Preliminary analysis on development of mathematics learning tools based on indicators of mathematical communication skills

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Abstract. The research is aimed to describe data of preliminary analysis on development of mathematics learning tools based on indicators of mathematical communication skills. Mathematical communication skills of senior high school students are still low. Therefore, the research intends to develop learning tools with RME approach by concentrating on redesigning students’ worksheet. This research is a qualitative research because the main data signifies the result of tests of mathematical communication skills. The result of research indicate that the students’ mathematical communication skills based on indicators were still weak and the mathematics learning tools that will be developed contains teaching-learning approach that will help students improving their mathematical communication skills.

1. Introduction
Mathematics is a universal science that is useful for human life as well as fundamental knowledge in developing modern science and technology. Mathematics has an important role in various disciplines to improve and develop human thought power [1]. The efforts to advance human thinking require the extension of practical mathematical abilities or mathematical skills. Currently, the majority of mathematics learning is dominated by mathematical calculations activities rather than mathematical thinking. As [2] confirms that many children are trained to do mathematical calculations rather than being educated to think mathematically. This condition results in teaching-learning process that is uncorrelated to the purposes of mathematics learning.

Quoted from [1], the goals of mathematics learning are:
“Students are expected to be able to communicate ideas, reasoning and be able to compile mathematical evidence using complete sentences, symbols, tables, diagrams, or other representations to clarify the situation or problem. Indicators for achieving this skill include: (a) Giving reasons or proof of the truth of a statement; (b) Estimating and examining conjecture; (c) Checking the validity or truth of an argument with inductive or deductive reasoning; and (d) Decreasing or proving the formula with deductive reasoning.”

Based on this mathematics educational guideline, successful teaching-learning are specified by indicators of mathematical communication. The mathematical communication indicators designated in this article are; (1) Expressing daily events into a language or mathematical symbol; (2) Connecting real objects, images, and diagrams into mathematical ideas, and (3) Explaining ideas, situations and mathematical relations verbally or in writing, with real objects, images, graphics, and algebra. Other
indicators of mathematical communication skills are [3]: (1) Reflecting and explaining students' thinking about mathematical ideas and relationships; (2) Formulating mathematical definitions and generalizing through discovery methods; (3) Declaring mathematical ideas both in spoken and written; (4) Reading mathematical discourse with understanding; (5) Clarifying and extending questions to the mathematics being learned; and (6) Appreciating the beauty and power of mathematical notation and its role in developing mathematical ideas.

Meanwhile, [4] formulates the extended version of mathematical communication. They are: (1) Organizing and combining mathematical thinking, encouraging learning new concepts by drawing objects, using diagrams, writing, and using mathematical symbols; (2) Communicating mathematical thinking logically and clearly to make it understandable; (3) Analyzing and evaluating mathematical thinking and other strategies, exploring other options and strategies in problem solving; and (4) Using mathematical language to express ideas correctly.

Mathematical communication ability is one of the most important points in the process of learning mathematics [5]. In addition to the significance of mathematical communication skills, mathematics learning basically sharpens students’ logical thinking through improving student’s mathematical communication skills [6]. Math is given to all students without exception to be trained to think logically, analytically, systematically, and creatively. Mathematics is a symbolic language in which everyone who learns math is required to have the ability to communicate by using the symbol language. As [7] states that problem will arise if the response given by the students is not in accordance with what is expected by the teacher, it causes the students need to get used to learn to communicate the idea. Thus, the mathematical communication skills are the ability to convey ideas or thoughts or messages or mathematical information from someone (informant) to others (communicants) so that both parties (informant and communicants) have the same perception or meaning to the contents of the mathematical message being delivered.

Based on the observations in some schools in the city of Padang on the students of Grade X, namely SMA Negeri 1 Padang (29 students), SMA Negeri 2 Padang (31 students), and SMA Negeri 10 Padang (29 students) in October-November 2018, generally, it is discovered that mathematics teaching-learning process performed by teachers to students is unable to support students’ mathematical communication skills. It is clarified by the teacher in the field of mathematics studies that in fact, it is hard for students to explain the lessons they have learnt, and to understand the problem in the story-formed questions. Therefore, this is the groundwork for the researcher to conduct mathematical communication skills test to determine the mathematical skills the students possess.

The mathematical communication skills that students’ have based on the test show that it is still weak and mathematics learning that has been going on so far has not been optimal in shaping students' mathematical abilities. Therefore, the researcher carries out some analysis at the preliminary research phase. Based on this background, the purpose of this research is to describe data of preliminary analysis on development of mathematics learning tools based on indicators of mathematical communication skills.

