Developing HOTS-based Model to Improve Mathematical Problem Solving Skill of Elementary School Teacher Education (PGSD) Students

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Abstract. The purpose of this development research is to produce Higher Order Thinking Skill (HOTS)-based pre-service training model for students of PGSD Study Program of STKIP Muhammadiyah Blora who take Mathematics I courses. The teaching materials are in the form of HOTS-based teaching materials and evaluation questions to measure students' mathematical problem solving abilities. Teaching materials developed meet valid and effective criteria. This type of research is development research following Borg and Gall procedures. This research leads to the improvement of students' mathematical problem solving abilities after applying Mathematics based on Higher Order Thinking. In addition, through this teaching material, students become accustomed to high-level thinking so that they are able to solve any mathematical problems given even the average student's mathematical problem-solving ability was increased from 57.50 to 87.90. Thus, the development of HOTS-based mathematics learning modules can improve students' mathematical problem solving abilities.

1. Introduction

Problems related to mathematics are still the main problems that occur in the educational world, both at the pre-school, elementary, junior and high school levels and even up to college. The problems are quite diverse: low interest, less motivation, low confidence, low learning achievement, low ability to understand both mathematical concepts and problem solving, and other problems which are the causes of these problems. Other supported factors such as disinterest in mathematics, and ineffective teaching method.

At the higher education level, especially for Elementary School Teacher Study Programs (PGSD), Mathematics is a compulsory subject. It is also applied in PGSD Study Program of STKIP Muhammadiyah Blora. It is proven that in the STKIP Muhammadiyah Blora curriculum, mathematics is given in five semesters with details of Basic Mathematics, Mathematics I, Mathematics II, developing mathematics learning media and elementary mathematics development. From the courses, the problems faced by the lecturers of the course were still the same as the problems mentioned above, especially in the low ability of students to solve mathematical problems.

Skill that must be possessed by someone who studies Mathematics. According to Windari (2014), through Mathematics, students are expected to be able to solve problems which include the ability to understand problems, design mathematical models, solve models, and interpret the solutions obtained. It is also applied in higher education. Problem solving itself is a skill to be able to formulate various ways to solve problems (Bradshaw & Hazell, 2017). From this opinion, it is explained the
importance of problem-solving abilities is learning Mathematics. The importance of problem-solving abilities is emphasized by Aydoğdu & Ayaz (2008) which states that problem-solving abilities can be a way for students to build ideas about Mathematics and can be responsible for the learning solutions they do. Because mathematics is very synonymous with solving mathematical problems besides that the main goal of education is for students to be able to solve mathematical problems which of course lead to solving problems in everyday life. The ability to solve mathematical problems is the ability of a person (student) to solve mathematical problems in accordance with the objectives set. This agrees with the opinion of Fauziah (2010) which states that the ability to solve mathematical problems is the ability of students to solve mathematical problems based on steps according to Polya: (1) understanding the problem, (2) making a plan for solving, carrying out the plan (4), and reviewing what has been done. From this opinion, it can be understood that problem solving ability is an important aspect.

Given the importance of students' mathematical problem solving abilities, it is necessary to find alternative ways to improve the mathematical solving abilities of students of PGSD Study Program specifically for mathematics courses. According to Mataka, et al. (2014), to improve problem solving abilities a teacher must have a pedagogical strategy to improve math problem solving abilities, so that research to improve the mathematical problem solving abilities of students studying mathematics is to develop a Higher Order Thinking Skill (HOTS)-based mathematical model. The solution was chosen because generally the problem-solving ability was caused by students not being accustomed to presenting material that required students to think at higher levels. Therefore, HOTS-based mathematical model that will be developed is a collection of Mathematics teaching materials that are prepared and presented prioritizing students' high-level thinking ability that prioritize two important aspects: critical and creativity aspects. This means that the model to be developed can guide students to be critical and creative in solving mathematical problems.

This development research will provide an overview of how the HOTS-based model is applied in higher education started from planning, development and implementation and it will be seen how it affects students' ability to solve mathematical problems. It is hoped that the application of HOTS-based mathematical models can improve students' mathematical problem solving abilities.

2. Method
This research was conducted in PGSD Study Program of STKIP Muhammadiyah Blora for Mathematics II, which amounted to 37 students. After the model is compiled, developed and validated, it is then tested and applied to PGSD students.

The results of the trial and application of the model are then analyzed and conclusions are drawn in relation to the effectiveness of HOTS-based mathematical models on students' mathematical problem solving abilities.

