Development of student worksheet to improve mathematical representation ability using realistic mathematics approach assisted by GeoGebra software

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Abstract. Nowadays, student worksheet is used with a lack of concern on students' mathematical representation ability. In fact, it is essential to encourage students to deliver their mathematical ideas in various ways for broader perspectives of mathematical problem-solving. This study aimed to generate a valid, practical, and effective student worksheet to improve students' mathematical representation ability with a Realistic Mathematics approach assisted by GeoGebra Software. The research is developmental research using the ADDIE model, which includes Analysis, Design, Development, Implementation, and Evaluation. The instruments used in this study included: assessment sheets (to measure the validity of the worksheet); student questionnaire; teacher questionnaire; observation sheets (to measure practicality of the worksheet implementation); and mathematical representation ability test (to measure the effectiveness of worksheet implementation). This study created a student worksheet for four meetings. The student worksheet met valid criteria, with an average score of 4.25. The practical criteria were indicated by student and teacher questionnaires, with an average of 4.25 and 4.4, respectively; and the learning implementation (81.72%). Furthermore, the learning material fulfilled the effectiveness criteria with the percentage of students' learning understanding was 85.71%.

1. Introduction
Mathematical representation ability is crucial for students to encourage them to convey their mathematical ideas in various ways so that they have a broader insight into mathematical problem-solving. The 2013 curriculum expects students to be able to present learning concepts in various models of mathematical representation, such as in symbols, tables, and diagrams, thus the problem becomes clearer [1]. These abilities are needed by students to help them adapt to working and community live [2]. If the students can use the representation skills appropriately on a problem, it is believed that the students’ mathematical thinking can be developed. The representation means translation of an idea or problem in a new model by modifying images and physical models into symbols, words, or sentences [3]. The representation ability helps students to expand mathematical ideas by describing and explaining important features in mathematics. The best initial step for students to learn concepts, skills, and postulates in mathematics is by organising students’ representation ability. Therefore, the teacher needs to develop students’ representation in the teaching and learning process so that the students can develop this ability.

One of the learning approaches that could foster students’ mathematical representation ability is a realistic approach. The primary characteristic of the realistic approach is to enable students to develop models of real situations and mathematical models to bridge the understanding and the use of...
instruments such as symbols, models, schemes, diagrams, and so on [4]. The characteristics of the realistic approach are in line with the concept of mathematical representation, namely: (1) students can abstract mathematical ideas or cognitive schemes through representation; (2) student can present a structured mathematical idea through images, symbols or patterns; (3) it can be used as knowledge of something that represents something else [5]. Based on the association of these characteristics, a realistic approach can help students to abstract mathematical ideas through images, symbols, or patterns so that students will have the representation ability. This means that students not only required to understand general mathematical concepts but also to communicate or apply mathematics confidently into symbols to clarify a situation or problem. The Realistic Mathematics approach can also be implemented at all educational level to improve students' mathematical representation skills [6].

The topic of solid geometry is very appropriate for contextual teaching [7]. In teaching geometry for junior high school students, a teacher should also pay attention to several aspects of mathematical standards and the expected ability of students in geometry. For example: visualising, imagining, and using geometric models in problem-solving, such as surface area and volume, using media to represent objects, problem-solving, and so on [8]. In reality, students find it challenging to solve problems related to solid geometry because they cannot imagine and distinguish the shape of the solid geometry sides. Besides, students also experience difficulty in explaining and distinguishing the elements of a solid geometry. They find it hard to solve problems related to the area and volume of the solid geometry. These problems need a solution because students require to understand and recognise the elements of solid geometry in solving problems related to this topic to bridge the idea of problem-solving with the concrete condition in the problem. Therefore, media is necessary so that students can describe and imagine the elements of solid geometry more clearly. One of the learning media that can provide a visual experience for students to interact with mathematical objects is mathematical software. In geometry, the software that can be utilised is GeoGebra. GeoGebra could be used to solve the problem, such as drawing geometric objects quickly and precisely [9]. This program can clearly describe the dots, lines, curves of a function, and plane geometry. The use of GeoGebra software could help students to represent mathematical problems [10,11].

Good learning media can increase the representation ability of students. The learning media are vital because through the learning media teacher will be easier to carry out the learning, while it will be more helpful for students in learning. One of the learning media that can be used is student worksheet. One of the media to use is student worksheet. Student worksheet contains tasks that must be done by students [12]. The use of student worksheet in learning can improve students' activity, and guide students to discover knowledge through their activities. The interview conducted by the researchers for several junior high school teachers indicated that the student worksheet used by teachers did not concern with the ability of students' mathematical representation. Most activities in the worksheet are ready-steps, formulas, and then questions that directly lead to answers, and less encourage students to build student representation skills.