2. Materials and Methods
Plomp model has been used by many researchers in the development of mathematics learning tools, for example see [8]–[11]. Based on a development study using Plomps’ model, this introductory stage consist of three phases, namely preliminary research phase, development or prototyping phase, and assessment phase [12]. The preliminary research phase consists of four analyses; there are prerequisite analysis, curriculum analysis, concept analysis and students’ analysis. This article describes the results of each phase.

Prerequisite analysis is needed to obtain information on issues in the field of education. The purpose is to get information on existing problems and likely to require improvement and innovation. The instruments used are an observation sheet, interview guidelines, and test sheet for mathematical communication skills that includes indicators of mathematical communication skills.
Curriculum analysis is investigation to Curriculum 2013 applied at the schools, especially for the field mathematics subject in Xth grade SMA/MA. The instrument is Curriculum 2013 documentation as stated in annex number sixteen of [13] about Core Competencies (KI) and Basic Competences (KD) in order to achieve Graduate Competence Standard (SKL). SKL is criteria regarding qualifications graduates’ abilities that include attitudes, knowledge, and skills as mentioned in [14].

Concept analysis is conducted to rearrange or to reorganize details of KD into several indicators and compile what subject will be learned by students by applying Realistic Mathematics Education (RME) Approach. The instrument also uses Curriculum 2013 documentation and combined with RME approach. But in this paper, the researcher has arrived at the stage of developing indicators, while the application of RME will be applied to the development of mathematics learning tools to improve students' mathematical communication.

Students analysis is conducted to find out how the character of students. It is included about the opinion or students’ difficulty while learning mathematics, knowing how they academic ability grows, knowing the students’ opinion about LKPD (Students’ worksheet), and knowing how to learn what students like. The instruments in this students’ analysis are the students’ questionnaire sheets.

3. Results and Discussion
This section contains results of data in preliminary research phases. The findings of the preliminary research analysis are divided into the results of prerequisite analysis, curriculum analysis, concept analysis, and students’ analysis.

The results of prerequisite analysis show that mathematics learning does not support students’ mathematical communication skills. This is based on the outcome of observations (teaching and learning tools) informed by the teacher. Based on the mathematical communication skill test, it can be seen in Table 1, Table 2, and Table 3 on the results of test.

Table 1. Test Results of 1st and 2nd Mathematical Skills Test of SMAN 1 Padang

| Indicator | 1st Test | Scale of 4 | Scale of 100 | 2nd Test | Scale of 4 | Scale of 100 |
|-----------|----------|------------|--------------|----------|------------|--------------|
| Score     | 0 1 2 3 4| 3.62 90.52 | 0 1 0 0 28  | 3.90 97.41| 0 1 0 6 22  | 3.66 91.38  |
| 1st Test  | 1.61 40.30| 2nd Test Average | 1.92 48.06 |          |            |              |


The students write it.

The teacher gives an exercise that is almost similar to the example problem, and so on. Furthermore, students show attention. Then the teacher gives an example while the students pay attention. After that, the teacher gives an exercise that is almost similar to the example problem, and so on. Furthermore, students show communication skills since normally it is showed that teacher teaches the lesson and the students pay attention. Then the teacher gives an example while the students pay attention. After that, the teacher gives an exercise that is almost similar to the example problem, and so on. Furthermore, students show communication skills since normally it is showed that teacher teaches the lesson and the students pay attention. Then the teacher gives an example while the students write it.

It is obtained that mathematical communication skills of Xth grade from three senior high schools are still low. It has become the basis for the researcher to develop learning tools for the next research that will help improving students’ mathematical communication skills. From Table 3, it is seen that the third indicator of the second test of SMAN 10 Padang cannot be achieved because no students filled out the questions for the indicator. Besides, the average achievement of indicators for scale 4 is still in the range of 1 decimal which confirms that the result of test of mathematical communication skill is far from satisfaction. In addition, the results of observations with the teacher include the detail that students are still having difficulty changing the story-formed questions into mathematical models.

Moreover, the results of curriculum analysis are the analysis to the formulation of indicators of achievement of the competence of the subject matter listed in the syllabus. No change in Ki and KD has been established, but there is a change in the formulation of the indicator form in the subject matter. The last one is the indicator of subject matter of teaching materials that will be given only in odd semester.

The results of concepts analysis are the subjects or concepts needed in the lesson are then arranged in the form of concept maps based on RME approach. But in this paper, the researcher only shares about indicator of KD which has been observed into several indicators to develop KD of achievement of competence. The formulation of the indicator form in the subject matter is shown in Table 4.

Finally, the result of students’ analysis in general is that the students need to use the students’ worksheet in learning process to improve their mathematical communication skills. The students’ worksheet is known as LKPD. Based on the information gained related to the description of mathematics learning, class activities did not yet show students learning mathematical communication skills since normally it is showed that teacher teaches the lesson and the students pay attention. Then the teacher gives an example while the students write it down. After that, the teacher gives an exercise that is almost similar to the example problem, and so on. Furthermore, students show that they like learning mathematics in groups.

