The mathematics learning based on realistic mathematics to improve the mathematical representation ability in elementary school

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Abstract. The ability of mathematical representation is one of the crucial aspects for students. However, the learning materials for elementary school students was limited. This study aimed to examine the effectiveness of mathematics learning materials based on the realistic mathematics approach to improve the representation ability of elementary students. This research was conducted by developing learning material that is valid, practical, and effective. This paper only discussed the results of the effectiveness test. Participants of this study were 20 students at Year 5 from one of primary school at Banda Aceh, Indonesia. The research instrument in this study was a test of students' mathematical representation abilities. The results showed that 1) the average score of student on-task activities is accounted for 90.06%; 2) the average activity of students shows above 90%; 3) there is an increase in the tendency of formative test scores at each meeting; 4) more than 50% of students give a positive response to the teaching-learning materials developed; and 5) the teacher provides a positive response to the teaching-learning materials developed. Since the developed learning materials satisfied 5 of the 6 effectiveness indicators, then the learning materials developed using realistic mathematics approach meet the effectiveness criteria.

1. Introduction

One of the mathematical abilities that need to be mastered by students is the ability of representation. There are several reasons which underline the representation capabilities, namely the basic ability to build concepts and to think mathematically and to solve problems. Representation is a form of interpretation of students' thinking about a problem that is used as a tool in finding solutions to these problems. The form of representation that arises from each student is totally different. It can be in the form of words, writings, pictures, tables, graphs, mathematical symbols and so on according to the ability of the student. Mathematical representation is very important because students are able to organize their thoughts when solving problems or questions. The ability of representation can also support students in understanding the mathematical concepts and its relevance to communicate or apply mathematical ideas in realistic mathematical problems through modelling [1-3]. Representation is an important element in the theory of mathematics teaching and learning because it has an important role in conceptualizing the real life [4]. Mathematics is abstract ideas, so that representation is highly recommended to solve mathematical problems in changing abstract ideas into real concepts.
Based on preliminary research, the researcher found that the mathematical representation ability of the students at elementary school in Banda Aceh, Indonesia were still lacking. The low ability of students’ representation was found in geometry topics, especially in the topic of plane geometry. This finding indicates that teachers need to give more effort and hard work to prepare mathematics problems in the form of mathematical representation and continue to train students to work on the question independently.

One of learning approach that can be applied to improve the ability of mathematical representation is the Realistic Mathematics approach (RME). One of the characteristics of the Realistic Mathematics approach is building mathematics through models (progressive mathematics). The use of the model functions as a bridge from a concrete level of mathematical knowledge to formal mathematical knowledge. In the Realistic Mathematics approach, there is a learning trajectory that must be designed by the teacher in mathematics learning. This learning trajectory describes mathematics as not ready-made, but as an acted-out. In the Realistic Mathematics approach, the learning trajectory starts from real problems, informal solutions of real problems (in the form of models/images-sketches/patterns), higher/wider/complicated mathematical abilities such as formulas, understandings and algorithms [4].

Several studies related to the Realistic Mathematics approach and the ability of representation in elementary schools has been carried out by several researchers, i.e., the research in the topic of rational number [5], in the topic of plane geometry [6], in integers [7], in solid geometry [8]. However, the review of previous studies shows that no research that have applied the Realistic Mathematics approach in geometry topic related to the mathematical representation skills of elementary school students. Therefore, it is necessary to develop an effective teaching-learning material. The research problem in this study is, "How is the effectiveness of teaching-learning materials that use the realistic mathematics approach to improve students' mathematical representation skills?"

2. Method
This research was design research describing the effectiveness of the teaching-learning materials (TLM) developed referring to Plomp’s model, and it consisted of three stages including preliminary research phase, prototyping phase and the assessment phase [9]. According to the development stages of Plomp, the TLM developed should be valid, practical, and effective. The subjects in this study were 20 Year 5 students from one of primary school in Banda Aceh. The selection of this subject is based on the consideration of the needs analysis results.

This paper only discussed the results of the effectiveness test of RME teaching-learning materials. In order to be effective, the instruments should fulfil five out of the following six effectiveness indicators: (1) the average of students’ answer on the worksheet should be at least 90%, (2) the average of students’ activities should be at least 90%, (3) the suitability level of the observed and expected student activities should be at least 80%, (4) there is an increasing trend of the formative test scores, (5) more than 50% of students provide a positive response on the learning instrument developed, and (6) the teachers provide a positive response on the TLM developed [10]. The research instruments used in this study were the students’ answer on the worksheet, students’ activities, formative test scores, students’ positive responses questionnaire, teacher responses questionnaire.

