The Use of Open-Ended Student Worksheet to Improve Mathematics Communication Skills in Algebra

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Abstract

Communication is the foundation of every learning activity. Mathematical communication is a skill to represent ideas in mathematical language so that it is understood by others who are used in problem-solving activities. This study aims to improve mathematical communication skills by using open-ended student worksheets in algebra. The research sample involved 6 junior high schools in Purworejo Regency, Indonesia which is divided into 2 groups, the experimental group consists of 91 students and the control group consists of 96 students. The study design used a randomized static group comparison design. The research instrument used 5 item essay tests that contained non-routine problems. The data analysis technique used an independent sample T-test. The results showed that the communication skills of students who were subjected to learning using open-ended student worksheets were better than the communication skills of students who were subjected to learning using student worksheets that are commonly used by teachers. These results provide an important impact that teachers should always integrate the presentation of non-routine problems in the form of worksheets as an integral part of mathematics learning.

Keywords: Open-Ended Student Worksheet; Mathematic Communication Skills; Group Discussion

1. Introduction

The implementation of the 2013 curriculum by the Ministry of National Education of the Republic of Indonesia in response to the 2011 TIMSS and PISA 2012 study reports is accompanied by hopes of a significant improvement in the quality of education in Indonesia. However, it seems that this is not enough, the 2015 TIMSS results ranked Indonesia 44th out of 49 participating countries and the 2015 PISA results ranked 62nd out of 70 participating countries.

The PISA 2015 results show that the average mathematics score with a score of 386. Based on the average score, Indonesia falls into the Level 1 category which is characterized by students who can complete assignments with low problem complexity and complexity with limited collaboration. They can provide the information requested and take action to make plans when requested. Students can confirm actions or proposals made by others. They tend to focus on their roles in the group. With the support of team members, and when working on simple problems, these students can help find solutions to the problems given.

The PISA results imply that Indonesian students still find it difficult to solve problems with a high degree of complexity. This happens because students are accustomed to dealing with problems with a low level of difficulty and do not require advanced thinking processes. This is reinforced by the results of the analysis of students' mathematical skills in which nearly 30% of Indonesian students showed medium performance and less than 5% showed high performance. The rest shows low performance.

The results of the National Mathematics Examination for Junior High School students in 2019 showed that only 51.24% of students answered correctly on algebra material. Algebra is one of the mathematical material that is very important to study because it is closely related to material calculus, geometry, trigonometry, and others. Algebra material is also very close to its application to everyday life. A teacher needs to remind that, algebra is the key to any success in mathematics at all and abstract algebra is critical to work in advanced mathematics' and life and work opportunities (Katz 2007). Success in learning algebra can be a gateway to obtain other more advanced mathematical skills in today's technology society (Hill 2020 & National Mathematics Advisory Panel 2008). No doubt that algebra is very closely related to other applied mathematical materials such as geometry, arithmetic, trigonometry, calculus, linear programs, and others. The main thing attached to the concept of algebra is the variable in which the concept is a basic construction in teaching mathematics in general and teaching algebra in particular (Sahin & Soylu 2011).

Presentation of algebraic problems is often associated with the context of everyday life in the form of story problems, in which problem solvers are required to be able to change the facts of the problem into mathematical equations that contain constants, variables, coefficients, and operations that correspond to the requested problem. The ability of students to use mathematical language, in this case, is very necessary. Failure to identify and change the facts of a problem into mathematical equations in algebraic form is the beginning of the difficulty of learning algebra. The use of mathematical language is closely related to mathematical communication. Why? Because mathematics is the language of communication itself.

Many findings in class in the form of student work shows the failure of students to understand the

language of mathematics communication, especially algebra. For example $x + x = x^2$, or $x \,.\, x = 2x$. These errors are only a few of the many errors that may occur experienced by students. Thus, based on the description of the problem mentioned above, it is considered important to be seen in more depth about how the right way to improve and enhance mathematical communication skills in the concept of algebra. A good understanding of the concept of algebra will certainly help students in problem-solving activities in the form of story problems in the form of non-routine problems.