Based on the above description, it is necessary to develop student worksheet of solid geometry using the RME approach, oriented to students’ mathematical representation ability, with GeoGebra. In this study, the developed student worksheet focused on the topic of a solid geometry.

2. Research Method
This research is design research. It aimed to develop student worksheet related to solid (geometry) to increase students' mathematical representation ability using the RME approach assisted by GeoGebra Software. This study used the ADDIE model, which includes five stages, namely: Analyse, Design, Development, Implementation, and Evaluation [13].

The analysis phase was the pre-planning stage, where the researchers thought about learning media that will be developed. This stage could be done by analysing the products that are suitable to the target students, analysing the curriculum, analysing the needs of students, and analysing the existing worksheet. The design phase was the stage of designing the worksheet to be compiled based on the results of curriculum analysis, needs analysis, and existing worksheet. The development stage was the stage of realising the product that had been designed at the design stage. After the product had been developed, a validity process by experts and mathematics teachers was needed to examine the validity.
aspects of the product. Revision of the product was also required after the validation process. The implementation stage was the testing phase of the developed student worksheet in the classroom situation. The implementation purpose was to test the quality of the product and to obtain data on practicality and effectiveness of the developed student worksheet. After the worksheet was tested, the evaluation phase was carried out to see the practicality and effectiveness of the worksheet and measure the achievement of the worksheet development, which was to improve student representation ability. The data could also be used as information to know where the students achieve results well.

The research instruments were used to measure the criteria of the developed products, including validity, practicality, and effectiveness. The instruments for measuring validity were prepared based on the feasibility aspects of the worksheet, namely the feasibility of content, language, display, and graphics. The instruments to measure practicality of the worksheet implementation were in the forms of teacher response questionnaires, student response questionnaires, and learning implementation observation sheets. However, the instrument to measure the effectiveness of the worksheet development was a paper-based test which refers to students' mathematical representation ability with description questions according to the competency indicators to achieve. Furthermore, the research participants were grade 8 students in Ulumul Quran Langsa, Islamic Junior High School. Year 8 students were selected because solid (geometry) was taught Year 8 in Indonesia. As for the school, Islamic Junior High School Ulumul Quran Langsa, it was chosen due to the adequate facilities available in the school such as the classroom; and the students' familiarity of technology.

The data analysis carried out in this study was in forms of validity, practicality, and effectiveness analysis. The validity analysis was the validity analysis of the worksheet conducted by four validators (two content experts, one learning expert, and one mathematics teacher). The analysis was performed using the following steps: (1) tabulation of data, (2) calculation of average scores, (3) conversion of average scores with guidelines as in Table 1. The learning media are valid if they at least meet the good criteria [14].

**Table 1. Classification of student worksheet assessments**

| Score Interval | Criteria    |
|----------------|-------------|
| $\bar{x}>4.20$ | Excellent   |
| $3.4<\bar{x} \leq 4.20$ | Good |
| $2.6<\bar{x} \leq 3.4$ | Fair |
| $1.8<\bar{x} \leq 2.6$ | Poor |
| $\bar{x} \leq 1.8$ | Very Poor |

Practical analysis in this study involved an analysis of student questionnaire, teacher questionnaires, and learning implementation observation sheets. Questionnaires for teacher and student responses were analysed using the same steps as the analysis of the instrument for evaluating the validity of the student worksheet. Whereas, the learning implementation observation sheet was analysed by several steps, including: (1) calculate the number of observers assessments who choose the "Yes" option for each positive statement or question and the number of "No" choices for negative statements or questions, (2) convert the average score into a qualitative value according to the practicality criteria in Table 2.

**Table 2. Practicality criteria of learning observation**

| Percentage of Involvement | Practicality |
|---------------------------|--------------|
| $0\leq n<21$              | Very Poor    |
| $21\leq n<41$             | Poor         |
| $41\leq n<61$             | Fair         |
| $61\leq n<81$             | Good         |
| $81\leq n<100$            | Excellent    |
The product is said to be practical if the minimum teacher response and the implementation of the product criteria are good.

Product effectiveness analysis used a paper-based test of students' mathematical representation ability. Test result analysis was carried out by the following steps: (1) determined the test results, (2) counted students who passed the test, (3) calculated the percentage of students who passed the test by using the following formula:

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\text{Percentage of students who passed the test (K)} = \frac{\text{Number of students who passed the test}}{\text{number of students in the class}} \times 100\%
\]

The next step was to categorise categories the percentage of students who passed the test based on the assessment of students’ academic achievement, as shown in Table 3[14]. The learning media are said to be effective if they meet at least good criteria.

| Percentage | Criteria        |
|------------|-----------------|
| K > 80     | Excellent       |
| 60 < K ≤ 80| Good            |
| 40 < K ≤ 60| Fair            |
| 20 < K ≤ 40| Poor            |
| K ≤ 20     | Very Poor       |

