Development of Mathematics Module Based on M-APOS Learning Model to Improve Students’ Mathematical Problem Solving Ability

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Abstract. This research aimed to develop mathematics module based on M-APOS learning model to improving students mathematical problem-solving abilities grade VII. This research used the Research and Development (RnD) method. The development model used is Analysis, Design, Development, Implementation, Evaluation (ADDIE). Data collection techniques include observation techniques, questionnaires, and math problem-solving skills tests. The result of the research that the development of a mathematical module is based on the M-APOS learning model to improve mathematical problem-solving abilities in the quadrilateral material of class VII of Junior High School by fulfilling valid, practical and effective criteria.

1. Introduction

In every level of education will certainly meet mathematics, ranging from abstract things to more concrete things. However, in fact, the quality of education in Indonesia is still low, especially in the field of mathematics. This was known from the results of research in The Trends International Mathematics and Science Study (TIMSS) in 2015 which confirmed the low mastery of Indonesian student mathematics. Various factors that influence the low quality of education, especially mathematics subjects. Among these problems are the lack of a variety of learning resources, errors in the textbooks [1], lack of understanding of mathematical concepts that affect mathematics problem-solving abilities, and lack of accuracy in the selection of learning models. For this reason, researchers are interested in developing modules on rectangular material based on the M-APOS learning model to improve students' mathematical problem-solving abilities.

In the Big Indonesian Dictionary (KBBI) found the understanding of modules which states that the module is an activity of teaching and learning programs that can be learned by students with minimal assistance from the teacher or supervisor, including planning goals to be achieved clearly, provision of subject matter, tools what is needed and tools for assessors, as well as measuring the success of students in the completion of learning [2]. According to the Ministry of National Education, a module has the characteristics of self-instructional, self-contained, stand-alone, adaptive, user-friendly [3]. The quality of the developed mathematical modules must meet valid, practical and effective assessment criteria [4].

The selection of one alternative M-APOS learning model is supported by the results of Nurlaelah & Sumarmo's research [5]. They stated that the achievement of learning outcomes with the M-APOS model was higher than the expository model. M-APOS learning model is a modification of the learning model based on the APOS theory. APOS stands for action, process, object and schema [6]. The philosophical basis of this theory is social constructivism. Ed Dubinsky is the developer of APOS theory. He argued that a person's knowledge and
understanding is a person's tendency to respond to a mathematical situation and reflect it on a social context. Furthermore, the person constructs or reconstructs mathematical ideas through actions, processes and mathematical objects, and the next one is organized in a scheme to be utilized in solving a problem at hand. Problems that are resolved both uses high-level thinking skills and basic thinking skills [7].

In addition, the M-APOS learning model presents several activities that encourage the independence and activeness of students in learning. More specifically it is stated that the M-APOS learning model is a mathematical learning model that has the characteristics of analyzing mental construction in understanding a concept, using computers in learning, students learning in small groups, and learning using ADE cycles (activities, discussions, and exercises).

In the discussion and practice stages, students can use questions in the form of mathematical problem-solving. Mathematical problem solving is a process that has many steps that must be taken by someone by using logical thinking, organizing and proving in solving problems [8]. In addition, problem-solving problems usually contain a situation that can encourage someone to solve it, but not directly know how. There are four main steps used in problem-solving, namely understanding the problem, preparing a resolution plan, carrying out the solution according to plan, and ending with re-examining all the steps that have been done [9]. Thus, it is hoped that the development of modules based on the M-APOS model can improve mathematical problem-solving abilities.

2. Research Method

This research is a Research and Development. It is a research method used to produce a particular product, and test the effectiveness of the product. The place of research was conducted at SMP Negeri 3 Banguntapan with the subject of this study were students of class VIIA. The design of this study using the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) development model. The steps of the ADDIE development model are at the analysis stage, and the activities carried out include analyzing the needs, characteristics of students and curriculum. Design phase, the activities carried out are determining the product design that is developed, the outline of presenting the material, collecting references, and compiling an assessment instrument. Development phase, the activities carried out are making products, validating and revising revisions. Implementation phase, the activities carried out are implementing the product, testing and dividing the response questionnaire. The product test design in this study was carried out in two stages: small group trials and large group trials. Then the evaluation stage, the activities carried out are evaluating the product and learning about mistakes. The instruments used in this study were questionnaire appraisal module by material experts, module assessment questionnaire by media experts, student response questionnaires, observation sheets for learning implementation, and mathematical problem-solving tests.

Data analysis techniques used are validity analysis techniques to analyze the quality of the mathematical module developed so that it is said to be valid, practical analysis techniques to analyze the quality of the mathematical module developed so that it can be said to be practical, and effectiveness analysis techniques to analyze the quality of mathematical modules can be said to be useful to improve students' mathematical problem solving. After that, test statistically to prove the significance of the effectiveness of these results by using the t-test for one sample.
3. Result and Discussion

This study produced a product in the form of a mathematical module based on the M-APOS learning model on a rectangular material to improve mathematical problem-solving skills of seventh-grade junior high school students using the ADDIE development model. The developed mathematics module has been tested and meets the criteria for valid, practical, and useful.

