Development of the Learning Instruction Based on Problem Based Learning Models Oriented with Mitigation of Mount Eruption and Lava Floods on the Mathematical Reasoning Ability of Class VIII Students of SMP / MTs

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Abstract. During 2019, the National Disaster Management Agency (BNPB) noted that there had been 3622 disasters in Indonesia, one of which was natural disasters such as volcanic eruptions and cold lava floods. In terms of volcanoes, Indonesia is the most active volcanoes location in the world and it have many tectonic plates that have the potential to cause volcanic eruptions, tsunamis, and earthquakes. Therefore, the Indonesia Government recommends providing education on natural disaster mitigation in schools. The goal of this study was to determine the mathematical reasoning abilities of students and the knowledge and attitudes of students towards mitigating natural disasters. This research is a development research, the development model used in this research is the Plomp model which consists of three phases, namely preliminary research, prototyping phase, and assessment phase. The instruments used during the research were observation sheets, interview guides, questionnaires, validation sheets for learning devices, and tests of students' mathematical reasoning abilities. From this research, it is proven that about 71.4% of MTsN 6 Agam students stated that there has been no learning about natural disaster mitigation. Based on the results of the mathematical reasoning ability test, there was an increase to 72.7% from the initial test result of 25.47%. Natural disaster mitigation knowledge does not have to be provided to students in specific subjects, but can be integrated into existing subjects, one of which is mathematics.

1. Introduction

The territory of the Unitary State of the Republic of Indonesia (NKRI) is a region that has uniqueness and distinctive features in the world. In terms of volcanoes, it is the location of the most active volcanoes in the world and is a meeting of tectonic plates in the world that has the potential to cause volcanic eruptions, earthquakes, and tsunamis. Indonesia has volcanic routes and is prone to eruptions along the ring of fire starting from Sumatra - Java - Bali - Nusa Tenggara - Sulawesi - Banda - Maluku - Papua [1]. Various natural disasters have occurred in Indonesia and continue to increase every year. Throughout 2019 the National Disaster Management Agency (BNPB) recorded 3622 disasters, including volcanic eruptions, flash floods, landslides, forest fires and many other natural events. The
natural disaster resulted in 475 deaths and 108 missing [2]. Natural disasters are natural events that can occur anywhere and anytime, which can cause material and immaterial losses to the lives of local communities [3]. There are still many people who do not have knowledge of natural disaster management.

To overcome this, knowledge about natural disaster mitigation needs to be provided to the community from an early age. It is better if natural disaster mitigation lessons are given through formal learning, especially at the SMP / MTs level. Children at the junior high school level are at a very rapid developmental age of cognitive, psychomotor, and affective aspects [4]. In line with the Government's program that knowledge about disasters is still lacking, learning about natural disaster mitigation is needed. It was quoted from Kompas.com that President Joko Widodo asked related ministries and institutions to improve community preparedness for disasters and knowledge of these natural disasters so that they could enter the content of the education system in Indonesia. This was said by the President in the Plenary Cabinet session at the State Palace, Jakarta, Monday (7/1/2019). Therefore, learning about natural disaster mitigation in schools is needed, considering that children's interactions occur more in school and the amount of knowledge that is gained in schools.

Natural disaster mitigation knowledge doesn't have to be provided in the form of special subjects, but can be integrated into existing subjects, such as mathematics. One of the studies that tries to integrate natural disaster mitigation into mathematics is trying to develop LUDO 3D-MB learning media for materials on flat-sided shapes. LUDO 3D-MB is a medium that can be an alternative for teachers in creative and innovative mathematics learning processes as well as introducing natural disaster mitigation. The name 3D-MB stands for 3 Dimensions-Disaster Mitigation and this medium is like a LUDO game. The components of LUDO 3D-MB consist of three fields, namely games, dice, and question cards. Based on the results of research conducted by Suwaibah et al, it can be concluded that the 3D-MB LUDO media is able to increase students' knowledge about natural disaster mitigation [5].

