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DEVELOPING HOTS-BASED MATHEMATICS ASSESSMENT INSTRUMENTS TO IMPROVE CRITICAL THINKING SKILLS OF PROSPECTIVE ELEMENTARY SCHOOL TEACHERS

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Abstract

The current reality is that most teachers have not developed their students' Higher Order Thinking (HOTS) skills. This is because the teachers themselves do not understand HOTS well. This research aims to develop HOTS-based mathematics assessment instruments for prospective elementary school teachers. The type and model of research conducted is research and development (R n D), Borg & Gall model. The product developed is a 10-item HOTS question. The questions that have been compiled are validated by three validators. Valid questions were tested on students who took Mathematics Learning courses. The trial was conducted with the aim of determining the quality of the instrument using classical test theory, namely validity, reliability, difficulty index, and distinguishing power. The results showed that the HOTS-based mathematics assessment instrument met the criteria of a quality instrument, namely very valid, high reliability, with good differentiation and difficulty levels. Thus, the instrument developed is suitable to be used to measure the HOTS ability of prospective teacher students. From the results of the test analysis, it was found that the students' ability to solve HOTS-based problems obtained an average of 74.65 was in the moderate category and the results of the analysis of students' critical thinking skills obtained 62.89% also in the moderate category. So it can be concluded that students' ability to solve HOTS-based questions is directly proportional to students' critical thinking skills. Thus, it can be concluded that HOTS-based assessment instruments can improve the critical thinking skills of prospective elementary school teachers.

Keywords: HOTS, instrument, Critical thinking, Mathematics

Abstrak

Kenyataan saat ini sebahagian besar guru belum mengembangkan ketrampilan Higher Order Thinking (HOTS) siswanya. Hal ini disebabkan karena guru itu sendiri belum memahami HOTS dengan baik. Penelitian ini bertujuan untuk mengembangkan instrumen penilaian matematika berbasis HOTS bagi calon guru Sekolah Dasar. Jenis dan model penelitian yang dilakukan adalah penelitian dan pengembangan (R n D), model Borg & Gall. Produk yang dikembangkan berupa soal HOTS sebanyak 10 butir. Soal yang telah di susun divalidasi oleh tiga orang validator. Soal yang valid diujicobakan kepada mahasiswa yang mengambil mata kuliah Pembelajaran Matematika. Uji coba dilakukan dengan tujuan untuk menentukan kualitas instrumen dengan menggunakan teori tes klasik yaitu validitas, reliabilitas, indeks kesukaran, dan daya pembeda. Hasil penelitian menunjukkan bahwa instrumen penilaian matematika Berbasis HOTS memenuhi kriteria instrumen yang berkualitas, yaitu sangat valid, reliabelitas yang tinggi, dengan daya beda dan tingkat kesukaran yang baik. Dengan demikian instrument yang dikembangkan layak digunakan untuk mengukur kemampuan HOTS mahasiswa calon guru. Dari hasil analisis tes ujicoba diperoleh bahwa kemampuan mahasiswa dalam menyelesaikan soal Berbasis HOTS diperoleh rata 74.65 ini berada pada kategori sedang dan hasil aalisis kemampuan berpikir kritis mahasiswa diperoleh 62.89% juga pada kategori sedang. Jadi dapat disimpulkan kemampuan siswa dalam menyelesaikan soal Berbasis HOTS berbanding lurus dengan kemampuan berpikir kritis mahasiswa. Dengan demikian dapat simpulkan instrument penilaian Berbasis HOTS dapat meningkatkan kemampuan berpikir kritis mahasiswa calon guru Sekolah Dasar.

Kata kunci: HOTS, instrumen, berpikir_kritis, Matematika

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INTRODUCTION

Education is the most important aspect in building quality human resources, both from the affective (attitudes: spiritual and social), cognitive (knowledge), and psychomotor (skills) aspects (Arifin, 2017). Through education, it will be able to form creative, innovative and productive human resources. Facing the era of the industrial revolution 4.0 is not an easy matter. This must be welcomed by preparing human resources that are adaptive to the demands of the industrial revolution 4.0 era. The role of educational institutions, including universities, plays an important role in preparing human resources, namely by increasing the competence of graduates who have skills according to the demands of the 21st century (learning and innovation skills) in addition to mastering science and technology in accordance with their fields (Zubaidah, 2018). Because the 21st century trend focuses more on certain specializations, the objectives of Indonesian national education must be directed at equipping graduates with 21st century skills. The 21st century skills referred to are Communication, Critical thinking, Creative thinking and Collaboration (4C) skills. 4C skills are soft skills that in their daily implementation are far more useful than the mastery of hard skills. College graduates in addition to having hard skills are also required to have soft skills to succeed in their work (Arief, 2012).

