Improving Student's Mathematical Communication Skills Through Mathematics Worksheet Based on Realistic Mathematics Education

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Abstract: Students' mathematical communication skills are still low. The reason is that the presentation of material is less related to student life. The purposes of this research is to develop mathematics worksheets based on Realistic Mathematics Education to improve students' communication skills. This type of research is the Plomp design research model with three stages, namely the preliminary investigation, prototyping stage, and assessment phase. The instruments used were observation sheets, interview guidelines, questionnaires, and tests. The results showed that the worksheet was practical, effective, and valid, and was able in improving students' mathematical communication skills. The use of problems related to the students' life makes learning more meaningful.

Keywords: M realistic mathematics education, worksheet, student's mathematical communication skills.

1. Introduction

This Mathematical communication skills are one of the goals of learning mathematics in junior high school [1]. Ontario [2] said that the mathematical communication is the essential for learning mathematics because through the communication, clarifying and expanding their ideas, and understanding of mathematical relationships and mathematical arguments. According to Baroody [3] communication in mathematics learning was very important because of two things, namely (i) mathematics as language; mathematics a thinking tool to aid, an invaluable tool for communicating a variety of ideas clearly, precisely, and succinctly, and (ii) mathematics learning as social activity; "Nurturing children 's mathematical potential".Mastery of mathematics material for junior high school students in Indonesia is still low ([4], [5]). Other results were also obtained from the Program for International Student Assessment (PISA) and Trends in the International Mathematics and Science Study (TIMSS) study. The reason is that the students are less involved in finding a mathematical concept. They are given concepts in final part, so they are less meaningful. For this reason, teaching materials are needed with a particular approach to guide the students in rediscovering the concept. One approach that can be used is realistic mathematics education (RME).When you submit your paper print it in two-column format, including figures and tables [1]. In addition, designate one author as the "corresponding author". This is the author to whom proofs of the paper will be sent. Proofs are sent to the corresponding author only [2]. In general, RME is applied in elementary schools [6]. The application of RME is enough to help the students in understanding the concept. But it is still rarely used for secondary schools. So in this study a worksheet based on the RME approach was created in junior high school. The RME approach uses real condition in the minds of students as a starting point for developing mathematical ideas and concepts. This approach gives chance to the students in term of communication with each other to develop the strategies and to build the mathematical concepts [7]. RME can provide learning experiences for students to practice mathematics communication well. There are two important points of view of RME on mathematics, namely: (1) mathematics must be closed to the students' life and relevant to every situation in daily life (realistic); (2) the idea that mathematics is a human activity, which means that mathematics education is organized as a process. Gravemeijer [8], suggests three principles related to Realistic Mathematics Education (RME), namely: 1) guided reinvention and progressive mathematical, 2) didactical phenomenology, and 3) self-developed models. In line with the three principles of RME, Gravemeijer [8] describes five characteristics of RME, such are:

a. The Use of Context

Learning begins with contextual problems in accordance to the environment faced by students, allowing the students to use prior experience and the initial knowledge directly, not starting from the formal system.

b. Use models, bridging by vertical instrument

In this model, the students build their own mathematical models. This models will be a bridge for students to connect them from real situations to abstracts or from informal to formal situations.

c. Student contribution

In this model, the students are hoped to be active and give more contribution in learning. Everything must be from the students and not from the teacher. Every contribution from are very valuable.

d. Interactivity

The main concept of this model is communication by the students along the learning process. The forms of

communication/interaction such as negotiation, explanation, justification, approval, questioning, or reflection are used to achieve the forms of informal mathematical knowledge. Teachers must provide the chance for students to communicate their ideas through an interactive learning process.

e. Intertwining

Various structures and concepts in mathematics are interrelated, so the interrelationships between topics or subject matter need to be explored to support so that learning is more meaningful. In the RME the integration of mathematics learning units is essential. With integration, it will make it easier for students to solve the problems given

2. Research Methods

The type of this research is the Plomp research design model [9] with three stages, namely preliminary research, prototyping stage, and assessment phase [10]. At preliminary research needs analysis, curriculum analysis, student analysis, and concept analysis are conducted. In the prototyping stage the worksheet is developed, validated, and practiced. In the assessment phase, a field test is conducted. The validity of the worksheet was assessed based on four aspects, namely the content aspect, didactic aspects/ presentation, linguistic aspects, and graphic aspects. Practicality is assessed by ease of use, interesting, easy to understand, time efficiency, and equivalence. Effectiveness is seen from the aspect of activity and mathematical communication skills. The instruments used were observation sheets, interview guidelines, questionnaires, and tests.