Communication is a vital skill for almost any profession, especially for teachers, in teacher-student relationships (Center for Excellence in Teaching 1999, 21). The idea of communication is more than a skill, it is a foundation for learning (Gorman 2020). Effective communication is essential to the success of both the student and the teacher. In the educational system, teachers and learners play a vital role in the communication process, in other words, it is possible to find a situation where two people say the same thing to a given audience, using the same language, even the same words, but the two will end up passing two different messages" (Abura 1998 in Osakwe 2009, 58). However, communication constraints and obstacles often occur in the learning process. The emergence of these communication barriers or obstacles will of course fail students in understanding the material being taught. One example of a case of communication barriers in the classroom is as follows: a typical situation of accessibility barrier for deaf or hard of hearing students is when the teacher is writing on the board while still talking. Students who need to read the lips miss all the information that the teacher is transmitting in this situation (Iglesias, Jimenez, Revuelta, & Moreno 2014). Not only that, but communication barriers will also make students unable to use their potential thinking abilities so they cannot convey ideas, opinions, and reasons to others. Many cases show that there are smart students, but he cannot help other students because he is not able to communicate his understanding well. If this happens, then the student will find it difficult to work in a collaborative team. This situation is exacerbated if students are not actively involved in learning activities.

Communicating effectively often means using a variety of modes (spoken, visual, etc.) to reach students who learn in different ways (Duta 2015, 626). In traditional classes that use spoken language as the main medium of the communication process, obstacles are more common. In these classes, the teacher is often the main actor, and students passively listen to the teacher's explanation, record what is on the blackboard, and get very few opportunities to express their ideas. This is further exacerbated by the teacher's reluctance to present open-ended questions to explore students' thinking abilities and to ask more questions that are merely repeating facts. As a result of this, of course, the function of communication as a tool to improve the ability to think becomes neglected and its potential cannot develop as it should.

Communication skills are important to be mastered by students because they are related to the development of one's creativity. Decision-making is what enables you to turn a jumble of ideas into a coherent communication (Intratot 2016). Decision making must be based on the ability to think, express ideas, write ideas, and design all of which lead to the acquisition of creativity. The learning process of a student that produces a pile of ideas that settles in his mind must be expressed in the form of oral and written ideas so that they can be understood by others. Ideas that continue to develop ultimately can create thinking creativity that ultimately can produce many ideas of problem-solving procedures. Solving these problems is the main focus of mathematics learning. A problem-solving approach is not only a way

of developing students' thinking, but it also provides a context for learning mathematical concepts. Problem-solving allows students to transfer what they have already learned to unfamiliar situations. A problem-solving approach provides a way for students to actively construct their ideas about mathematics and to take responsibility for their learning (Klerlein & Hervey 2019, 4).

Based on the foregoing, research related to mathematical communication skills is important to apply and must be integrated into the whole mathematics learning process. Two-way communication that is well established between the teacher and students will greatly help students complete their learning tasks so that they will play an important role in problem-solving activities. Problem-solving activities as the core of the mathematics curriculum are closely related to the ability to produce creative ideas to produce problem-solving with a variety of procedures and unexpected.

Communication as a fundamental part of learning in the classroom plays a very important role in the realization of quality education. Communication in learning is a means by which teachers and students can share the process of learning, understanding, and doing mathematics. Mathematical communication is an essential process for learning mathematics because through communication, students reflect upon, clarify, and expand their ideas and understanding of mathematical relationships and mathematical arguments (Ontario Ministry of Education 2005). Therefore effective communication is needed between the teacher and students. Effective mathematical communication as a respectful but engaged conversation in which students can clarify their thinking and learn from others through talk (Chapin, O'Connor & Anderson 2003, 5). Students need to be able to express their thoughts and problem-solving processes both in written and oral form. Furthermore, the communication between the teacher and students must be clear and complete enough to be understood by others (Cai, Jakabscin, and Lane 1996).

A fundamental difficulty in learning mathematics is understanding mathematics as a language of communication. Mathematics is itself a language (i.e., algebraic language and geometric language) for communication (Capraro, Capraro, & Rupley 2011). Mathematics is so often conveyed in symbols, oral, and written, communication about mathematical ideas is not always recognized as an important part of mathematics education. Students don't necessarily talk about mathematics naturally; teachers need to help them learn how to do so (Cobb, Wood, & Yackel 1994). Therefore, assistance from teachers and other students is needed to produce good communication. Communication is not only limited to the delivery of material but also related to the problem-solving process. Problem-solving activities that often involve problems in the form of story problems require a proper understanding of the written mathematical communication language. Solving problems with a story requires clarity and complication of the complete procedure so that it can be understood by others.

