The development of mathematical learning devices based on model-eliciting activities and GeoGebra

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Abstract. This research aims to produce learning devices in the form of lesson plan (RPP) and students worksheet (LKPD) based on Model-Eliciting Activities and GeoGebra (MEA & GEO) to promote students’ mathematical communication skills. The development model used is a Plomp model. The research data was collected through questionnaires, observation sheets, mathematical communication skills test, and interviews. The results showed that the learning devices based on MEA & GEO are valid, practical, and effective categories.

1. Introduction

Indonesian students’ mathematical abilities in all level of education have not been satisfactory [1-6], some of them are mathematical reasoning ability [7,8] and mathematical communication ability [3]. In learning mathematics communication becomes very important, even communication is one of the abilities set by the National Council of Teachers of Mathematics (NCTM) as a standard process that must be owned by students [9]. The survey at Junior High School (SMP) 1 Rambatan, Tanah Datar West Sumatra show that many students have difficulties in solve the mathematical communication skills test (see Figure 1, 2, and 3).

Problem 1

Draw point R (-3, 5) at the Cartesian coordinates and then draw 3 lines that intersect with the X-axis and Y-axis through the R point!

Figure 1. One example of students’ answer in Junior High School 1 Rambatan for problem 1

Based on the answers of students in Figure 1, it appears that students can already determine the location of point R, but students are still difficult to paint 3 lines that intersect with the X-axis and Y-axis through point R.

Problem 2
If the m line is parallel to the n line and both are perpendicular to the Y-axis, do the two lines have the same distance as the X-axis? Explain your solution!

Figure 2. One example of students’ answer in Junior High School 1 Rambatan for problem 2

From the answers of students in Figure 2, it appears that students have not been able to explain correctly, because not all m lines parallel to the n line which are both perpendicular to the Y-axis have the same distance as the X-axis. It depends on the position of the lines m and n on the Cartesian coordinates.

Problem 3

The picture above is an illustration of a river flow past several points in the Cartesian plane.

a. Mention 5 coordinates of the points traversed by the river flow

b. Mention the points that are passed by the river that are in quadrant I, quadrant II, quadrant III, and quadrant IV

Figure 3. One example of students’ answer in Junior High School 1 Rambatan for problem 3

From the answers of students in Figure 3, it appears that students are still unable to interpret the coordinates of each point in the problem, then students also have difficulty in classifying any points in quadrants I, quadrant II, quadrant III, and quadrant IV.

Based on the test results about the communication skills it is seen that the mathematical communication skills of students are still not optimal, students are still less able to apply the concepts of learning when given practice. In addition, there are no special learning devices available that can facilitate students’ mathematical communication skills. Responding to the low mathematical communication skills of students, the teacher as one of the success factors in seeking to improve the quality of education. Among them by developing innovative and quality learning devices to improve students' mathematical communication skills.

Prastowo [9] state that the interesting and innovative teaching material can have a big influence in the learning process, for example student worksheet (LKPD) and lesson plan (RPP), where the lesson plan used as a guide in learning. In mathematics learning activities, especially for junior high school age students, concrete things that are needed to help them understand learning include using
Information and Communication Technology (ICT) GeoGebra is one ICT teaching aids that can improve communication skills [10-12].

Learning devices that are developed based on an approach that can activate students in building the knowledge they have and are student-centered, one of which is the Model-Eliciting Activities (MEA) approach. MEA is one approach where activities direct students to mathematical modeling or MEA is an approach to understanding, explaining, and communicating that concept contained in problems given by modeling [13-17]. The harmony of mathematical communication skills, MEA, and GeoGebra are both able to produce mathematical models that are supported by research results that have been done by previous researchers who stated that MEA can improve mastery of concepts, communication skills, critical and creative thinking skills [18-21].

2. Materials and Method
The type of research used were research and development. This research was conducted at SMP negeri 1 Rambat Academic Year 2019/2020 with the subjects of class viii. The development model used is Plomp model that has three development stages (1) Preliminary Research, (2) Prototyping Phase, (3) Assessment Phase [22]. Many researcher has been used Plomp model in development of learning material ([23-29]). Data collection techniques using research instruments in the form of questionnaires, observation sheets, interview guides and mathematical communication skills test. The data obtained in the form of qualitative and quantitative data.

The practicality sheet assessment uses the rating scale calculation scale format. Rating scale is a way of collecting data in which the data obtained in the form of numbers are then interpreted in a qualitative sense. This type of rating scale is considered the simplest form and its administration [30, 31]). The following was the formula for calculating product validity and practicality (K). The product is valid or practice if K > 60% [32].

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K = \text{Validity/ practicality level} = \frac{\text{Score}}{\text{Total Score}} \times 100\%,
\]

The effectiveness of the use learning devices based on MEA & GEO by looking at the extent to which these learning devices can help achieve students' mathematical communication skills. Communication ability is assessed by referring to the rubric for assessing students' mathematical communication skills. Based on the score the communication skills test, the learning device said to be effective if the students are complete ≥ 66%.

3. Results and Discussion
The initial step of the prototyping phase is designing learning devices in the form of LKPD and RPP based on MEA & GEO. RPP and LKPD are designed to include components of the MEA approach, GeoGebra, and the characteristics of RPP and LKPD. The prototype I of RPP and LKPD have been validated by five validator and the results presented in Table 1.

| Learning Device | Percentage % | Criteria |
|-----------------|--------------|----------|
| RPP             | 87%          | Very Valid |
| LKPD            | 82.5%        | Very Valid |

Table 1. The results of experts review on RPP and LKPD based on MEA & GEO

Based on expert review suggestions, the RPP and LKPD is revised and then the one to one evaluation is carried out.