Table 2. Test Results of 1st and 2nd Mathematical Skills Test of SMAN 2 Padang

| Indicator | 1st Test | 2nd Test |
|-----------|----------|----------|
|           | Score    | Scale of 4 | Scale of 100 | Score    | Scale of 4 | Scale of 100 |
| 1         | 0 1 0 1 0 30 | 3.94 | 98.39 | 2 1 0 1 27 | 3.61 | 90.32 |
| 2         | 19 12 0 0 0 0 | 0.39 | 9.68 | 18 0 0 8 5 | 1.42 | 35.48 |
| 3         | 10 9 3 9 0 1 | 1.35 | 33.87 | 25 1 0 2 3 | 0.61 | 15.32 |
| 1st Test Average | 1.42 | 35.48 | 2nd Test Average | 1.41 | 35.28 |

Table 3. Test Results of 1st and 2nd Mathematical Skills Test of SMAN 10 Padang

| Indicator | 1st Test | 2nd Test |
|-----------|----------|----------|
|           | Score    | Scale of 4 | Scale of 100 | Score    | Scale of 4 | Scale of 100 |
| 1         | 4 5 17 0 3 | 1.76 | 43.97 | 0 0 3 2 24 | 3.72 | 93.10 |
| 2         | 7 5 14 0 3 | 1.55 | 38.79 | 14 1 2 12 0 | 1.41 | 35.34 |
| 3         | 17 6 4 2 0 | 0.69 | 17.24 | 29 0 0 0 0 | 0.00 | 0.00 |
| 1st Test Average | 1.00 | 25.00 | 2nd Test Average | 1.28 | 32.11 |

It is obtained that mathematical communication skills of Xth grade from three senior high schools are still low. It has become the basis for the researcher to develop learning tools for the next research that will help improving students’ mathematical communication skills. From Table 3, it is seen that the third indicator of the second test of SMAN 10 Padang cannot be achieved because no students filled out the questions for the indicator. Besides, the average achievement of indicators for scale 4 is still in the range of 1 decimal which confirms that the result of test of mathematical communication skill is far from satisfaction. In addition, the results of observations with the teacher include the detail that students are still having difficulty changing the story-formed questions into mathematical models.

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### Table 4. Formulation of Indicators of KD for Grade X SMA/MA

| KD | Indicators on Syllabus | New Structure Indicators |
|----|------------------------|--------------------------|
| 3.1 Interpret the equations and inequalities of absolute values of linear forms of single variable with other linear algebraic equations and inequalities. | 3.1.1 Describe the concept of absolute value.  
3.1.2 Arrange equations for linear absolute values of single variable.  
3.1.3 Solving the equation for an absolute linear value of single variable.  
3.1.4 Arrange inequalities of linear absolute values of single variable.  
3.1.5 Complete the inequality of linear absolute values of single variable. | 3.1.1 Express the definition of absolute value.  
3.1.2 Declare the concept of the absolute value of a single variable linear form.  
3.1.3 Express the concept of the inequality of absolute values of single variable linear form.  
3.1.4 Drawing sketches of the equations of absolute values of a single variable linear form.  
3.1.5 Make a number line inequality of the absolute value of a single variable linear form.  
3.1.6 Determining the completion of an absolute linear value equation of single variable using the absolute value definition.  
3.1.7 Determining the completion of an absolute single variable absolute value equation using the properties $|x| = \sqrt{x^2}$.  
3.1.8 Using the properties of the inequalities of one linear variable absolute value.  
3.1.9 Determine the completion of a single variable absolute value inequality. |
| 4.1 Resolve problems related to equations and inequalities of absolute values of linear forms of single variable. | 4.1.1 Resolve contextual problems related to absolute values.  
4.1.2 Resolve contextual problems related to the equality of absolute values.  
4.1.3 Resolve contextual problems relating to inequalities of absolute value. | 4.1.1 Creating a mathematical model of contextual problems related to the equation of absolute values of a single variable linear form.  
4.1.2 Resolve contextual problems related to the equation of absolute values of a single variable linear form.  
4.1.3 Create a mathematical model of a contextual problem that is related to the inequality of absolute values of a single variable linear form.  
4.1.4 Resolve contextual problems related to the inequality of absolute values of a linear form of single variable. |
4. Conclusion
Based on the preliminary research phase that has been done, it can be concluded that the students’ mathematical communication skills based on indicators of math communication were still weak and in the mathematics learning tools that will be developed contains learning approach that will help student to improve mathematical communication skills.

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