The results of data analysis that measures the validity of the modules developed in this study are as follows.

| Evaluation Aspect                  | Number of Each Aspect | Average of Each Aspect | Criteria     |
|------------------------------------|-----------------------|------------------------|--------------|
| Material Feasibility               | 51                    | 3                      | Good         |
| Presentation Feasibility           | 46                    | 3.29                   | Good         |
| Language                           | 30                    | 3                      | Good         |
| Integration with the M-APOS learning model | 12                    | 4                      | Very Good    |
| **Total**                          | **139**               | **3.16**               | **Good**     |

Ideal Score = 4

Table 2. Result of Evaluation Analysis of Media Expert Module

| Evaluation Aspect      | Number of Each Aspect | Average of Each Aspect | Criteria    |
|------------------------|-----------------------|------------------------|-------------|
| Display                | 27                    | 3.86                   | Very Good   |
| Language               | 11                    | 2.75                   | Enough      |
| **Total**              | **38**                | **3.45**               | **Very Good** |

Ideal Score = 4

Based on Tables 1 and 2, it can be seen that the results of the module assessment for material experts showed that the total or overall average obtained was 3.16 from the ideal score 4 with the criteria of "Good", while the results of the module assessment for media experts showed that the average the total or total obtained is 3.45 from the ideal score 4 with the criteria of "Very Good". Based on the results of the assessment, researchers can conclude that the developed mathematics module meets valid criteria.

The results of data analysis that measures the validity of the modules developed are as follows.

Table 3. Results of Learning Implementation Observation Sheet Analysis

| Aspect     | Percentage of Meet |
|------------|--------------------|
|            | 1                  | 2                  |
| Introduction | 100%               | 100%               |
| Core        | 100%               | 100%               |
| Conclusion  | 66.67%             | 100%               |
Table 4. Results of the Questionnaire Analysis of Students' Small-scale Trial Response

| Aspect      | Average of Aspect | Sum of Average | Criteria      |
|-------------|-------------------|----------------|---------------|
| Display     | 3.58              | 3.42           | Very Good     |
| Presentation| 3.30              |                |               |
| Benefit     | 3.40              |                |               |
| Ideal score | 4                 |                |               |

Based on the results of the learning implementation observation sheet above, it was found that the development of mathematics modules based on the M-APOS learning model meet the practical criteria, because the average percentage of total learning activities was 96.42% of the ideal score of 100% meeting the criteria of "Very Good". While the results of the student response questionnaire analysis in small-scale trials reached a total average of 3.42 from the ideal score 4 with the criteria of "Very Good", and the results of the large-scale trial response questionnaire analysis reached a total average of 3.50 from the ideal score 4 with a criterion of "Very Good". Based on the results of student response questionnaire data analysis and learning implementation observation sheet, it can be concluded that the mathematics module based on the M-APOS learning model developed meets the practical criteria.

The results of the analysis of mathematical problem solving tests indicate that the average student's mathematical problem solving ability is 81.85 of the ideal score of 100 with the criteria of "Very high". While students who have the student's mathematical problem solving ability with the category "High" or more reach more than the indicator of success that is 70%. Thus, it can be concluded that the development of mathematical modules based on the M-APOS learning model on rectangular material can improve student's mathematical problem solving ability effectively.

To test the significance of the effectiveness of the results, test data on mathematical problem solving abilities were tested statistically by one sample t test. The results of data analysis with normality test obtained $D_{count} = 0.18$ and $D_{table} = 0.26$, then the data is normally distributed. The results of the t test analysis of one sample obtained $t_{count} = 8.79$ and $t_{table} = 2.05$. This shows that the development of mathematical modules based on the M-APOS learning model on rectangular material is effective and significant to improve mathematical problem solving abilities.

In this study, the development of mathematical modules based on the M-APOS learning model is intended to develop students' mathematical abilities, especially mathematical problem solving abilities. Mathematical problem solving abilities can increase after learning
using a mathematical module developed based on the M-APOS learning model seen from the test of mathematical problem solving skills. The success of the M-APOS learning model as an alternative learning model used can make student-centered learning. This is consistent with the opinion of Nurlaelah & Sumarmo who suggested that the stages in the M-APOS learning model, namely ADL (activities, discussions, and exercises) provide opportunities for students to be more active in exploring the information needed to be able to complete tasks independently or group from various learning sources [10]. In line with the opinion of Saefudin it is stated that the use of M-APOS learning models through ADL stages such as giving assignments and practice questions can improve learning independence and students' mathematical abilities compared to conventional learning [11]. Furthermore, Saefudin & Kintoko suggested that students who learn in groups according to the stages of the M-APOS learning model are possible to be embedded and meaningful in students' memories [12]. In addition, the stages in the M-APOS learning model can assist students in preparing the learning process at the next meeting.

Based on expert opinion, the theoretical basis of several other researchers relevant to this study, as well as the results of the research described above, it can be concluded that the development research conducted produced a mathematical module based on the M-APOS learning model on rectangular material with valid, practical quality, and effective criteria.

4. Conclusion

Based on the results of the research and discussion that has been carried out, it is concluded that the development of a mathematical module is based on the M-APOS learning model to improve mathematical problem solving skills in the quadrilateral material of class VII of Junior High School by fulfilling valid, practical and effective criteria.

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