This is a development research where the focus of development is a HOTS-based mathematical model designed in such a way that students are directed to develop their mathematical problem solving abilities. The model is the Borg and Gall development model. This research model is considered suitable and in accordance with the characteristics of the development of teaching materials and other manipulative materials (Muruganantham, 2015).

The development of HOTS-based model was carried out in several stage: (1) Analysis Phase. Before carrying out model development, the first step is to perform an analysis. The analysis stage has been carried out by the researcher as part of the initial observations before the research implementation. The analysis in question is the analysis of the PGSD Study Program curriculum and the analysis of the needs of PGSD students to determine the cognitive development of students in solving mathematical problems, the learning tools used by students, and the learning models applied to students. (2) Design Stage. This stage include making a map of teaching material needs, determining the structure of teaching materials, compiling research instruments, and validating research instruments by validators. (3) Development Stage. This stage include the development stage are the creation of a Hypotheses Learning Trajectory (HLT) learning path, writing models, and model validation by material experts and media experts. (4) Implementation Stage. This stage is a step to test the models that have been developed. HOTS-based
model was tested on PGSD students. (5) Evaluation Phase. The evaluation stage is the assessment stage of the model seen from the components of the eligibility of content, presentation, language, to determine the quality of the model developed. In addition, at this stage an assessment of the effectiveness of the model is also carried out in facilitating the mathematical problem solving abilities of PGSD students.

3. Result and Discussion
The development of this model includes ten stages and is summarized into 5 stages: conducting analysis, developing initial products, expert validation and revision, limited class field testing and product revisions, extensive field trials. Before starting the model development, the first step is to analyze the problem and analyze the solution suited to the needs of the student. Analysis of student problems is carried out through research observations. Observations were made on PGSD students who took Mathematics I (Advanced Class Mathematics) subject. From the results of observations, there are problems faced by students: (1) students have not been able to understand the intent and purpose of Mathematics problems given by the lecturer during teaching, (2) because they do not understand these questions, students are not able to make or planning problem solving solutions, and students are unable to conclude whether the results of the work that have been done are appropriate or not. Based on the analysis of the problem, the problems faced by students in the class were identified as having difficulty solving Mathematics problems. Therefore, accustoming students to higher-order thinking is a solution to student problems. And one of the right steps is to create a HOTS-based model.

At the design stage, things are done based on the results or findings obtained at the analysis stage. The results and findings obtained are used as the basis for designing the model, in this case the HOTS-based assessment module and instrument. The things that are done include mapping the needs of the model, the content of the model, determining the structure of the model, preparing assessment instruments, research instruments, and validating research instruments by expert lecturers. From these results, HOTS-based mathematical model design plan for mathematics subjects in PGSD Study Program of STKIP Muhammadiyah Blora students is described.

| Table 1. Design of HOTS-based learning module |
|-----------------------------------------------|
| Module’s Sections   | Module                              |
| INTRODUCTION        | 1. Cover                            |
|                    | 2. Dedication                       |
|                    | 3. Table of Content                 |
| CONTENT             | 1. Title of Material                |
|                    | 2. First Page of Material           |
|                    | 3. Title of sub material            |
|                    | 4. Context Columns                  |
|                    | 5. Discussion KolomDiskusi          |
|                    | 6. Exercises                        |
| CLOSURE             | 1. Glossary                         |
|                    | 2. Reference                        |
|                    | 3. Key answer and discussion        |

At the development stage, the researcher compiled a model based on Higher Order Thinking Skills. The focus of development in this research is the development of module and assessment instrument. The material chosen in the development of this module is the material taught to students who take Mathematics in the even semester. Meanwhile, the assessment instruments developed were questions that could stimulate students’ higher thinking processes. The aspects that are considered by researchers in developing this model are 1) the model developed must be able to provoke students to develop their reasoning skills, 2) the model developed must be able to lure students to analyze and evaluate the given mathematical problems 3). The model developed must be able to stimulate students' thought processes
to create and think of alternative answers to any given problem. These three aspects are the basis for developing HOTS-based models because these three aspects are characteristics of HOTS.