Presentation of problem-solving is part of written mathematical communication. Writing develops students' mathematical content learning (Meel 1999). Writing is seen as a way for individuals to reflect on or explain in detail certain mathematical ideas. It helps students to articulate strategies, therefore increasing their procedural knowledge and producing cognitive benefits in general (Silver, Kilpatrick, & Schlesinger 1990; Whitin 2004; Jurdak & Abu Zein 1998; and Kroll & Halaby 1997). Writing will not only clarify students' thinking but also provide other students with fresh insights gained from viewing the problem explanation from a new perspective (Lomibao, Luna, & Namoco 2016, 379). Based on this, the presentation of the results of student work as outlined in the worksheet should be something that teachers

also pay attention to. The teacher should help students to arrange solutions coherently and logically so that it can be understood by others. The most important thing about a student's work is that the procedure for addressing the problem must be shared with others. So that a settlement is not monopolized by students themselves but can also be emulated by other students. Sharing the results of the work to all students will give effect to the mastery of the procedure for handling problems by the whole class. This means that the quality of education will improve.

Many attempts were made to improve the quality of mathematical communication skills. Encouraging children to discuss and share ideas can enhance the assimilation of new and old experiences as well as facilitate the use of appropriate, informal mathematical communication (Cooke & Buchholz 2005, 369). Teachers must foster children's emerging abilities to participate in 'reflective' and 'collective' discourse and to become skilled at supporting such conversations. They argued that children actively construct their mathematical understandings as they participate in classroom social processes (Cobb, Boufi, McClain, & Whitenack 1997). Some of the opinions above complement other opinions stating that mathematical communication skills can be improved through small group discussions and whole-class discussions. Discussion activities can help students to convey ideas, opinions, rebuttal, and reasons to others in a comfortable atmosphere. Under these conditions, the potential for students' thinking will be more optimal because they do not feel under pressure, worry, and the same feeling in their academic abilities. Democracy in an atmosphere of learning like this provides equal opportunities for each student to develop according to his abilities and support from other students.

Another method used to improve mathematical communication skills is through the provision of open-ended tasks/problems. Open-ended and challenging tasks that build on students' prior knowledge are conducive to discussions because they encourage students to think collaboratively and build upon one another's ideas (Stein, Smith, Henningsen & Silver 2000). Giving challenging assignments to students has a far more satisfying impact on building relationships between mathematical concepts compared to giving routine problems, namely problems that have procedures that have been defined and memorized in daily life (Stein & Smith 1998). Emphasis on the use of open-ended tasks supports student involvement in classroom activities and encourages them to explore and investigate, increase their motivation for generalization, finding models and links, communicating, discussing and identifying possible problem-solving alternatives (Osana, Lacroix, Tucker & Desrosiers 2006).

This research will use a new approach to improve mathematical communication skills, modifying what has been done before. The class discussion that has been taking place in the form of the delivery of ideas will be changed to a more systematic discussion performance using 4 steps, namely: reason, express, write, and share. Each student is encouraged to think logically about the problem given to obtain an idea that might be used to solve the problem. Students then express ideas in their minds comfortably and confidently. Students write down all possible alternative solutions that have been submitted before and rethink the best alternative procedure. The final answer is then shared with other students. To increase the effectiveness of the discussion, a challenging task must be given, in this case, an open-ended student worksheet is used. Open-ended student worksheets are student worksheets that contain problems related to the context of everyday life that enable the discovery of various alternative answers. Open-ended student worksheets are given as a group assignment, consisting of 3-5 questions and arranged in such a

way that each question is not solved by the same procedure. Thus, students will have many alternative problem-solving procedures that can be applied to new problems given at other opportunities.

It is hoped that with this new approach, students will have learning experiences that can elevate their mathematical communication skills. Through this approach, it is very possible to achieve an increase in mathematical communication skills given the integration of two learning activities that have proven effective for learning to communicate mathematics.