For other methods, there are no mathematics teaching materials regarding natural disaster mitigation in learning. For this reason, it is necessary to make teaching materials or learning tools that are more effective to increase students' knowledge of mitigating natural disasters. One of the alternatives for researchers to increase students' knowledge of natural disaster mitigation is to develop learning tools based on Problem Based Learning oriented to natural disaster mitigation. In its application, it can help students to find out about natural disaster mitigation.

The learning method in the Problem Based Learning model uses contextual problems as a media for students so that students can learn to think critically in solving problems that are aimed at obtaining essential knowledge or concepts from learning materials [6]. Meanwhile, according to Tan, Problem Based Learning is the use of various kinds of intelligence needed to confront real world challenges, the ability to face new situation and solving its complexity [7].

Nur in [8] states that the characteristics of Problem Based Learning (PBL) are focusing on interdisciplinary, authentic investigation, producing real work and showing it off, and collaboration. Meanwhile, according to [9], that "PBL is an instructional method that challenges students to learn, work together in groups to find solutions to real problems". This problem is used to link students' curiosity and analytical skills and initiative on the subject matter. Problem Based Learning prepares students to think critically and analytically to find and use appropriate learning resources [10].

Problem Based Learning is an innovation in learning because the thinking skills of students are really optimized through a systematic group or team work process, so that students can empower, hone, test, and develop their thinking skills on an ongoing basis. Then Problem Based Learning is also a learning that requires students to construct their own knowledge through problems.

From the description above, the researcher concluded that this Problem Based Learning-based model could help introduce natural disaster mitigation to students and was also able to increase students' insights about how to protect themselves from natural disasters. In the development of this device, there are several mathematical materials that can be used, one of which is the flat-sided shape.
This material is used because it is able to mitigate natural disasters such as volcanic eruptions and cold lava floods.

The material of the flat side room becomes important because it is often found in everyday life. The scope of this material includes blocks, cubes, prisms, and pyramids [11]. Although the material of flat-sided building is often found in everyday life, students are still not able to apply it in everyday life, one of the factors causing it is that students' understanding is still limited [12]. With the existence of learning tools based on the Problem Based Learning model, it is expected that students will be able to provide knowledge and insight regarding the use and application of flat-side space building material in everyday life and be able to improve students' mathematical abilities as well as an introduction to natural disaster mitigation.

2. Research Methods

This research is a development research used to produce certain products and test the validity, practicality, and effectiveness of these products [13]. The development model used in this research is the Plomp development model. According to [14], this development model consists of three stages, namely the preliminary research stage, the development or prototyping phase and the assessment phase. The activities carried out at the three stages are in the preliminary research or the initial investigation phase, the needs analysis, curriculum analysis, concept analysis and student analysis are carried out. Furthermore, in the development phase or making a prototype, learning device design, self evaluation, expert review, one to one evaluation, and small group evaluation are carried out. The next stage is the assessment phase. In the assessment phase, it was carried out by testing the practicality and testing the effectiveness of learning devices. Research procedures are research steps or strands of research activities that are presented specifically and chronologically [15].

The test subjects for this study were students of class VIII.3 MTsN 6 Agam. Product trials were conducted twice, namely the one to one evaluation stage and the small group evaluation. The data collected in this trial were in the form of observation sheets for the implementation of PBL-based lesson plans based on natural disaster mitigation towards students' mathematical reasoning abilities, practicality questionnaires and interview guides, and tests of mathematical reasoning abilities. The type of data used in this research is qualitative data and quantitative data. The instruments used were the instruments used in the initial investigation phase, the prototype development phase, and the assessment phase.

3. Results and Discussion

This research aims to develop and produce learning designs on the topic of flat-sided building based on Problem Based Learning (PBL) oriented to natural disaster mitigation to train mathematical reasoning skills and introduce natural disaster mitigation to students of class VIII SMP / MTs. In order for the PBL-based learning tools to be oriented towards natural disaster mitigation that meets valid, practical, and effective criteria, several development steps are carried out starting from the preliminary research stage, the prototyping stage, and the assessment stage. The preliminary research stage consists of needs analysis, curriculum analysis, concept analysis and student analysis. After obtaining the results at the preliminary research stage, then a self-evaluation is carried out, namely evaluating the learning tools that have been made and validating them by experts (expert review). After producing a valid Problem Based Learning-oriented learning tool for natural disaster mitigation, it is continued with the prototyping stage with the aim of seeing the practicality of the learning device. The stages consisted of one to one evaluation and small group evaluation for class VIII.3 MTsN 6 Agam students. The effectiveness is viewed from the mathematical reasoning abilities of students by looking at the final test results.