3. Results and discussion
Based on the effectiveness test of the teaching-learning materials following the indicators of effectiveness proposed by [10], the results are as follows.

3.1. The analysis of student answer on the worksheet
The results of students’ on-task activities were determined based on the scores of student worksheet from meeting I to IV. The developed student worksheets consisted of Worksheet 1, 2, 3, and 4. The students worked on the worksheets in groups. The students’ works were then analysed using the assessment rubric, one of the answer presented in Figure 1.
Figure 1. The answer of a group of students that got an excellent score.

Table 1 shows the analysis results of students' scores for the worksheet. Table 1 shows that the average scores for group III and IV are excellent, while the score for the group I and II are good. The overall score of the students is 90.06. The quality of student group collaboration kept increasing in each meeting, as evidenced by the increasing group scores in solving problems presented in the worksheet through the RME approach model from the first to the fourth lesson. Based on the overall mean score of the worksheet, students had been able to use and work on the worksheet developed very well. Thus, the analysis results of students’ on-task, as indicated by the group scores in each meeting, were achieved. The increasing scores on the worksheet were because students could easily understand the problems.

Table 1. Students’ worksheet score analysis

| No | Group | Worksheet 1 | Worksheet 2 | Worksheet 3 | Worksheet 4 | Mean Score | Criteria |
|----|-------|-------------|-------------|-------------|-------------|------------|----------|
| 1  | I     | 80          | 85          | 90          | 90          | 86.25      | Good     |
| 2  | II    | 85          | 90          | 80          | 95          | 87.50      | Good     |
| 3  | III   | 88          | 90          | 90          | 100         | 92         | Excellent|
| 4  | IV    | 100         | 95          | 88          | 95          | 94.5       | Excellent|
|    |       | Total Mean  | 90.06       |             |             |            | Good     |

3.2. The analysis of students’ activities
The observation of student activities aimed to investigate students' learning activities using the TLM developed. The observation data were gathered from two mathematics teachers. The data were analysed using descriptive analysis (percentage). Table 2 presents the analysis results of the observation data on students' activities.

The overall mean indicates that the students' activities during the learning steadily increased in each lesson; furthermore, each group's activities are categorized as excellent. On average, students' activities score in the group was more than 90% for each lesson. This means that student learning activities in the learning utilizing the developed instruments fall into the excellent category. The learning conducted with the RME teaching-learning materials can stimulate students to learn.
Table 2. The analysis results of the student’s activities.

| No | Group | Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Total Mean (%) |
|----|-------|----------|----------|----------|----------|----------------|
| 1  | I     | 88       | 94       | 91       | 92       | 90             | 92             | 94             |
| 2  | II    | 90       | 92       | 91       | 90       | 96             | 93             | 96             | 95             |
| 3  | III   | 92       | 94       | 94       | 96       | 100            | 98             | 93             | 100            | 96             |
| 4  | IV    | 95       | 88       | 92       | 88       | 96             | 92             | 88             | 94             | 92             |
| 5  |       |          |          |          |          | 92             | 94             | 95             | 100            |

3.3. The analysis of students' tendency to increasing formative test scores

The increasing of students' ability toward mathematical representation can be seen from the tendency of increasing formative test scores at each meeting by using the developed TLM after the learning process. Formative tests, which are in the form of homework, were given to students after each meeting. The results of the formative test analysis are presented in Table 3.

Table 3. The analysis results of formative tests in the form of homework.

| No | Name      | Score |
|----|-----------|-------|
|    |           | Homework 1 | Homework 2 | Homework 3 | Homework 4 |
| 1  | Student 1 | 80      | 80        | 85         | 90         |
| 2  | Student 2 | 70      | 85        | 75         | 80         |
| 3  | Student 3 | 80      | 90        | 85         | 100        |
| 4  | Student 4 | 80      | 95        | 90         | 80         |
| 5  | Student 5 | 70      | 85        | 85         | 85         |
| 6  | Student 6 | 70      | 75        | 90         | 80         |
| 7  | Student 7 | 90      | 85        | 95         | 100        |
| 8  | Student 8 | 80      | 65        | 75         | 100        |
| 9  | Student 9 | 70      | 85        | 90         | 85         |
| 10 | Student 10| 75      | 90        | 95         | 80         |
| 11 | Student 11| 80      | 85        | 75         | 80         |
| 12 | Student 12| 80      | 90        | 85         | 90         |
| 13 | Student 13| 70      | 95        | 95         | 85         |
| 14 | Student 14| 80      | 85        | 95         | 90         |
| 15 | Student 15| 75      | 75        | 90         | 85         |
| 16 | Student 16| 80      | 95        | 90         | 80         |
| 17 | Student 17| 85      | 65        | 85         | 90         |
| 18 | Student 18| 80      | 75        | 95         | 85         |
| 19 | Student 19| 80      | 90        | 80         | 100        |
| 20 | Student 20| 100     | 95        | 90         | 95         |