The problem raised in this study is whether the use of open-ended student worksheets can improve students' mathematical communication skills? The giving of open-ended student worksheets in this study was carried out through small group discussion activities in the hope that an exchange of ideas could occur during the completion of the given task. Open-ended student worksheets are arranged to contain non-routine problems, namely problems that are based on real situations and allow the discovery of several settlement procedures. This open-ended student worksheet is expected to be able to encourage students to communicate all ideas and opinions to produce several alternative problem-solving procedures. Thus, communication can take a role in the ability to think that can be applied in a variety of situations.

2. Method

2.1 Research Design

This research is a quasi-experimental research with the randomized static group comparison design. The study was conducted from September to October 2019. The research population was all 7^{th}-grade junior high school (SMP) students in Purworejo Regency, Indonesia. Two groups are compared, namely groups that are subjected to open-ended student worksheets (experimental groups) and groups that are subjected to worksheets that are commonly used by teachers (comparison groups).

Both groups have the same characteristics, which are both taught by teachers who are certified as professional educators, using the same teaching material in the form of electronic school books published by the Ministry of National Education, and learning is carried out at the same time between 07.30 - 12.00 am. The equality of ability or achievement characteristics before treatment was given to each group was further measured by an equilibrium test using an independent sample t-test.

2.2. Population, Sample, and Technique Sampling

The population of this research is all 7^{th}-grade students of Junior High School (SMP) in Purworejo Regency with an average age of 13 years. The number of SMP in Purworejo Regency is 43 schools. The sampling technique used is stratified cluster random sampling. All schools are categorized into 3 levels of the high, medium, and low achievers based on previous National Examination results. In each category taken one school by drawing. Obtained SMP N 5, SMP N 12, and SMP N 13 as an experimental group and SMP N 3, SMP N 16, and SMP N 14 as a control group.

In the experimental group, 91 students were consisting of 42 male students and 49 female students. In the control group, 96 students were consisting of 47 male students and 49 female students.

Table 1: Description of Research Sample

	Experimental Group			*Control Group*		
	SMP 5	*SMP 12*	*SMP 13*	*SMP 3*	*SMP 16*	*SMP 14*
Male	14	16	12	15	18	14
Female	17	14	18	17	14	18
Total	31	30	30	32	32	32

2.3. Reasearch Instrument

The research instrument used 5 essay test items to measure mathematical communication skills. The test was composed of non-routine problems that were worked on for 75 minutes. Measurement of mathematical communication skills using a holistic scoring technique shown in Table 2. Tests are given to each group (experimental and comparison groups) after learning in 5 meetings.

Before being used in data retrieval, the test was tested for content validity through expert judgment involving 3 experts. The results of the assessment of the three experts revealed an average score of 3.6 (maximum score of 4.0). Furthermore, the test instrument was improved according to the advice given by the expert (validator). Instrument reliability was measured using the Alpha Cronbach test resulting in a reliability index of r_{11} = 0. 857.

Table 2: Rubric Holystik Scoring Technique

Criteria	*Score*
Provide complete responses with explanations and/or clear, unambiguous descriptions; can include appropriate and complete diagrams; communicate effectively; presents strong, logical and complete supporting arguments; can provide, distinguish, explain, and identify algebraic forms (variables, coefficients, and constants)	4
Provide explanations or descriptions that are quite complete and clear; can present almost complete and appropriate pictures/graphs/diagrams/tables; generally can communicate effectively explanation; presents supporting arguments that are logical but may contain some minor errors	3
Make significant progress toward solving the problem, but the explanation or description may be somewhat ambiguous or unclear; communication may be somewhat vague or difficult to interpret, and arguments may be incomplete or may be based on unclear logic	2
Has a pretty good explanation but fails to resolve to be a complete answer; eliminating some important parts of the problem so it is difficult to follow/understand; including in making drawings/ graphs/diagrams/tables that are not following the existing problem situation	1
Ineffective explanation; the explanation does not reflect the problem at hand; including in making drawings/graphs /diagrams that are completely incompatible with the existing problem situation	0

The results of student work are also carried out a content analysis to see the extent of the quality of student work in each group. Content analysis is focused on 5 things: 1) Awareness of answers, 2) Clarity of delivery, 3) accuracy of the use of mathematical language, 4) use of non-routine procedures, and 5)

Appropriate conclusions of answers. The results of the analysis are outlined in the form of an observation table that will be compared to descriptively between groups.