3. Results and Discussions
The learning instruments in this study was developed through five stages of ADDIE, including Analysis, Design, Development, Implementation and Evaluation. These stages enabled the researchers to examine the quality of learning instruments developed. The student worksheet developed was evaluated by four validators. They examined and provided scores related to the validity of the product developed. The researchers also used the comments and suggestions provided by the validators to revise the learning instrument developed. The assessment results of the four validators showed that the average score of the student worksheet was 4.25 from a maximum score of 5 with excellent criteria. Thus, the developed worksheet is valid since it has reached a minimum of good criteria. The result shows that the developed worksheet fulfils the feasibility aspects of teaching materials that are following Realistic Mathematics Approach to enhance students’ mathematical representation ability. The average score for each aspect of the worksheet assessment can be seen in Table 4.

In addition to the overall validity criteria, the validity of each aspect of the student worksheet can also be presented (see Table 4).

| No | Criteria        | Average | Classifications |
|----|-----------------|---------|-----------------|
| 1  | Content Validity| 4.25    | Excellent       |
| 2  | Context Validity| 4.5     | Excellent       |
| 3  | Language Validity| 4      | Good            |
|    | Average         | 4.25    | Excellent       |

Based on the assessment results of the experts, it can be concluded that the final product of the student workshop is valid, satisfying very good criteria. Student worksheet on the polyhedron topic (solid geometry with flat faces) had also been revised based on feedback or suggestions from experts. Based on the assessment of the experts, the final product of student worksheet using GeoGebra with
RME approach for students’ mathematical representation ability has satisfied the valid category (very good criteria).

The practicality of learning materials was measured based on the results of student response questionnaires, teacher response questionnaires, and learning implementation observation sheets. The analysis results of the teacher questionnaire, student questionnaire, and the learning implementation observation can be seen in Table 5, 6, and 7 accordingly.

**Table 5. Result of teacher response questionnaire**

| Criteria                                                  | Score |
|----------------------------------------------------------|-------|
| Clear instruction                                        | 5     |
| Ease of use                                              | 4     |
| Clear pictures/ illustration and guide students to find   | 4     |
| the Geometry formula by themselves                       |       |
| Time efficiency                                          | 4     |
| Achieved learning objectives                              | 5     |
| **Average**                                              | **4.4**|

**Table 6. Result of student response questionnaires**

| Aspects                                        | Score |
|-----------------------------------------------|-------|
| Fun in the learning process                   | 5     |
| Innovation in the learning process            | 4     |
| Interested in following the learning process  | 4     |
| Curiosity in the learning process             | 4     |
| **Average**                                   | **4.25**|

**Table 7. The average assessment of learning implementation**

| Learning implementation | Percentage of Implementation | Qualification |
|-------------------------|------------------------------|---------------|
| 1                       | 84.61%                       | Excellent     |
| 2                       | 80.76%                       | Good          |
| 3                       | 76.92%                       | Good          |
| 4                       | 84.61%                       | Excellent     |
| **Average**             | **81.72%**                   | **Excellent** |

Based on Table 5, teacher response to the worksheet that has been used in the learning process shows an average score of 4.4 from a maximum score of 5. This result indicates that the teacher response to the learning process using the worksheet developed in a highly practical category. The average result of the student response questionnaire was 4.25 from a maximum score of 5 with excellent qualifications. The result of the classroom observation represents that the average score of learning implementation was 81.72% with an excellent category. Based on the outcome of the student response questionnaire, teacher response questionnaire, and learning implementation observation sheet, the developed student worksheet is a practical learning material to improve students' mathematical representation ability with realistic mathematics education approach. The designed worksheet can be implemented and easy to use in the learning process.

The effectiveness of student worksheet in this study was reviewed from the results of students’ mathematical representation ability test. The test was conducted after the lesson had ended. The assessment of students’ mathematical representation ability was based on the representation indicators, and the assessment rubrics developed. The results of the test showed that 24 out of 28 students passed the test (85.71%), while the other four students did not pass the test (14.29%). Since there were more than 85% of students who passed the test, the learning objective has been achieved.
4. Conclusions
Based on the results and discussion of the study, it can be concluded that the development of student worksheet to improve students' mathematical representation skills using Realistic Mathematics approach assisted by GeoGebra Software is valid (excellent category). The worksheet is practical to use based on the analysis results of the student questionnaire, teacher questionnaire, and learning implementation observation sheets. The results indicate that the developed student worksheet can be well implemented and easy to use in learning. The student learning outcomes show that 24 out of 28 students passed the test (85.71%), whereas four students did not pass the test (14.29%). The students' test results indicate that the learning objective has been achieved since more than 85% of students passed the test.

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