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Development of Two-Dimentional Geometry Module based on APOS Theory for 4th Grader Students

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a b s t r a c t

This study aims to produce two-dimentional geometri module based on the APOS theory for 4th grader students is valid and feasible. This research method is research and development (R&D) using a 4D development model (define, design, develop, and disseminate). However, in this study, the 3-D development was modified, namely the disseminate stage was not carried out due to limited time, energy, and cost in carrying out this research. The subject of this research is the 4th grader of Semarang State Islamic Elementary School (MIN Semarang). Based on the results of the study, it was found that (1) module assessment by material and media expert the quality of the module quality by material and media expert validators is in the very good category with a value of 4,7 and 4,4. (2) Student learning outcomes from field trials obtained an average of 79,8 with a completeness level of 78.6%. It can be concluded that the product of two-dimensional geometri module based on the APOS theory is valid and feasible for use in learning

K e y w o r d s:

INTRODUCTION

Mathematics is one of the subjects that emphasizes problem solving and plays an important role in developing and influencing students' creativity (Maryam, Masykur, & Andriani, 2019). Therefore, mathematics really needs to be given to students of all school levels. Mathematics learning should be structured to encourage students to develop mathematical skills such as the ability to understand, explain, relate, reason, and solve problems (Junaedi & Asikin, 2012).

Teaching materials are an important thing used in learning. The use of teaching materials in the teaching and learning process aims to make learning meaningful (Gradini, Mulyani, & Asnawi, 2021). In the Ministry of National Education, teaching materials are anything that teachers use to assist teachers in learning. Among them are the types of teaching languages, namely printed teaching materials such as handouts, modules, books, student worksheets, photos/pictures (Departemen Pendidikan Nasional, 2008).

Based on the results of observations with 4th grade teachers of Semarang State Islamic Elementary School (MIN Semarang) that the teaching materials used in learning are in the form of textbooks from publishers and have not developed the teaching materials used. In addition, the contents of the textbook do not contain questions that encourage students to provide explanations for the answers obtained and describe the characteristics of a concept. From the results of interviews, the teacher stated that students still often made mistakes when working on math problems. This happens because of the lack of understanding of students related to mathematical concepts.

Considering this situation, a solution is needed to help students learn. One alternative is to make teaching materials in the form of modules based on APOS (Action, Process, Object, Schema) theory. Modules are teaching materials that include materials, methods, and evaluations so that students can learn independently without or with teacher guidance (Tjiptiany, As'ari, & Muksar, 2016). The purpose of learning using modules is for students to be able to study independently or with minimal teacher assistance and accommodate various levels of student learning speed (Prastowo, 2011).

APOS is one theory to describe how mathematical concepts are learned. In studying mathematics, individuals tend to solve mathematical problems by building mental activities from mathematical actions, processes, and objects then organizing them into schemas to understand and solve the problem (Dubinsky & Mcdonald, 2001; Inglis, 2015). The presence of APOS Theory is an attempt to understand the mechanism of reflective abstraction introduced by Piaget to describe the development of mathematical logical thinking in children, and develop this idea into further mathematical concepts (Mulyono, 2011). Action is an individual's effort to mentally focus on understanding a concrete mathematical concept. While, the process is a stage of action that occurs entirely in the mind. At this stage the individual is able to understand abstract mathematical concepts. The object stage occurs when a process is understood as an embodiment in which the actions performed in the mind become an object, and the object can be decomposed back into a process. Schema is an arrangement of stages of action, process, and object so as to form a series of interrelated in the minds of individuals (Herlina, 2013; Wijayanti, Waluya, Kartono, & Isnarto, 2018).

APOS theory-based module teaching materials can help students construct their thinking in capturing mathematical ideas and enable students to learn independently (Ningsih, 2017; Oktari, T, Hartono, Y & Santoso, 2017; Prasetyo, 2020; Sukestiyarno & Rahmawati, 2019), so that it has a potential effect on learning outcomes in the affective (attitude) and cognitive (knowledge) domains (Lestari, Darmawijoyo, & Aisyah, 2018; Marsitin, 2017)

Based on these recommendations, research findings, and field studies, it is important for teachers to develop APOS theory-based module teaching materials. The application of APOS theory has been widely used in universities and secondary schools, but is still rarely used at the elementary school level. Therefore, in this study the aim is to develop Two-Dimensional Geometry Module based on APOS Theory for Grader 4th students.