The one to one evaluation stage is conducted outside of class hours so as not to disrupt the activities of students in the learning process. The subjects in this study were 3 students with high ability, medium and low. One to one evaluation activity was conducted 6 times. In the initial stages of the constraints that occur when students write the formula of the flat area they describe, but to ensure
the answers given the students are asked to follow the steps of the geogebra that has been provided. In addition, students are still rigid in using geogebra applications, but they can slowly use and find solutions to their problems. In students worksheet also found errors in the relationship between the beam volume table and the volume of the triangular prism, which makes students confused and difficult to solve. This error was revised. Based on observations at this stage it can be concluded that LKPD can be used, easy to understand and do despite some slight improvements. After being revised based on the results of one to one evaluation, the small group stage is carried out.

The small group stage is carried out at school, but outside school hours. Research subjects were 6 students who were divided into 2 groups with high, medium and low abilities. The selection of students is done by the subject teacher concerned. Activities carried out as many as 6 meetings that learn in class. Where at this stage also seen the implementation of lesson plans in learning observed by the observer. From the small group activities carried out there are not many obstacles and it appears that students are accustomed to learning activities to discuss, present the results of their group work, and provide feedback to the presenter group. The time allocation is in accordance with the stipulated lesson plan. The results of exercises done by students show that there is an increase in mathematical communication skills of each student. Overall the learning process very well.

| Table 2. The results of observation on RPP implementation at the Small Group Stage |
|------------------------------|----------------|----------------|
| Rated Aspect                | Percentage % | Criteria       |
| Preliminary Activities      | 91.75         | Very Practical |
| Core Activities             | 86.75         | Very Practical |
| Closing Activities          | 81.25         | Very Practical |
| Average                     | 86.58         | Very Practical |

| Table 3. The Results of Questionnaire Responses to LKPD at Small Group stage |
|------------------------------|----------------|----------------|
| Rated Aspect                  | Percentage % | Criteria       |
| Easy to Use                   | 86.1           | Very Practical |
| Time Efficient                | 87.75          | Very Practical |
| Attractiveness                | 88.5           | Very Practical |
| Easy to Understand           | 91.75          | Very Practical |
| Benefits of LKPD             | 93.25          | Very Practical |
| Average                      | 89.4           | Very Practical |

Based on Table 3, it can be seen that LKPD based on MEA & GEO for each aspect of the assessment are in the very practical category. The suggestions and input from teachers or students at this stage serve as material for revision, before the field test stage is carried out.

Field test was conducted in class viii.1 with 30 students. This stage was conducted to see the practicality and effectiveness of learning devices based on MEA & GEO. Learning activities using RPP and LKPD based on MEA & GEO are carried out through group learning. Learning activities carried out as many as 6 meetings held by researchers and mathematics teachers of SMP 1 Rambatan as observers. At the first meeting the students were still a lot of confusion in working on LKPD or using GeoGebra in learning, but over time for the next meeting students began to get used the GeoGebra. Students are able to present the results of their group work well to the front of the class. Mathematical communication skills of students have increased this can be seen from the results of the work on the given exercise. After participating in the learning, students are asked to fill in the practical response questionnaire, the result presented in Table 4.

| Table 4. Results of Questionnaire Responses to LKPD at Field Test |
Based on Table 4, an average percentage of practicality was 93.5%. This means learning devices based on MEA & GEO meets the very practical category. The results of observations on the implementation of RPP in field test stage presented in Table 5.

| Rated aspect       | Percentage % | Criteria         |
|--------------------|--------------|------------------|
| Easy to Use        | 91.75        | Very Practical   |
| Time Efficient     | 95.75        | Very Practical   |
| Attractiveness     | 94.5         | Very Practical   |
| Easy to Understand | 93           | Very Practical   |
| Benefits of LKPD   | 92.5         | Very Practical   |
| Average            | 93.5         | Very Practical   |

Based on the Table 5, it can be concluded that the learning devices based on MEA & GEO are classified as very practical.

The effectiveness of learning devices based on MEA & GEO can be seen from the score of communication ability test. Based on that score, it was found that 23 people out of 30 students were completed with a percentage of completeness of 76.6%. If seen from the percentage of classical completeness ≥ 66 %, mathematical communication skills of students have met the criteria for success in mathematical communication ability tests. Thus, it can be concluded that the learning devices based on MEA & GEO are effective for improving students' mathematical communication skills.

Why learning devices based on MEA & GEO can improve mathematical communication skills? There are at least three answers to this question. First, learning devices (RPP and LKPD) based on MEA & GEO has fulfilled valid criteria, this means the contents of RPP and LKPD are already in accordance with the Indonesian mathematics syllabus of class viii junior high school and student activity during the learning process is in accordance with the syntax MEAs [23]. Second, Learning Devices (RPP and LKPD) based on MEA & GEO has fulfilled practical criteria, this means RPP and LKPD have been able to assist students in understanding mathematics materials and have helped teachers teach mathematics to make it easier for students to understand. Third, learning Devices (RPP and LKPD) based on MEA & GEO has fulfilled effective criteria, this means RPP and LKPD have a positive impact on improving students' mathematical communication skills.

4. Conclusion
The conclusion are: (1) learning devices (RPP and LKPD) based on MEA & GEO has meet valid criteria, (2) learning devices (RPP and LKPD) based on MEA & GEO has meet practical criteria, (3) learning devices (RPP and LKPD) based on MEA & GEO has meet effective criteria.

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