Table 2. The Result of Validation Model based on HOTS

| Aspects           | Expert Material | Expert Media | Average Score | Value   |
|-------------------|-----------------|--------------|---------------|---------|
| Content Eligibility| 75              | 78           | 76.5          | Good    |
| Language Eligibility| 76          | 80           | 78            | Good    |
| Presentation Eligibility | 80      | 79           | 79.5          | Good    |

Conclusion 78 Good

After being developed, the model developed must be validated first to see the eligibility of the model. The applied model must be declared valid from new experts, then it is used for research. The following is a summary of the validation results by experts:

From Table 2 above, it can be said that the model developed is in the good category. This means that based on the opinions of material experts and teaching material media experts developed in the good category, in other words, the developed model is valid. Because the results of the validation are said to be valid or categorized as good, the next step is to conduct trials. Teaching materials that do not meet the minimum good (valid) category in this study will be taken into consideration for revising the product before being tested.

After the HOTS-based model developed is declared valid by the experts, then the model will be tested. However, before the trial, all input and comments from experts, both material experts and media experts, must be used as a basis for revision first. The trial was conducted on the fifth semester students with a total of 10 students. Improvements and findings obtained during the testing of the instrument were repaired. After making improvements, the HOTS-based model is actually applied to the third semester students of the PGSD Study Program for research.

The last stage to take is to carry out evaluation activities. Evaluation of model development is carried out after the development process is complete and even the product trial and product research stages have been completed. Evaluation is carried out with the aim of improving teaching materials. The results of the posttest that measure mathematical problem solving abilities are also a consideration for the improvement and refinement of products developed both modules and HOTS assessment instruments. In this study, an evaluation of student responses to the use of HOTS-based modules was also conducted. The student responses to the use of the HOTS-based model are described as follows:

Table 3. Students’ Response on the Used Model

| Aspects            | HOTS Module | Assessment Instrument of HOTS |
|--------------------|-------------|-------------------------------|
| Content Eligibility| 85          | 87                            |
| Language Eligibility| 87         | 85                            |
| Presentation Eligibility | 86   | 86                            |
| Average            | 86          | 84.33                         |
| Conclusion         | Very Good   | Very Good                     |

Based on the table above, it can be concluded that the use of models for both HOTS-based modules and assessment instruments are both in very good or very feasible categories which are assessed from three aspects, namely the eligibility of content, language and presentation or appearance. With these
results, the HOTS-based model is very feasible to be developed or used in mathematics learning in the PGSD Study Program of STKIP Muhammadiyah Blora.

After developing a HOTS-based model, students then take part in the lecture process using the HOTS-based model module. Furthermore, to measure students' mathematical problem solving abilities, HOTS-based instruments were also used. However, to see the increase and effect of using HOTS-based mathematics modules, it will be analyzed from the data or scores obtained by students before using the module and after using the HOTS-based module. Data on students' mathematical problem solving abilities before using HOTS-based modules can be seen in Table 6.

| Variable      | Pretest | Postest |
|---------------|---------|---------|
| Average       | 55.70   | 87.90   |
| Passed        | 12      | 29      |
| Total Students| 37      | 37      |
| Comprehension (%) | 32.43%  | 78.37%  |

Based on Table 6, it can be explained that before using HOTS-based modules the average value of student problem solving abilities obtained was 55.70. After using the HOTS-based module the value obtained was 87.90 with the respective percentages of 32.43% and 78.37%.

In general, this research has several stages where the first stage begins with analyzing the needs of students at the PGSD Study Program of STKIP Muhammadiyah Blora focused on students who will take mathematics courses, followed by developing HOTS-based mathematical models, followed by model validation, limited trials, research implementation and finally data analysis. This development research describes the use of HOTS-based models to improve students' mathematical problem solving abilities. The HOTS-based model is intended to accustom students to always think at a high level so that with this habit students have good problem-solving skills.

The results showed that the development of HOTS-based teaching materials could improve mathematical problem solving abilities. This is in line with the opinion of Zohar (2013) which states that by having Higher Order Thinking Skills a person will be able to learn, provide reasoning correctly (Creative Thinking), make decisions, and solving problem. This opinion explains that Higher Order Thinking Skills can improve several competencies, one of which is the ability to solve mathematical problems. This theory is in line with the opinion of Dinni (2018) which states that through Higher Order Thinking Skills, students will be able to distinguish ideas clearly, argue well, solve problems, construct explanations, hypothesize and understand complex matters. It becomes clearer where this ability clearly shows how students reason. From these two opinions it can be said that designing HOTS-based learning, mathematical problem solving abilities can be formed in students who use the HOTS-based model.