3. Title, Authors, Body Paragraphs,Sections Headings and References

3.1 The Result of Preliminary Stage

In the needs analysis activities, interviews were conducted with students and mathematics teachers, observed learning activities and worksheets used. Based on the preliminary analysis that has been done, the students did not understand mathematical problems contextually. When given questions related to the problems about daily life, the students tend to copy their friend's answers because the questions given are difficult to present into mathematical models. Based on the results of interviews with the teachers, it was found that one of the most difficult material to be followed by students was material about expressing daily events in language symbols or mathematical models. The teacher only focuses on delivering the material according to the teacher's hand books and student books. The teacher also said that the mathematics books used so far were inadequate to facilitate students in learning mathematics. Based on the results of the questionnaire, the students need the student's worksheet in understanding mathematics material. However, since the frequency of using student's worksheet rarely, it also impacted to their mathematical abilities. Based on the initial investigation carried out, it is necessary to make improvements from the worksheet that the teacher has used so far. Then it is necessary to design a worksheet that uses an RME approach. The worksheets designed are able to help students in understanding mathematics contextually, making the students more interested in learning mathematics through the benefits of mathematics on their daily life, so as to improve the communication skills of the students.

3.2 The Result of Development or Prototype Stage

The product design results at the initial stage are called prototypes I. In prototypes I carried out self evaluation and expert reviews. In this stage a mathematical worksheet based on the RME approach was designed for eighth grade students of junior high school. At the expert review stage, validation of the worksheet has been developed with regard to the feasibility aspects of the content, language, presentation, and graphics. Expert review of RME worksheets was carried out by 3 professors in the field of mathematics, 1 mathematics teacher who graduated from Master Degree, 1 expert lecturer in the field of language, 1 expert lecturer in educational technology. The following result of the worksheet validation:

Table 1 *Validation result of RME worksheet by the experts.*

No.	*Aspect*	*Mean*	*Category*
1.	*Presentation/Didactic*	*3.40*	*Very Valid*
2.	*Contents*	*3.33*	*Very Valid*
3.	*Language*	*3.50*	*Very Valid*
4.	*Graphics/Display*	*3.33*	*Very Valid*
Total Mean		*3,39*	*Very Valid*

Based on Table 1, the average results of RME-based worksheet validation are 3.39 with very valid categories. The suggestions from the validators is a less attractive cover that previously mixed colors replaced the cover background to green and associated with the world around students. Assessment should be given in a worksheet. There are names of students and group names, which means there are individual judgements. Worksheet material contains the problems, exercises that are done in groups. Each of them should have their own judgement. Practical test of worksheet (prototype II), carried out in three stages, namely one to one evaluation, small group and field test.

3.2. 1. The Result of One to one Evaluation

One to one evaluation was carried out on 3 students who were low, medium and high ability. Students are asked to understand the material that will be done in the worksheet. Each student is given the opportunity to understand the material provided within 10 minutes. Then the researcher retrieves the material in the hands of the students and tells the students to sit separately and ready to work on the worksheet. The students with low ability are still experiencing difficulties, these students are still having trouble in understanding the problems given. He needs a long time to analyze the question and understand the problem clearly. After being given a question that led him to do it. But students with moderate and high abilities can do it well.

3.2. 2. The Result of Small Group Evaluation

The small group activity is to carry out actual learning followed by six people who are capable of low, medium, and high. After learning activities, the students and teachers respond to the given worksheet. The results of the questionnaire responses and interviews can be seen in Table 2 and Table 3 below:

Table 2 *The result of questionnaire about student's response to the worksheet.*

Aspects	Mean	Practicality (%)	Category
Presentation	3,33	84,17	Practical
Ease of Use	3,43	86,11	Very Practical
Readable	3,34	87,5	Very Practical
Time Allocation	3,67	95,83	Very Practical
Mean	3.52	88,40	Very Practical