One of the indicators of improving human resources (HR) in the education system is students with good Higher Order Thinking Skills (HOTS), because the main goal of learning in the 21st century is to develop and improve students' HOTS. HOTS has several aspects, including applying, analyzing, evaluating, and creating (Misrom et al., 2020). In addition, the 4Cs also include HOTS (Yusuf et al., 2020) and problem solving (Friyatmi & Elvi Rahmi, 2020). The basis of categorization includes critical thinking, creative thinking, metacognitive thinking and retrieval (Parlan, 2021) Based on the opinions of several experts above, in this study the representation of HOTS consists of 3 aspects, namely analyzing, evaluating, and creating. The use of HOTS assessment in education is an important issue that must be responded to by all educational actors (Johansson, 2020). To obtain quality instruments, in addition to theoretical analysis (reviewing items based on content, construction, and linguistic aspects) empirical item analysis also needs to be done (Rahmawati, 2022). Referring to Benjamin Bloom's (1965) opinion on HOTS levels in Bloom's taxonomy consists of analyzing, evaluating, and creating (Kilicoglu & Kaplan, 2022). In this taxonomy, students are required not only to understand

and apply mathematical concepts, but also to be able to analyze and solve in the right way, not even ruling out the possibility of finding new things or solutions.

The characteristics of HOTS questions are (1) measuring high-level thinking abilities, (2) contextually based and (3) using various forms of questions (Widana, 2017). Anderson and Krathwohl (2001) classify higher level thinking processes as creating, expressing and analyzing. So educators in creating HOTS questions must refer to the characteristics and stages of high-level thinking. Meanwhile, the steps that can be taken in solving HOTS questions are (1) analyzing the information in the question, (2) understanding the meaning of the question, (3) understanding the concept instead of memorizing, (4) creating the things needed to solve the question, (5) understand how to solve questions and (6) apply how to solve questions to get answers (Haryani, 2019).

One aspect of 21st century skills is critical thinking. This critical thinking ability is related to higher-order thinking or HOTS, creative, and metacognitive skills. Critical thinking is defined as "a cognitive talent that requires active thinking" and "a belief in the pursuit of truth based on problems to be solved with complete consideration and analysis. Critical thinking is also defined as rational and reflective thinking that focuses on making decisions about what to believe and do.

Critical thinking skills are thinking skills to solve problems or make decisions on the problems faced. This skill is absolutely necessary for everyone to be able to solve problems and make decisions on problems faced in real life. In addition, critical thinking skills include the ability to distinguish truth or lies, facts or opinions, or fiction and non-fiction. Critical thinking skills can be practiced in learning by challenging learners with contextual problems in everyday life (Johson, 2010).

Critical thinking is very important to achieve goals and be able to solve all problems faced in the real world (Subhi, 2023). Critical thinking skills cannot be formed suddenly, but requires a long process, one of which is through the learning process. Critical thinking skills must be developed when learning mathematics because critical thinking and mathematics are inseparable and interrelated. One example is the use of critical thinking to solve HOTS type problems. Because in general, many students dislike math because it is difficult to solve problems involving numbers and formulas that they find difficult to understand.

To improve critical thinking skills, there are several efforts that can be made, one of which is through learning that uses a Higher Order Thinking Skill (HOTS) based learning model. Educators must be able to develop and convert from learning that is still Lower Order Thinking Skill (LOTS) to Higher Order Thinking Skill (HOTS), and this must have started since designing the Semester Learning Plan (RPS), in the implementation of learning to providing assessment or evaluation (Amrina, 2022). However, in reality, there are still many educators who do not understand HOTS. This can be seen in the RPS made by educators, from the formulation of indicators, objectives, as well as learning activities and assessments that are not HOTS-based. Likewise, the implementation of learning is still LOTS-based. And also the assessment still gives questions at the LOTS level. For this reason, it is very important to develop HOTS-based assessment instruments so that lecturers and students are skilled in using and working on HOTS questions.