2.4. Data Analysis Technique

Students' mathematic communication skills test scores are then analyzed using an independent sample T-test to see whether groups that are subject to open-ended student worksheets are better than groups that are subject to learning sheets that have been used by teachers. The results of student work are also carried out by content analysts to see how far the students' communication skills are. This will be seen in how the resolution settlements and whether found a variety of problem-solving procedures.

3. Result.

The data to be analyzed in this study is in the form of a score of the mathematics communication test results. Furthermore, based on the results of the test will be obtained the final test score data and observation score data achievement mathematical communication indicators. Both of these data are used to compare which treatment is better for improving students' mathematical communication skills, whether the treatment is with an open-ended student worksheet or with a student worksheet that has been used by the teacher.

The provision of treatment at the experimental group has been done with open-ended student worksheets is done through learning through spontaneous exploration with small group discussions (4 students per group). Each group is given the assignment to complete an open-ended student worksheet, which is a student worksheet that contains questions with non-routine types. Students in each group discuss the solution to each problem given by using 4 steps, namely: reason, express, write, and divide. Students in each group are asked to think carefully about the subject matter that is given and think about the right solution to each problem that is given. Students are encouraged to express (convey) the idea of completion that has been thought to other friends in turn. The idea is written in the answer sheet by one group member and supervised by the other group members as a form of correction so that answers are obtained that are coherent and easy to understand. The results of the answers are shared (delivered) to each group member and students in the other groups in the form of class discussions so that an exchange of ideas occurs so that in 1 problem a variety of ideas will be obtained. During class discussions, it is possible for debates between students. The teacher acts as the mediator of the discussion to direct the conclusion obtained from the given problem.

The provision of treatment in the comparison class is done by giving students worksheets that have been used by the teacher. worksheets that have been used by teachers in the form of worksheets that are published commercially by a book publisher appointed by the school to provide worksheets at the school. The worksheet consists of a summary of teaching material and some practice exercises for students to do individually (independently). The questions presented on the worksheet are arranged with varying degrees of difficulty but are dominated by questions with routine problem types that merely reveal facts and do not require higher reasoning abilities. The results of student work on worksheets will be assessed by the teacher by being collected and corrected independently by the teacher.

Before giving treatment, a balance test is first performed to ensure that the abilities of each group are the same. so that the difference that occurs between the two groups at the end of learning is caused by differences in the treatment given. Average t-test results indicate that t_{obs} = 1,245 < t_{tab} = 1,973 it is considered that H_0 is accepted. thus it was concluded that both groups had the same ability before the treatment was given.

4.1. Mathematics Communication Skill Result

The results of the problem communication skills test by giving 5 essay test items containing non-routine problems can be seen in Table 3.

Table 3: Description of Math Communication Score

Groups	*Score test*				
	N	$\bar{X}$	*sd*	*Score max*	*Score min*
Experimental Group	91	70,242	15,975	95	25
Control Group	96	51,198	18,435	90	15

Based on the summary of the results of the test scores above, then the average t-test is performed, the following results are obtained in Table 4.

Table 4: Summary of T-test

Group	*n*	$\bar{X}$	*Sd*	*Sp*	t_{obs}	t_{tab}
Experimental Group	91	70,242	15,975	17,282	7,532	1,649
Control Group	96	51,198	18,435			

In the Table 4, it can be seen that the results of the average comparison between the two groups obtained t_{obs} = 7,532 > 1,649 = t_{tab} so that the decision obtained by the H_0 test is rejected. Thus it can be concluded that students' mathematical communication skills that are subjected to open-ended student worksheets are better than students' mathematical communication skills that are subjected to student worksheets that have been used by teachers.

4.2. Observation Data on Mathematical Communication Skill Achievement Indicators

Indicators of achievement of mathematical communication skills are set as follows: 1) Rareness of answers, 2) Clarity of delivery, 3) accuracy of the use of mathematical language, 4) use of non-routine procedures, 5) Appropriate conclusions of answers. Observation data on the achievements of each indicator can be seen in Table 5.