The initial investigation phase consists of four main steps, namely needs analysis, curriculum analysis, concept analysis, and student analysis. The purpose of the needs analysis phase is to see the conditions in the field related to the mathematics learning process in class VIII.3 MTsN 6 Agam and
obtain information about existing problems that may require improvement and innovation to obtain temporary characteristics of the product being developed. In the needs analysis, observations, interviews and questionnaires were distributed to obtain any information needed by students in improving the learning process. To be more certain about how the development of students' mathematical reasoning abilities, researchers also observed students' mathematical reasoning abilities by giving initial tests. The observation results obtained for students' mathematical reasoning abilities can be seen in Table 1 below.

Table 1. Percentage of Preliminary Test Results on Mathematical Reasoning Ability of Class VIII.3 Students of MTsN 6 Agam

| Indicator | Percentage of Score | Total |
|-----------|---------------------|-------|
| Ability to submit allegations | 1,2% 17,2% 6,4% | 24,8% |
| The ability to compile evidence, provide reasons, or proof of the correctness of a solution | 7,4% 27% 2,1% | 36,5% |
| The ability to draw conclusions from the statement | 3,7% 4,9% 6,5% | 15,1% |
| **Average** | | **25,47%** |

From the test results in Table 1, it can be seen that there is still a small percentage of students who get the ideal score. The mathematical reasoning ability of students represented by 3 indicators is still not optimal. The results of the analysis carried out showed that students needed innovation in the mathematics learning process in the form of new learning models besides learning so far, which could help students optimize students' mathematical reasoning abilities and from the overall questionnaire results it was concluded that students' knowledge about disaster response was still somewhat lacking, this is due to the absence of socialization regarding the importance of knowledge of natural disaster response. One of the efforts to overcome the problems in the learning process is to develop learning tools in the form of lesson plans and LKPD based on natural disaster mitigation oriented PBL that are designed in such a way as to improve students' mathematical reasoning skills and introduce how to respond to disasters to grade VIII SMP / MTs students.

Furthermore, curriculum analysis is carried out. The purpose of analyzing the curriculum is to find out whether the material taught is in accordance with the expected competencies. Curriculum analysis was carried out on curriculum 13 for mathematics class VIII SMP / MTs. The results of this curriculum analysis will be used to formulate indicators of learning achievement that will be used as guidelines in the development of PBL-based mathematics learning tools oriented to natural disaster mitigation to improve the mathematical reasoning abilities of students of class VIII SMP / MTs. Furthermore, a concept analysis was carried out. Concept analysis aims to determine the content and subject matter required in the development of learning tools. Based on the results of the analysis, it was found that teaching the topic of flat-sided building has not yet led students to use their reasoning skills in finding a concept and solving existing problems. Next is the analysis of students which aims to determine the characteristics of these students.

The second stage is the development phase or prototyping. The stages carried out in this phase are designing PBL-based learning tools oriented to mitigating natural disasters towards the mathematical reasoning abilities of students. At this stage, the RPP validation and LKPD validation are carried out. Overall the results of the RPP validation and can be seen in Table 2 below.
Table 2. Results of Overall Analysis of RPP Validity

| No | Aspects Assessed               | Validity Value | Category |
|----|--------------------------------|----------------|----------|
| 1  | Components of RPP              | 3.8            | Valid    |
| 2  | Identity of RPP                | 3.8            | Valid    |
| 3  | Competency Achievement Indicators | 3.8          | Valid    |
| 4  | Learning Objectives            | 3.8            | Valid    |
| 5  | Teaching Material              | 3.8            | Valid    |
| 6  | Learning Strategies            | 3.8            | Valid    |
| 7  | Learning Steps                 | 3.8            | Valid    |
| 8  | Learning Resources             | 3.8            | Valid    |
| 9  | Assessment                     | 3.8            | Valid    |
| 10 | Language and Writing           | 3.8            | Valid    |
| 11 | Benefit of RPP                 | 3.8            | Valid    |
|    | **Validity Average**           | **3.8**        | **Valid**|