Based on Table 2, it can be seen that the RME-based worksheet for each aspect of the assessment is very practical and the practicality percentage is 88.40%. The results of interviews with the students were obtained that they were greatly helped from the presentation of the worksheets that linked to the real situation. Because the worksheet is easy for students to read so that the students understand the subject matter easily. But in terms of time, students feel less because there are some parts they need to collaborate and communicate in groups working on worksheet exercises. Because the teacher also provided an opportunity for the participants in working on the worksheet independently, in groups, and presenting what they had discussed. Furthermore, the results of interviews with three students can be seen in Table 3 below:

Table 3 *The Result of Interview to the Students in Small Group*

No	Aspects	Student
1	Presentation	Font and paper size The picture already appropriate to the real condition and more easy to understand Contextual problem helps in understanding mathematics
2	Ease of Use	Worksheet can be understood well There is a challenge and easy to follow The queries on worksheet are a bit difficult
4	Readable	The writing on worksheet is clear and readable
5	Time Allocation	Need enough time Can understand the material as the time allocation

Based on the observations and interviews with the students, worksheets are easy to understand and solve even though there is little improvement. So it can be said to be practical because it can be used and understood easily. The effectiveness of the RME-based worksheet on the small group was carried out to see an increase in mathematical communication skills. The results of the mathematical communication skills test in the small group can be seen in Table 4.

Table 4 *The Result of Mathematics Communication Skill's*

Student	Test Result	Note
Student 1	93.33	Pass
Student 2	80.00	Pass
Student 3	46.67	Fail
Student 4	93.33	Pass
Student 5	80.00	Pass
Student 6	93.33	Pass
Percentage of Completeness	84,67	

The percentage of learning completeness in the small group obtained in the table above is 84.67%. While the minimum percentage of completeness is 80%. Then it can be concluded that the learning by using an RME-based worksheet influences the improvement of mathematical communication skills so that the worksheet is said to be effective/

3.3 The Result of Assessment Phase (Field Test)

Field tests are carried out after the worksheet is valid, practical, and effective. The activity was held for six meetings with 32 people. The learning by using an RME-based worksheet is carried out through heterogeneous group learning. Each study group is arranged based on the level of academic ability, which is high, medium and low, which has been determined by the teacher of the subject, where the teacher grouped the students based on the results of daily tests and the activity of students in learning. Other things also considered from gender, there were variations of men and women in the group. The results of the field test of mathematical communication skills can be seen in Table 5. The test was followed by 32 students with an average of 81.46. Thus it can be said that the RME-based worksheet has been effective. Next is described the percentage value of each indicator of students' mathematical communication skills before using an RME-based worksheet. Assessment Phase was also conducted to see the effectiveness of RME-based worksheets using quasi design experiments. In the assessment stage, two classes were chosen randomly after the normality and similarity tests were carried out on average. The potential impact tested in the study is the students' mathematical communication skills.

Table 5 *The Descriptive Statistics of score from control class and experimental class*

	N	$\bar{x}$	DS	Max	Min
Control Class	32	55	9.58	73.33	33,33
Experimental Class	32	81,46	9.69	100	60

From Table 5 it can be seen that the average test results of the experimental class are higher than the results of the control class. The difference between the average test of the control class and the experimental class is 26.46. Meanwhile, the variance of the experimental class test results was higher than the control class. This shows that the results of the mathematical communication skills of the experimental class students are more uniform than the control class. Before carrying out the difference test, the normality test and the variance homogeneity test were carried out on average. The results of the normality test on the control class data obtained P-Value is 0.055 with $\alpha = 0.05$ and $N = 32$. Because of the P-value > 0.05, it can be concluded that the distribution of test data values of mathematical communication skills of students is normally distributed. Furthermore, from the normality test the results of the experimental class test data obtained P-Value 0.063 with $\alpha = 0.05$ and $N = 29$. Because of the P-value > 0.05, then it can be concluded that the distribution of the data is normally distributed. Whereas the variance homogeneity test is done by the F test, where the P-value obtained is 0.950. Because the P-value obtained is more than the real level $\alpha = 0.05$, it can be stated that the test of the two sample classes has a homogeneous variance. Because the results of the control class tests and experimental class tests of mathematical communication