Table 5: Observation Math Communication Data

Indicator	*Average Score*	
	Experimental Group	*Control Group*
Rareness of answers	75.206	56.497
Clarity of delivery	72.316	50.356
accuracy of the use of mathematical language	67.236	48.483

use of non-routine procedures	67.954	47.541
Appropriate conclusions of answers	68.514	53.109

Based on the data on the achievement score of the mathematical communication skills indicator as shown in the table above shows that the score of the achievement indicators of the groups that are subjected to open-ended student worksheets is better than the groups that are subjected to student worksheets that are commonly used by teachers. This shows that learning through discussion of solving non-routine problems in the experimental group can empower students' thinking potential so that they can express ideas and opinions in solving non-routine problems.

4.3. Content Analysis of Student Work Result

This research is a quasi-experimental research with the randomized static group comparison design. The study was conducted from September to October 2019. The research population was all 7th-grade junior high school (SMP) students in Purworejo Regency, Indonesia. Two groups are compared, namely groups that are subjected to open-ended student worksheets (experimental groups) and groups that are subjected to worksheets that are commonly used by teachers (comparison groups).

Analysis of the results of student work shows a very striking difference between groups that are subject to open-ended student worksheets and groups that are subject to student worksheets that are commonly used by teachers. in groups that are subjected to open-ended student worksheets showing the results of work that is coherent, easy to understand, and shows the existence of several different problem-solving procedures. This happens because students are accustomed to expressing ideas of problem-solving and writing them down with other students' corrections during the discussion.

In groups that are subjected to student worksheets that are commonly used by teachers, students tend to answer carelessly. Some even only write down the final result without a description of the settlement procedure. Students in this group tend to use the same problem-solving procedures. Even in 1 class only found 1 type of problem-solving procedure. This happens because there is a habit for students to follow what was exemplified by the teacher before. On the one hand, the teacher also does not try to solve a problem with a variety of solving procedures. The percentage of many students who use problem-solving strategies can be seen in Table 6.

Table 6: Problem-Solving Strategies

Strategies	*Experimental Group*	*Control Group*
Algebraic Manipulation	35%	52%
Bar Model	26%	0%
Backward	19%	16%
Tables/ Graphic	12%	9%
Trial and error	8%	29%

Table 6 shows that the use of problem-solving strategies in the experimental class that is subjected to open-ended student worksheets is more even and diverse. Whereas in the control class almost half the

population uses only one strategy. This result clearly shows that the communication skills of students in the experimental group are better than the control group. The ideas conveyed during group discussions and whole-class discussions can be implemented by each student in solving new problems independently. A striking difference from the results of the work in the two groups is creativity. Creativity thinking to solve problems is very necessary for problem-solving activities. Thinking creativity can occur if a student can optimize all the potential that exists in him, including communication skills. Through proper communication empowerment, students can be encouraged to express and share ideas with others freely and without worrying so that they can make the right decision about a thing (in problem-solving activities). Confidence, learning motivation, and a feeling of equality of abilities developed during discussions in completing open-ended student worksheets have a positive influence on the creation of a comfortable and pleasant learning environment. This environment will make it easier for students to bring up all their potential thinking. The absence of efforts to encourage students to be creative would certainly be a negative impact that can not be avoided because communication skills are not considered during the learning process.

5. Discussion

The communication skills of students who were subjected to learning using open-ended student worksheets were better than the communication skills of students who were subjected to learning using student worksheets that are commonly used by teachers. This happens because with the use of open-ended student worksheets students are free to express their ideas and opinions verbally and in writing. The emergence of a variety of ideas is triggered by the characteristics of open-ended tasks that allow to be completed with erratic procedures. Thus, each student will be free to propose a completion strategy following what he understands. This is certainly different in the application of student worksheets that are commonly used by teachers. The worksheet only contains questions with procedures that are commonly exemplified by the teacher. Students are not challenged and it is not possible to solve them in different ways. Therefore, communication skills are not honed because of learning mechanically.