Based on Table 2, it can be stated that the lesson plan based on natural disaster mitigation oriented towards the mathematical reasoning abilities of students developed is valid in terms of content and construct so that it can be used by teachers in the learning process. Overall the results of the LKPD validation and can be seen in Table 3 below.

Table 3. Results of the Overall Validity Analysis of LKPD

| No | Aspects of Validation      | Validity Value | Category |
|----|-----------------------------|----------------|----------|
| 1  | Content and presentation    | 3.67           | Valid    |
| 2  | Languages                   | 3.83           | Valid    |
| 3  | Graphics and display        | 3.29           | Valid    |
|    | **Average value of validity** | **3.6**        | **Valid**|

Based on Table 3, PBL-based LKPD is oriented towards natural disaster mitigation towards students' mathematical reasoning abilities which are designed to be valid in assessing didactic aspects, linguistic aspects and graphic aspects with an average validity index of 3.6. It can be concluded that the PBL-based LKPD is oriented towards natural disaster mitigation towards students' mathematical reasoning abilities that meet the "Valid" criteria.

A learning device is said to be practical if the device is easy to use by teachers and students in the learning process. Practical PBL-based learning tools are oriented towards natural disaster mitigation. The results of the one-to-one student response questionnaire analysis can be seen in Table 4 below.
Table 4. Average Overall Results Percentage of One-to-One Student Response Questionnaire Analysis

| No | Aspects Assessed       | (%)  | Average Practicality | Category |
|----|------------------------|------|----------------------|----------|
|    |                        | R    | S                    | T        |
| 1  | Ease of Use            | 21   | 23                   | 22       | 79%      | Practical |
| 2  | Time efficiency        | 3    | 3                    | 4        | 83%      | Practical |
| 3  | Benefit of LKPD        | 18   | 18                   | 19       | 76%      | Practical |
|    |                        |      |                      | Overall Practicality Average | 79.3% | Practical |

Based on Table 4, the average practical level of PBL-based LKPDs oriented to natural disaster mitigation according to the implementation questionnaire is 79.3%, so it can be concluded that PBL-based LKPD is oriented towards practical natural disaster mitigation based on its implementation.

After all the meetings have been completed, students are asked to fill out a questionnaire on the responses of students to the PBL-based LKPD oriented to natural disaster mitigation to the students' mathematical reasoning abilities that have been used. The results of the student response questionnaire analysis to the practicality of PBL-based LKPD oriented to natural disaster mitigation can be seen in Table 5 below.

Table 5. Percentage of Average Student Response Questionnaire Analysis Results

| No | Aspects Assessed      | Practically Average | Category |
|----|------------------------|---------------------|----------|
| 1  | Ease of Use            | 81.1%               | Practical |
| 2  | Time Efficiency        | 77.3%               | Practical |
| 3  | Benefit of LKPD        | 81.6%               | Practical |
|    |                        | Overall Practicality Average | 80% | Practical |

Based on the results of the analysis of students' responses to the practicality of PBL-based LKPDs oriented to natural disaster mitigation towards students' mathematical reasoning abilities, they are in the category of practical, practical and very practical so that on average, PBL-based LKPD is oriented towards natural disaster mitigation towards students' mathematical reasoning abilities, is in the practical category with a value of 80%. This means that PBL-based LKPD is oriented towards natural disaster mitigation towards students' mathematical reasoning abilities according to practical students to use in learning.

Furthermore, a questionnaire on teacher responses to PBL-based LKPD was conducted with natural disaster mitigation orientation towards students' mathematical reasoning abilities. The percentage of the results of the teacher response questionnaire can be seen in Table 6 below.