This study was conducted to develop HOTS-based mathematics assessment instruments that are valid, reliable, with differentiating power, and good difficulty levels to improve the critical thinking skills of prospective elementary school teachers. Previous studies (Partono et al., 2021) have never developed HOTS-based assessment instruments aimed at prospective elementary school teachers. In fact, prospective elementary school teachers will be the first to instill the concepts and foundations of higher order thinking skills. Therefore, prospective teachers should be able to develop and create an atmosphere and assessment instruments that can develop students' HOTS abilities. So that students not only remember and understand concepts, but also can analyze, synthesize, evaluate, and create a concept well. These skills will be used when students receive new information and store it to be used or rearranged for problem solving purposes.

METHODS

This research is a research and development (R n D) The development model used is the Borg & Gall model (dalam Sugiono, 2017). This model consists of ten main stages, namely: Research and information collection, Planning, Develop preliminary form of product, Preliminary field testing, Main product revision, Main field testing, Operational product revision, Operational field testing, Final product revision and Dissemination and Implementation (Ali & Asrori, 2014). Of the 10 stages, this research will only apply five stages,

namely: Research and Information collection, Planning, Develop Preliminary form of Product, Preliminary Field Testing and Main Product Revision. Each stage will be carried out as follows:

1. Research and Information Collection

At this stage of the research, a literature review relevant to the criteria of HOTS questions was conducted. HOTS questions are questions at the C4 (Analyze), C5 (Evaluate), and C6 (Create) cognitive stages referring to the revised Bloom criteria (Kim; 2019, Saravanan 2021).

2. Planning

At this stage, the Semester Learning Plan of the Elementary Mathematics Learning course in the Elementary School Teacher Education Study Program was analyzed. Furthermore, the indicators that will be created for the HOTS assessment instrument are determined. The selected indicators cover all materials in the Elementary Mathematics Learning course.

3. Develop Preliminary form of Product.

At this stage, the design of HOTS-based assessment instruments for elementary school teacher candidates was carried out, which consisted of instrument grids, HOTS questions totaling 10 items, completion keys and scoring guidelines. The assessment instrument is in the form of a description that is prepared in accordance with the method of preparing a quality instrument. Scoring guidelines are prepared based on the method of assessing an instrument, where the weight is given higher if the question is a difficult question, or takes a long time to work on or contains extensive material coverage. At this stage, a questionnaire was also prepared to validate the instrument. The questionnaire consists of a series of questions that will be given to experts (construct validators) to validate the assessment instrument developed. Instrument is said to be valid if it measures what should be measured (Amrina: 2022). Validation of this instrument is carried out by three experts, the results of this validation will obtain qualitative data and quantitative data. Quantitative data will be analyzed using the percentage formula and qualitative data is used to revise the instrument developed. The validity criteria used use the following criteria (Amrina et al., 2022).

Table 1: Validity Score Criteria

Validity Scale (%)	Validity criteria	information
85-100	Very valid	Can be used without revision
70-84	Valid	Can be used with minor revisions
55-69	Fairly valid	Partially revised

50-54	Less valid	Revised according to validator suggestions
0-49	Invalid	Cannot be used

4. Preliminary Field Testing

The test subjects of this research were 39 students who took the Mathematics Learning course. The products developed were tested on prospective elementary school teacher students who were the test subjects. The trial was conducted with the aim of determining the quality of the instrument using classical test theory. According to the view of classical test theory, empirically the quality of items is determined by item statistics which include validity, reliability, difficulty index, and question differentiation. Data analysis was carried out with the help of Microsoft excel application. The results of the overall instrument analysis can be categorized as follows (Amrina et al., 2022):

Table 2. Classification of Item Quality

Category	Assessment Criteria
Good	If (1). The difficulty level is $0.25 \leq p \leq 0.75$ and the item differentiation index ≥ 0.40 and validity >= 70
Revised	If (1). Level of difficulty $p < 0.25$ or $p > 0.75$ but Item discriminating power index ≥ 0.40 or Difficulty level $0.25 \leq p \leq 0.75$ and the item discriminating power index is between 0.20 to 0.30 and the validity index is > 50
Not good/question discarded	If (1). The difficulty level $p < 0.25$ or $p > 0.75$ and Item differentiability index < 0.20, and validity index < 50

In accordance with the quality criteria of the question, a question reliability analysis is carried out, to see the quality of the question's determination. The formula used is Cronbach Alpha (Amrina et al., 2022). The reliability index obtained will determine the determination of the questions developed.