The results showed that the use of open-ended student worksheets in small group discussions by applying 4 steps: reasoning, expressing, writing, and for being able to improve mathematical communication skills. Giving open-ended problems in the form of non-routine problems allows the use of various problem-solving procedures. The discovery of various solving procedures can occur through group discussion activities. Students' habits in problem-solving activities through various non-procedural solution alternatives through discussion activities will help students achieve mathematical communication skills. Group discussion allows each student to try to get students to present their ideas and ask each other questions by taking on a more moderating role (Stein et al 2008). It is this habit of expressing ideas in a comfortable setting that encourages students to use these abilities on other occasions at different points, both individually and in groups. By regulating the social interactions that are generated in the classroom, communication enables the sharing of ideas and clarification of mathematical understanding (Viseu & Oliveira 2012, 288).

The use of open-ended problems in the form of student worksheets can encourage students to solve given

problems with a variety of problem-solving strategies. In this case, giving open-ended problems can encourage students to think creatively to produce a variety of problem-solving that is not procedural. Creativity in finding various strategies emerged as a result of the delivery of ideas and opinions from several students through discussion activities. The purpose of open-ended is to help develop creative activities and mathematical mindsets in problem-solving activities. Submitting ideas, both orally and in writing will help improve students' communication skills (Nohda 2000).

Open-ended student worksheets are one of the most effective strategies in the process of improving mathematical communication. Giving an open-ended student worksheet to a student discussion group will be more effective in improving mathematical communication. Open-ended and challenging tasks that build on students' prior knowledge are conducive to discussions because they encourage students to think collaboratively and build upon one another's ideas (Stein, Smith, Henningsen, & Silver 2000). Discussion is one of the active learning that should be able to provide equal opportunities for students to be actively involved in problem-solving activities. One aspect of taking students' ideas seriously is ensuring that their classmates attend to the ideas and work to understand them (Koellner, Jacobs, Pittman, & Borko 2005). Thus, a good discussion is a discussion that engages students actively and guarantees that no student will just listen. Thus, the process of communication through the delivery of ideas from each group member can occur.

The provision of open-ended problems has a great effect on the emergence of students' mathematical communication skills by producing various alternative solutions to problems. This can occur because the nature of open-ended problems that can present a variety of problem-solving strategies can be raised through discussion activities through the exchange of ideas. Each student in the group shares ideas and responds. The process of delivering ideas from students to students can be recorded by students in their memory so that it can be applied by students in solving other problems individually. Through discourse, students can elaborate, extend, and refine their thinking. As a result, students are learning mathematical content as well as habits of mind that will strengthen their mathematics problem-solving capabilities (Carley 2011). Thus, students' habits in conveying ideas and responding to ideas can make students able to improve their mathematical thinking skills so that they can solve problems in various ways.

Completing the open-ended student worksheet through discussion activities provides an opportunity for students who provide ideas to convey their ideas clearly to other students. This of course can help students in the communication process in the classroom. The open-ended assessment tasks ask students to show their solution processes and provide justifications for their answers (Cai, Jakabscin, & Lane 1996). In other words, the ability of students to explain problem-solving ideas can mean that students can communicate their ideas to others.

The results of this study also show that giving open-ended student worksheets through discussion activities can provide a great opportunity for students to convey all ideas both verbally and in writing. Mathematical communication skills by conveying ideas can increase understanding in depth of concepts so that they can be used for further problem-solving activities. The collaboration of ideas between students will create various alternative solutions to problems that can be applied to other problem contexts.

6. Conclusion

The results showed that the communication skills of students who were subjected to learning using open-ended student worksheets were better than the communication skills of students who were subjected to learning using student worksheets that are commonly used by teachers. These results provide an important impact that teachers should always integrate the presentation of non-routine problems in the form of worksheets as an integral part of mathematics learning.

Mathematical communication skills must be constantly improved so students can convey messages clearly to others, both verbally and in writing. Successful communication will overcome the obstacles of misunderstanding so that the problem-solving process can occur properly. Therefore, teachers should provide opportunities for students to express ideas, opinions, and reasons so that they are accustomed to thinking freely.

As a follow-up to this research, mathematical communication skills can be tested verbally or its application in other teaching materials. Research on mathematical communication more broadly will greatly assist the management of learning to provide appropriate skills for students in the future.

7. Acknowledgement

This research is part of the results of a dissertation study at the Faculty of Teacher Training and Education, Sebelas Maret University Surakarta, Indonesia. Thank you to the promoters, the teachers involved during data collection at school, and colleagues who participated in the development of research instruments for their help and contribution so that research can run well.

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