METHODS

This research method is research and development (R&D) using a 4-D development model which consists of define, design, develop, and disseminate(Thiagarajan. Semmel & Semmel, 1974). However, in this study, the 3-D development was modified, namely the disseminate stage was not carried out due to limited time, energy, and cost in carrying out this research. The subject of this research is the 4th grader of Semarang State Islamic Elementary School (MIN Semarang).

Data collection techniques used are observation, interviews, questionnaires, documentation and tests. The data analysis technique used is the validity and feasibility of the module based on the APOS theory. Modules with a valid category are if the results of the module assessment by expert validators are at least good. While the module with the feasible category is if the average student learning outcomes ≥ 75 and the proportion of students who achieve completeness $\geq 75\%$

Following are the criteria for assessing the validity of the module (Widoyoko, 2010) and this research and development planning scheme, respectively, is reflected in table 1 and figure 1.

Table 1. Module Validity Score

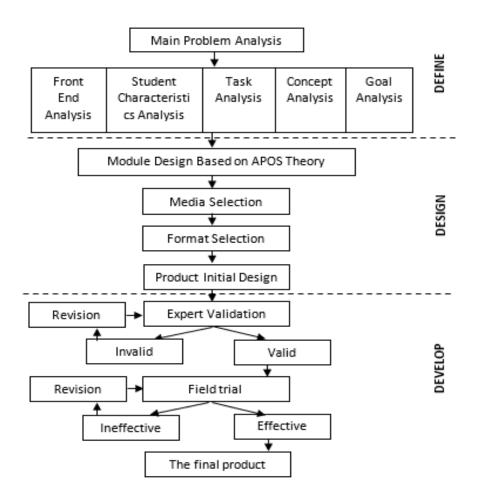| Interval	Category
$4{,}20 < \bar{x} \leq 5{,}00$	Very Good
$3{,}40 < \bar{x} \leq 4{,}20$	Good
$2{,}60 < \bar{x} \leq 3{,}40$	Fair
$1{,}80 < \bar{x} \leq 2{,}60$	Poor
$1{,}00 < \bar{x} \leq 1{,}80$	Very Poor

Figure 1. Research and Development Scheme

RESULT AND DISCUSSION

1. Define

This phase aims to determine and define the needs in the learning process. The define phase consists of front end analysis, learner analysis, task analysis, concept analysis, and specifying instructional objectives. The following are the results at the define stage phase:

a. Front end analysis

The results of observations and interviews conducted with MIN Semarang teachers on January 6, 2020, obtained that the teacher had not developed the teaching materials used in learning themselves. The textbooks used are in the form of package books from publishers and are not fully based on the APOS theoretical framework. Students still have difficulty understanding mathematical concepts and often make mistakes when working on problems.

b. Learner analysis

The results of student analysis showed that students still had difficulty understanding mathematical concepts and often made mistakes when working on questions.

c. Task analysis

Task analysis is adjusted to the learning objectives according to the syllabus. The material of this module is two-dimentional geometry. The tasks are adapted to the basic competencies in accordance with the material of two-dimentional geometry (types of polygons, perimeter and area of square, rectangle, and triangle).

d. Concept analysis

The mathematical concepts of two-dimentional geometry that are taught and expected to be mastered by students are based on the grade 4 mathematics syllabus of the 2013 curriculum which includes analyzing the properties of regular polygons; analyze the properties of an irregular polygon; identify regular polygons; identify irregular polygons; describe and determine the perimeter of squares, rectangles and triangles; explain and determine the area of squares, rectangles and triangles including the square root of the square root; solve problems related to the perimeter of squares, rectangles and triangles; solve problems involving the area of squares, rectangles and triangles including the square root of the square root

e. Specifying instructional objectives
Based on the 2013 curriculum syllabus, the Basic Competencies are as follows:

Table 2. Basic Competencies

Basic Competencies	
3.8	Analyze the properties of regular polygons and irregular polygons.
3.9	Explain and determine the perimeter and area of squares, rectangles and triangles and the relationship of the cube to the square root.
4.8	Identify regular polygons and irregular polygons.
4.9	Solve problems related to the perimeter and area of squares, rectangles and triangles including involving the cube with the square root.

