Developing mathematics module of Kapita Selekta course based on higher-order thinking skills for high school

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Abstract. Higher-order thinking skills can be seen through Bloom’s taxonomic cognitive level. The cognitive level in Bloom’s taxonomy includes analysis, evaluation, and create. In the Kapita Selekta Pendidikan Matematika 2 course that deals with high school mathematics material, pre-service teachers are expected to be able to master higher-order thinking skills. With the HOTS-based mathematics module for high school it can help the pre-service teacher in compiling questions. The results of the research development of HOTS-based mathematics problem modules are included in the valid category. It means that students of Mathematics Education at Universitas Pekalongan in the subject of Kapita Selekta Pendidikan Matematika 2 can use HOTS-based mathematics modules.

1. Introduction

Indonesia’s minister of education and culture regulations state that the purpose of the assessment of learning outcomes is to monitor and evaluate the process, progress of learning, and continuous improvement of student learning outcomes. It can be said that the assessment is used not only to know the students’ ability to understand the material that has been delivered by the teacher. Also, the assessment is used as teachers’ reflection, mostly reflection about how to improve the learning process that still less than optimal.

The problem that occurs is the teaching process. There are still teachers who give cognitive questions at a low level compared to providing cognitive questions for a high level [1]. Improving higher-order thinking skills requires collaboration between subject teachers and education levels. Steps that can be taken by including their subjects with problem-solving, critical thinking, and decision-making activities will help students improve higher-order thinking skills [2]. Also, it is known that there is a linear, positive, and strong relationship between higher-order thinking skills (HOTS) and student mathematics learning outcomes [3]. A person has high-order thinking skills, which can solve a problem and then be able to analyze and use his knowledge in new situations.

Higher-order thinking skills is a process of thinking of students in a higher cognitive level that is developed from various concepts and methods of cognitive and taxonomy of learning. Questions to measure students’ high-level thinking skills are at least a cognitive level C-4 (analyzing), C-5 (evaluating) and C-6 (creating), problem-solving skills, and creative thinking [4]. It appears in figure 1, students must master the level of remembering, understanding, and application before able to reach the level of analysis, evaluation, and create. So a teacher must be able to direct teaching towards it. Although teachers already know that students can be trained on HOTS by using several learning models (e.g.,
problem-based learning, project-based learning, inquiry learning, cooperative learning), teachers still confuse activities in certain learning models [5].

To overcome activities in the application of the learning model, the teacher needs to 1) present the problem, 2) organize students in study groups, 3) provide scaffolding (assistance) during the investigation process to the drawing conclusions stage, 4) use high-level questions [6]. Meanwhile, so that students can have high-order thinking skills, student activities that can be done are exploring 1) required information, 2) proposing assumptions, 3) conducting inquiries, 4) carrying out conjectures, 5) looking for alternatives, and 6) drawing conclusions [7]. Also, it can also use a module related to the preparation of math problems based on higher-order thinking skills [8].

2. Method
The research method used is the adoption of Plom’s development research. The development research model includes several phases, namely: 1) preliminary investigation, 2) development or prototyping phase, 3) assessment phase [9]. This article only discusses the preliminary investigation and development or prototyping phase, as can be seen in figure 2.

The subjects of this development research were 39 students of mathematics education study program Universitas Pekalongan in semester 5 of 2019/2020 academic year who took the Kapita Selektta Pendidikan Matematika 2 course. Data collection techniques used were observation, interviews, documentation, and questionnaire (questionnaire). Observations and interviews were conducted for the preliminary investigation phase related to higher-order thinking skills (HOTS). Documentation techniques for gathering material in the preparation of the HOTS module. Then the questionnaire is used to validate the HOTS module to experts.

Validation is carried out to determine the quality of the HOTS question module that meets the specified criteria. To find out the valid level using data analysis by Hobri [10]. The steps are a recapitulation of validity assessment data into a table that includes aspects, indicators, and validation of each validator. Next, look for averages for all validators and all aspects. The final part is done on the average total, which value is then consulted with table 1.
Table 1. Validity criteria for the HOTS module.

| $V_a$ | Explanation |
|-------|-------------|
| $3 \leq V_a \leq 4$ | Valid |
| $2 \leq V_a \leq 2.9$ | Quite valid |
| $1 \leq V_a \leq 1.9$ | Invalid |

3. Result and discussion

Based on the Plomp’s development research model, the following phases have been carried out.

3.1. Preliminary investigation

The module is one of the solutions in independent learning. Learning through modules can give a positive response to students [11]. Besides that, it can develop an independent character, diligent, conscientious, tenacious, and responsible [12]. Observation activities were carried out to identify problems that occurred in students’ understanding of HOTS-based math problems. Students are asked to make high school math problems based on HOTS. The results obtained were that the students already knew the types of math problems that were included in HOTS [13]. These questions are adjusted to Bloom’s cognitive domain indicator.