Mean: 78.75, 84.25, 87.25, 88.00

3.4. The analysis of students’ positive responses to the teaching-learning materials developed

Student responses are obtained from questionnaires given to students after the end of the learning process and filled by 20 students. The results of the students' responses to questionnaires are presented in tables 4 to 7.
Table 4. Percentage of students’ impressions of teaching-learning components

| No | Responded Aspects     | Frequency | Percentage |
|----|-----------------------|-----------|------------|
|    |                       | Happy     | Unhappy    | Happy | Unhappy |
| 1  | Learning Topics       | 19        | 1          | 95.0  | 5.0     |
| 2  | Worksheets            | 19        | 1          | 95.0  | 5.0     |
| 3  | Learning Atmosphere   | 18        | 2          | 90.0  | 10.0    |
| 4  | Teaching Method       | 18        | 2          | 90.0  | 10.0    |

Table 5. Percentage of students’ opinions of learning components

| No | Responded Aspects     | Frequency | Percentage |
|----|-----------------------|-----------|------------|
|    |                       | Recent    | Not Recent | Recent | Not Recent |
| 1  | Learning Topics       | 17        | 3          | 85.0  | 15.0     |
| 2  | Worksheets            | 20        | 0          | 100.0 | 0.0      |
| 3  | Learning Materials    | 19        | 1          | 95.0  | 5.0      |
| 4  | Teaching Method       | 18        | 2          | 90.0  | 10.0     |

Table 6. Percentage of students’ opinions of the language used in the worksheet.

| No | Responded Aspects | Frequency | Percentage |
|----|-------------------|-----------|------------|
|    |                   | Clear     | Unclear    | Clear | Unclear |
| 1  | Worksheets        | 18        | 2          | 90.0  | 10.0    |

Table 7. Percentage of students’ opinions about the display of TLM.

| No | Responded Aspects | Frequency | Percentage |
|----|-------------------|-----------|------------|
|    |                   | Clear     | Unclear    | Clear | Unclear |
| 1  | Worksheets        | 17        | 3          | 85.0  | 15.0    |

Table 4 to 7 indicates that more than 85% of students are happy with the learning components as the TLM used the Realistic Mathematics approach. In terms of the language used in the worksheets, 90% of students responded that the worksheets used clear language, 85% of the students agreed that the worksheets display is clear. Based on these results, it can be concluded that 50% of 20 students positively assessed the instruments developed.

3.5. The analysis of teacher responses to the learning instrument developed

Data from the teacher questionnaire concerned with the assessment of the Lesson Plan and student worksheet from the teachers' perspective. The data was obtained from two mathematics teachers and analysed using descriptive analysis (percentage). The data analysis of the teacher questionnaire showed that the assessment for lesson plan and student worksheet resulted at 82.28% and 85.50%, indicating that the teacher's assessment of the lesson plan and student worksheet were categorized as good. This finding suggests teachers' positive evaluation of the TLM developed.

After conducting mathematics learning using the developed TLM, it was concluded that based on the students’ and the observer’s assessment, the mean score of students’ answer on the worksheet exceeded 90%. Learning by using a realistic mathematics approach to make student activities lead to positive things related to paying attention, understanding learning material and making conclusion [11,12]. In addition, the scores concerning students’ representation skills test and students’ questionnaires related to the developed TLM increased and the observer provided positive responses for the TLM developed. It’s means that students respond positively to the learning developed using a realistic mathematics approach, student can pay attention to each process and connect between various representation [13,14]. Therefore, the TLM developed satisfied five out of six indicators of effectiveness. Furthermore, the aim of this
study, which was to improve students’ mathematical representation skills, has been fulfilled. Therefore, based on the criteria proposed by [10], it can be concluded that the developed TLM are effective.

4. Conclusion
The RME teaching-learning materials developed in this research satisfied the criteria of effectiveness as evidenced by: 1) The results of the average analysis of students’ answer on the worksheet is accounted for 90.06%; 2) The average activity of students shows above 90%; 3) There is an increase in the tendency of formative test scores at each meeting; 4) More than 50% of students give a positive response to the teaching-learning materials developed; and 5) The teacher gives a positive response to the teaching-learning materials developed.

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