2. Design

This phase aims to design two-dimentional geometry module that will be developed to obtain a prototype. This phase consists of media selection, format selection, and initial design. This module consists of an introductory section, a module content section, and a concluding section. The results of the initial design of the module are then consulted with the supervisor. Furthermore, the module that has been approved by the supervisor is then submitted to the material expert and media expert to be validated.

3. Develop

This phase is module validation, namely 1 material expert validator and 1 media expert validator. Mrs. Mujiasih, M.Pd as material expert validator (V.1) and Mr. Hamdan Husein Batubara, M.Pd.I as media expert validator (V.2). Material expert validators provide module assessments on aspects of content feasibility, linguistic feasibility, presentation feasibility, and APOS stages. Meanwhile, media expert validators provide module assessments on aspects of presentation, graphic feasibility, and display quality. Notes and input from expert validators are used as the basis for improving the preparation of the module so that the final product is obtained. The results of the recapitulation of module quality validation by experts in first phase and second phase can be seen in figure 2 and 3:
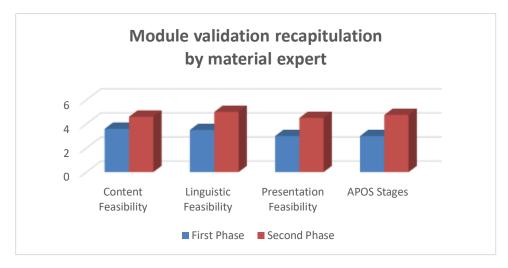
Figure 2. Modul Validation Recapitulation by Material Expert

Based on the diagram in Figure 2, it was obtained that there was an increase in the validation results from stage 1 to stage 2 by material expert. The results of first phase and second phase validation by material expert respectively obtained the mean value of all aspects from 3,3 to 4,7 with a very good category.
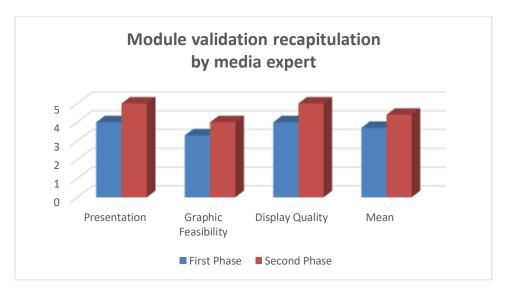

Figure 3. Modul Validation Recapitulation by Media Expert

Based on the diagram in Figure 3, it was obtained that there was an increase in the validation results from stage 1 to stage 2 by media expert. The results of first phase and second phase validation by media expert respectively obtained the mean value of all aspects from 3,7 to 4,4 with a very good category. Thus, notes and suggestions from experts greatly influence the development of the module. Furthermore, the revised module deserves to be tested.

A good module has at least seven elements that must be present in making the module, namely titles, instructions for use, competencies to be achieved, materials, exercises, work instructions, and evaluations (Daryanto, 2013). The following presents the results of the revised two-dimentional geometry module based on APOS theory.

1. Cover the front and back of the module
   Notes from the validator for the front cover of the module are designed to contain pictures and writings related to the material discussed, while the back cover contains a brief description of the contents of the module. The front and back covers can be seen in Figure 4.

