interaction between mathematical initial knowledge and learning approaches on students' mathematical communication ability.
3. The process of solving mathematical communication problems shown by students in their working who study mathematics in the experimental class are better than those who study in conventional classes. The criteria for mathematical communication ability of students

who learn through the Realistic Mathematics Approach aided by Microsoft Mathematics software is in the category of "good". The idea of ‘horizontal mathematization’ and ‘vertical mathematization’ or ‘model of’ and ‘model for’ in RME can improve the mathematical communication ability of junior high school students in Medan City.

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