skills of students are normal and homogeneous, the statistical test used for hypothesis testing is the t test. Based on the analysis results obtained that P-Value = 0,000 with α = 0.05 and degree of freedom (df) = 61. Because the P-Value < 0.05, the average test results of the experimental class are higher than the average of control class. Based on the results of the statistical test, it can be concluded that the worksheet has a positive impact on the mathematical communication skills of students or the RME-based worksheet has been effective. Students' mathematical communication skills can be improved by using an RME-based worksheet. Students are given contextual problems, so the students are used to think critically and creatively. They easily understand the concepts given because they are met in everyday life. The RME approach emphasizes that mathematics is understood as human activity (Gavemeijer 1994). The students Learning with RME is doing mathematics. So, there are two important points of view of RME on mathematics, namely: (1) mathematics must be close to the students and relevant to every situation in daily life (realistic); (2) the idea that mathematics is a human activity, which means that mathematics education is organized as a process. Gravemeijer describes five characteristics of RME, namely: The Use of Context, use models, bridging by vertical instrument, student contribution, interactivity, intertwining. Students are given the widest chances to develop a variety of informal strategies that can lead to the construction of various procedures to solve problems. Various structures and concepts in mathematics are interrelated, so that the linkages or integration between topics or subject matter need to be explored to support so that learning is more meaningful. The results of this study are in line with several previous studies ([11], [12], [13]). Rustam [14], Isabel Val [15], Khoiriyah [16], and Asnawati [17] also reported that students' mathematical communication skills could increase with the use of RME-based worksheets. The validity of the RME-based worksheet was assessed based on four aspects, namely the content aspect, didactic aspects/ presentation, linguistic aspects, and graphic aspects. The content aspect was assessed from the suitability of the products produced with the material, activities at the RME, and learning models. The presentation aspect is assessed from the suitability of the product produced with the product arrangement or the appropriate product content. Linguistic aspects are the suitability of the language used in the product that is produced by the level of understanding of the product users, in language also includes the suitability of the placement of punctuation, and the truth in typing. The graphic aspect is assessed from the appearance of the products produced. From the results of the assessment analysis of 5 experts which are consisting of 3 mathematicians, 1 language expert, and 1 education technology expert, it was found that the worksheet was valid for all aspects of the assessment. Practicality is related to the use of worksheets by students and teachers. The learning process is obtained that students can find the concepts or understand each concept of the material being studied. From the learning by using an RME-based worksheet, it can be seen that the time provided is sufficient and students also have no difficulty in completing the given student's worksheet. Based on the questionnaireabout teacher's response and students' response, it shows that the worksheet developed is interesting and easy to use, it can be concluded that the RME-based learning device is practical. The effectiveness of the worksheet is seen from the students' mathematical communication skills. From the test it was found that the average mathematical communication skills of the experimental class was higher than the control class. Learning begins with the contextual problems in accordance with the reality or environment faced by students so as to enable students to use their previous experience and initial knowledge directly. As a result, the students were happy and enthusiastic in reading and understanding the commands from the worksheet [18]. Situations and mathematical models that are self-built by students (self developed models), which is a bridge for students to make their own models from informal to formal situations. Students make their own models (horizontal mathematical) in solving contextual problems which are the linkages between models of real situations that are relevant to the environment of students into mathematical models (vertical mathematical). The students are given the widest opportunity to develop a variety of informal strategies that can lead to the construction of various procedures to solve problems. Students become active in the learning process [19]. The mind of the students is very cared for or appreciated by both himself and his friends. Optimizing the learning process through interaction between students, students with teachers, and students with facilities and infrastructure. Forms of interaction such as negotiation, explanation, justification, approval, questioning, or reflection are used to achieve the form of informal mathematical knowledge that students themselves find. Students also have good reasoning and understanding ([20], [6], [21]). By this kind of worksheet, the teachers can use various strategies in learning mathematics. In the implementation, the teachers will try to make the media so that the instructions on the worksheet run well. Learning by using RME is largely determined by the media used. If the strategy and media are well designed, the RME-based worksheet will be able to improve students' mathematical communication skills.

4. Conclusions

The conclusion of this research are, 1) A valid, practical and effective RME based worksheet has been produced, 2) RME-based worksheets can improve students' mathematical communication skills, 3) The use of problems related to the students' life make learning more meaningful.

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