During the research implementation, the use of HOTS-based models had a significant effect on student learning activities. Learning becomes more productive, especially in socio-cognitive interactions, for example in terms of: (1) asking questions, increasing collaboration and group discussions among students, curiosity, increasing the ability to explain the concept of discussion results, completing assignments and exercises properly, and students are increasingly happy to solve the questions or problems given. All of these positive effects have a direct impact on the increase in students' mathematical problem-solving abilities which also have an impact on student learning outcomes.

The success of this research is supported by research that has been carried out before, including research conducted by Fanani (2018) with the results of the benefits or advantages of the HOTS assessment which is an increase in student motivation because the HOTS assessment connects the subject matter in the classroom with the real world context so that learning is more meaningful. In addition, the HOTS assessment can improve student learning outcomes because it can train students to think creatively and critically, namely the ability to think that does not just remember (recall), restate, or refer without processing (recite), and HOTS assessments can increase the achievement of student learning outcomes so that students are able to compete both nationally and internationally.
In addition, HOTS and its relation to mathematical problem solving abilities are also supported by the results of research conducted by Sumaryanta (2018) which states that assessments involving students’ HOTS abilities include critical, logical, reflective, metacognitive, creative, problem solving thinking skills. non-routine, non-algorithmic, analysis, evaluation, creating, involves “concept building, critical thinking, creativity / brainstorming, problem solving, mental representation, use of rules, reasoning, and logical thinking, and / or requires thinking to a higher level than just restating the facts. This means that when teaching materials are developed based on HOT, the automatic content in them contains mathematical problem solving abilities. Thus it can be concluded that the HOTS-based model development can improve students' mathematical problem solving abilities.

4. Conclusion
Based on the results of research and data analysis, the conclusion of this study is that the development of a HOTS-based model with the procedure using the Borg and Gall procedure can improve students' mathematical problem solving abilities. In addition, it was also obtained that the HOTS-based model could improve students' mathematical problem solving abilities with an average increase from 57.50 to 87.90, (3) from the results of the validity test by experts, both media experts and material experts, it can be concluded that the HOTS-based model is stated. valid with an average value of 78 or with a good or valid category. This means that the HOTS-based model is suitable to be used to improve students' mathematical problem solving abilities.

References
[1] Aydoğdu, M., & Ayaz, M. F. (2008). The Importance Of Problem Solving In Mathematics Curricu- lum. Physical Sciences, 3(4), 538-545.
[2] Bradshaw, Z., & Hazell, A. (2017). Developing problem- solving skills in mathematics: a lesson study. In- ternational Journal for Lesson and Learning Stud- ies, 6(1), 32-44.
[3] Dinni, H. N. (2018, February). HOTS (High Order Think- ing Skills) dan Kaitannya dengan Kemampuan Literasi Matematika. In PRISMA, Prosiding Semi- nar Nasional Matematika (Vol. 1, pp. 170-176).
[4] Fanani, M. Z. (2018). Strategi Pengembangan Soal HOTS Pada Kurikulum 2013. EDUDEENA, 2(1), 59-76.
[5] Fauziah, A. (2010, June). Peningkatan kemampuan pemahaman dan pemecahan masalah matema- tik siswa SMP melalui strategi REACT. In Forum kependidikan (Vol. 30, No. 1, pp. 1-13).
[6] Mataka, L. M., Cobern, W. W., Grunert, M. L., Mutam- buki, J., & Akom, G. (2014). The effect of using an explicit general problem solving teaching ap- proach on elementary pre-service teachers’ abil- ity to solve heat transfer problems. International Journal of Education in Mathematics, Science and Technology, 2(3), 164-173.
[7] Muruganantham, G. (2015). Developing of E-content package by using ADDIE model. International Journal of Applied Research, 1(3), 52-54.
[8] Sumaryanta, (2018). Penilaian HOTS dalam Pembelaja- ran Matematika. Indonesian Digital Journal of Mathematics and Education, 8(8), 500-509.
[9] Windari, F. (2014). Meningkatkan Kemampuan Pemec- han Masalah Matematika Siswa Kelas Viii SMPN
[10] Padang Tahun Pelajaran 2013/2014 dengan Menggunakan Strategi Pembelajaran Inkuiri. Ju- rnal Pendidikan Matematika, 3(2).
[11] Zohar, A. (2013). Challenges in wide scale implemen- tation efforts to foster higher order thinking (HOT) in science education across a whole wide system. Journal of Thinking Skills and Creativity, 10(2), 233-249