Figure 4. Cover the front and back of the module

2. Modul introduction
   In the introduction to the module, an explanation regarding the APOS theory is given. The preliminary view can be seen in Figure 5.
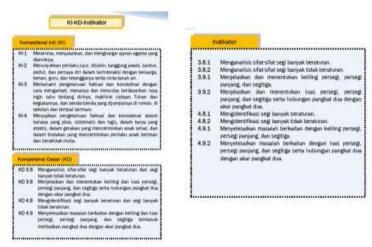

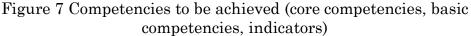Figure 5. Modul Introduction

3. Instructions for use
   The module is equipped with instructions for use for teachers and students.
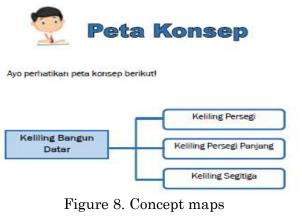
Figure 6. Instructions for use

4. Competencies to be achieved (core competencies, basic competencies, indicators)

Figure 7 Competencies to be achieved (core competencies, basic competencies, indicators)

5. Module content

The module contains 3 lessons, each of which is based on the APOS theoretical framework (action, process, object, schema). Each lesson contains material in addition to being equipped with concept maps, materials, practice questions, formative tests, assessment guidelines, and formative test answer keys. The following is a display of the module contents in one of the learning activities:

Figure 8. Concept maps

Figure 9. Action & Procces Stage

Action is an individual's effort to mentally focus on understanding a concrete mathematical concept. While the process is a stage of action that occurs entirely in the mind. At this stage the individual is able to understand abstract mathematical concepts (Herlina, 2013; Wijayanti et al., 2018). To facilitate students in understanding mathematical concepts well, the module at the action stage is presented with material along with concrete examples in everyday life. as an example of circumferential material. Students can understand what circumference is if given an illustration of the circumference of a flat shape and the elements that must be known. After students understand the concept of circumference with pictures or concrete manipulations. Furthermore, in the process stage students have reflected on the actions that have been carried out and occur internally without the help of concrete objects. And then schema is an arrangement of stages of action, process, and object so as to form a series of interrelated in the minds of individuals.
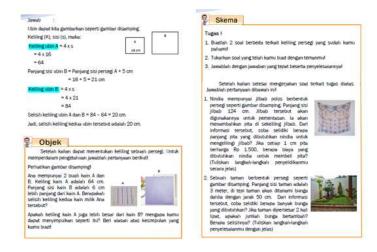

Figure 10. Object & Schema Stage

Students are said to have carried out the object stage of a mathematical concept, if they have (1) been able to treat the concept as a cognitive object which includes the

ability to take action on the object, and provide an explanation of its properties, (2) able to parse it again. an object becomes the process as it came from when the properties of the object in question are used (Herlina, 2013; Mulyono, 2011; Wijayanti et al., 2018). The object stages in the module are presented, where students are not only required to solve problems about circumference but also give reasons related to their answers. The indicator of students having schema is if they have the ability to construct examples of a mathematical concept in accordance with the properties of the concept (Herlina, 2013). In the module, a problem is given that requires students to collaborate on actions, processes, objects and previously constructed schemas.

Figure 11. Evaluations

After validation by material and media experts, then and it was declared feasible to be applied in learning, the two-dimentional geometry module based on the APOS theory was tested on 4th grade MIN Semarang with 28 students. The field trial phase was carried out to determine the feasibility of the module. The module is used in learning for 4 meetings for learning and 1 meeting for tests.

Based on the test results, the average student learning outcomes are 79.8 with the percentage of scores above the minimum completeness criteria is 78.6%. It shows that the module is feasible for use in learning

CONCLUSION AND IMPLICATION

The results of the validation of two-dimentional geometry module based on the APOS theory on 4th grade by material and media experts obtained a score of 4.7 and 4.4 with a very good category. Based on the test results of testing the application of module products in learning, the average student learning outcomes of class is 79.8 with the percentage

value above the minimum completeness criteria is 78.6%. Based on the results of the validation and test, it shows that the module is valid and feasible for use in learning. The produced module could facilitate learners to understand the materials and enrich their learning experience. Teachers could use this module as a reference for their teaching when they needed it. For further research, it is recommended to develop teaching materials based on APOS theory on other mathematical materials with ethnomathematical nuances.

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