Table 6. Results of Average Percentage of Teacher Response Questionnaire Analysis

| No | Aspects Assessed      | Practicality Average | Category |
|----|------------------------|----------------------|----------|
| 1  | Ease of Use            | 75%                  | Practical |
| 2  | Time efficiency        | 75%                  | Practical |
| 3  | Benefit of LKPD        | 75%                  | Practical |
|    |                        | Overall Practicality Average | 75% | Practical |

Based on Table 6 above, the practicality of LKPD from the results of the teacher response questionnaire was 75% in the practical category. Based on the results of the analysis of the teacher's
questionnaire, it was concluded that the LKPD used was easy to use, students very clearly understood the language and material available in the LKPD so as to motivate students in the learning process.

The effectiveness of the research was conducted to see to what extent the usefulness and benefits of PBL-based learning tools oriented to natural disaster mitigation on the mathematical reasoning abilities of students. Assessment of this effectiveness is done by giving reasoning ability test questions to students. According to Trianto (2009) test results can be used to evaluate various aspects of the teaching process. Based on the data analysis, there were 3 out of 6 students above the specified KKM value, namely ≥ 80. For recapitulation can be seen in Table 7.

### Table 7. Final Test Results for Class VIII.3 MTsN 6 Agam Students

| No | Name of Student | Score | Value  | Criteria |
|----|----------------|-------|--------|----------|
| 1  | A              | 40    | 78.4   | Good     |
| 2  | B              | 35    | 68.6   | Good     |
| 3  | C              | 36    | 70.6   | Good     |
| 4  | D              | 39    | 76.5   | Good     |
| 5  | E              | 41    | 80.4   | Very Good|
| 6  | F              | 44    | 86.3   | Very Good|
|    | Average        | 39.17 | 76.8   | Baik     |

Researchers also analyzed the percentage of students' answers for each indicator of mathematical reasoning ability. The results of the analysis can be seen in Table 8.

### Table 8. The Value of Mathematical Reasoning Ability on the Topic of Constructing Flat Spaces

| Indicators                                                                 | Percentage of scores of students for each Indikator | Category       |
|---------------------------------------------------------------------------|----------------------------------------------------|----------------|
| Ability to submit allegations                                             | 81.3 %                                             | Very Successful|
| Ability to do math manipulation                                           | 75.7%                                              | Very Successful|
| Ability to compile evidence, provide reasons, or evidence of the correctness of the solution | 92.6%                                              | Very Successful|
| Finding patterns or properties of mathematical symptoms to make generalizations | 62.6%                                              | Successful     |
| Ability to draw conclusions from statements                                | 51.3%                                              | Less Successful|
| **Rata-rata**                                                             | **72.7%**                                          | **Successful** |

Based on the data analysis from Table 7, it can be concluded that the PBL-based LKPD is oriented towards natural disaster mitigation which is said to be effective because the average score of students is 76.8 in a good category. And for the analysis table of students' mathematical reasoning abilities, an average of 72.7% was obtained with the successful category. This shows that the questions given can be understood by students and provides an illustration that the application of PBL-based LKPDs oriented to natural disaster mitigation can instill the concept of flat-sided building and increase
students' knowledge about natural disaster response. So it can be said that the learning tools developed can be categorized in the effective category.

The development of PBL-based mathematics learning tools oriented to natural disaster mitigation of students' mathematical reasoning abilities is carried out as an effort to meet the needs of students. The learning tools developed are expected to be able to help students play an active role in the learning process of mathematics in the classroom so that they can achieve one of the objectives of learning mathematics, namely increasing mathematical reasoning skills and can help students to increase their knowledge of how to respond to natural disasters.

4. Conclusion

The process of developing PBL-based learning tools that are oriented towards natural disaster mitigation of students' mathematical reasoning abilities is carried out by the Plomp method which consists of three stages, namely the preliminary research stage, the development stage and the assessment stage. PBL-based learning tools that are oriented towards natural disaster mitigation on the mathematical reasoning abilities of students developed in this study have met the criteria of being valid, practical, and effective.
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