Level C-4 analysis [14] has several indicators 1) analyzing incoming information and dividing or structuring information into smaller parts to recognize patterns or linking them, 2) able to recognize and distinguish the causes and effects of a complex scenario, 3 ) identify or formulate questions [11]. 31 students made questions at the level of analysis. The problems have been related to daily life.

At the C-5 level evaluating [15] the indicators are 1) providing an assessment of solutions, ideas, and methodologies using suitable criteria or existing standards to ascertain the value of effectiveness or benefits, 2) making hypotheses, criticizing and testing, 3) accepting or reject a statement based on established criteria. Seventeen students make questions at the evaluation level.

For the C-6 level, create [16] indicators used 1) generalize an idea or way of looking at something, 2) design a way to solve a problem [17], 3) organize elements or parts into new structures that have never existed before [12]. While at the create level, there are no students who are able to make it.

3.2. Development or prototyping phase

At this stage, three things are done 1) determining basic competencies, the format of the questions, and the problem grids; 2) make a question card; 3) making scoring. Basic competencies are used based on the 2013 curriculum. Start from tenth grade to twelfth grade, by choosing basic competencies that can be directed to higher-order thinking skills. After determining the basic competencies that have been made, the next step is to design a HOTS-based math problem module. The preparation of this module pays attention to 4 aspects 1) content eligibility, 2) linguistic, 3) presentation, 4) graphic [18].

In the aspect of content eligibility, there are several criteria for the compatibility of the module content with core competencies and basic competence, several criteria for mathematical questions to measure higher-order thinking skills, the truth of the learning substance, and the benefits to add insight. HOTS-based mathematical criteria are also considered that must be able to measure problem-solving abilities, measure creative and critical thinking skills, and fulfill one of the top three levels in Bloom’s cognitive dimension.

In the linguistic aspect, the criteria that need to be considered are the use of standard language according to spelling and typography. The sentence structure in the module is effective, follows Indonesian grammar, is easy to understand, and can stimulate students to think critically [19]. Whereas in the aspect of presenting the criteria, it is important to note that the presentation of the information shown is complete and precise. As well as for the visual element, the module layout and the packing of interest questions are the vital things to be consider.

The following is the design of the mathematics module consists of 1) cover design (figure 3), 2) module contents (figure 4), 3) Steps in Developing High-Level thinking skills (figure 5), and 4) bibliography (figure 6).
Figure 3. Module cover.

Figure 4. Example of module contents.

Figure 5. Example of steps in developing high-level thinking skills in module.

Figure 6. Bibliography.
After the module is prepared and meets the aspects that have been determined, then validation is done by experts. The validators fill out the validation questionnaire with four aspects and 26 statement items. Each statement has five ratings, i.e., very appropriate (5), appropriate (4), quite appropriate (3), less appropriate (2), not suitable (1). The validity result can be seen in table 2.

**Table 2.** Validity criteria for the HOTS module.

| Aspect            | Score | Average Total | Criteria |
|-------------------|-------|---------------|----------|
| content eligibility | 3.67  |               |          |
| linguistic        | 4     |               |          |
| Presentation      | 3.53  | 3.82          | Valid    |
| graphic           | 4.07  |               |          |

After the recapitulation of the validation assessment data into a table that includes aspects, indicators, and validations of each validator, then it looks for an average for all validators, and all aspects finally get a total average of 3.82 as in table 2. The 3.82 value was consulted in table 1 and included in the valid criteria. It means that the HOTS-based mathematics module can be used by students of Mathematics Education in the Universitas Pekalongan 5th semester in the Kapita Selekta Mathematics Education 2. Besides, it can also be used by students to be taught to high school students. Or in other words, this HOTS-based mathematics module can be tested on students when doing micro. A prospective teacher must have related pedagogic information, choose the right learning method, and prepare an appropriate learning environment [20]. Or in other words, this HOTS-based math module can be tested on students when doing micro-teaching or teaching practice in schools (PPL in Indonesia). Before teaching HOTS-based math problems, of course, students as prospective teachers also need to master these skills. So that when students provide evaluation after teaching, there are guidelines for assessing higher-order thinking skills. Assessing the learning outcomes, in terms of attitudes, aspects of knowledge, and skills, are carried out systematically [21]. So that in developing HOTS in students, it is necessary to start with examples and practice questions based on open tests [3].

It is necessary because to be able to develop the mathematical literacy skills of high school students, one of them is applying HOTS-based math problems. Applying mathematics in everyday life to solve a problem and how to communicate can be seen as students’ mathematical thinking processes [4].

4. **Conclusion**

Research on the development of HOTS-based mathematics modules produces valid products. Valid criteria meet four aspects of content eligibility, linguistics, presentation, and graphic. So it can be used for learning the Kapita Selekta Pendidikan Matematika 2 course.

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