RESULTS AND DISCUSSION

This study aims to produce HOTS-based assessment instruments in Mathematics Learning courses in the PGSD study program at FKIP Bung Hatta University to improve students' critical thinking skills. The results of the analysis of the instrument product trial consisting of the validity test, the test of the difficulty level of the question, the test of the

distinguishing power of the question and the reliability of the question are described as follows.

Instrument Validity Results

Based on the results of the data analysis of the construct validity test (content) of 10 items developed from 3 validators, the results are as shown in table 3 below

Table 3: Construct Validity Results

No	Validator	Score	Validity Value	Criteria
1	Validator 1	36	90%	Very Valid
2	Validator 2	38	95%	Very Valid
3	Validator 3	35	87,5%	Very Valid
	Rata-rata	36,33	90,83%	Very Valid

Because the results of the construct validation analysis show very valid criteria, the suggestions given by validators related to sentence structure and incorrect and inappropriate writing are used as a basis for improving the instrument. Furthermore, after the questions were corrected according to the validator's suggestions, the questions were tested on 39 prospective elementary school teacher students who took the Mathematics Learning course. The test aims to determine the index of the difficulty level of the question, the differentiating power of the question and the reliability of the instrument developed. The results of the analysis of the test results are presented in the following description.

From the results of data analysis, it is calculated that the validity of the items after being tested is obtained as shown in Table 4 below.

Table 4. Results of the Problem Validity Test

No	Validity	Category	Number of Questions
1	0,80 – 1,00	Very High	2
2	0,60 – 0,80	High	6
3	0,40 – 0,60	Fair	2
4	0,20 – 0,40	Low	0
5	0,00 – 0,20	Very Low	0
6	$\leq$ 0,00	Invalid	0

From the analysis, it was found that all questions were valid for use, where 8 questions were already questions with a high validity index.

Results of Problem Difficulty Level Analysis

A good question is one that is not too easy and not too difficult. HOTS questions are not difficult questions but because they are required to think at a high level, HOTS questions tend to be difficult. The results of the analysis of the question difficulty index can be presented in the following table.

Table 5. The results of the analysis of the question difficulty index

No	Difficulty Index	Category	Number of Questions
1	0,00 – 0,30	difficult	6
2	0,31 – 0,70	Fair	2
3	0,71 – 1,00	Easy	1

From the results of the test analysis, the majority of the questions developed were indeed in the difficult category. This can be understood that HOTS questions do require a high level of ability of students to be able to solve From this data it can be seen that most students are indeed at a moderate level of thinking ability.

The results of the question differentiator analysis

The differentiating power of questions is the ability of questions to distinguish between students who are good and those who are not good. The results of the analysis of the differentiating power of the HOTS questions developed are presented in table 6.

Table 6: Results of the question differentiator analysis

No	**Distinguishing Power Index**	**Category**	**Total**
1	0,00 – 0,20	Bad	0
2	0,21 – 0,40	Fair	1
3	0,41 – 0,70	Good	6
4	0,71 – 1,00	Excellent	3

From the results of the analysis of the validity of the questions, the index of difficulty of the questions and the differentiating power of the questions, it shows that the HOT questions consisting of 10 items show that the 10 items developed are in the category of good questions based on the criteria in table 2. This shows that HOTS questions consisting of 10 items can be used to measure the higher order thinking skills of prospective teachers in the Elementary School Teacher Education program at FKIP Bung Hatta University.

Results of Problem Reliability Analysis

After analyzing to determine the question reliability index, the instrument reliability index is 0.64. These results indicate a question reliability index in the high category. So it can be concluded that the HOTS-based mathematics learning assessment questions consisting of 10 items can and should be used to measure the high-level abilities of prospective elementary school teachers.

Furthermore, if we consider the scores obtained by students in solving HOTS-based questions, the average score is 74.65. This is in the good category. This means that the ability of prospective elementary school teachers in solving HOTS questions is in the moderate category.

Furthermore, the analysis was conducted to determine the critical thinking skills of students. The analysis was carried out based on indicators of critical thinking skills according to the difficulty of the question 60% of the questions were categorized as difficult questions. We can see how the students' critical thinking skills are in working on these HOTS-based questions. This can be seen from the indicators of their critical thinking skills. Critical thinking skills can be viewed from several aspects.

Ability to Formulate Problems

The first indicator observed is the ability of students to formulate problems. Based on the analysis of student test results, the ability to formulate student problems obtained a percentage of 71.22%. Of course, this result has not achieved what is desired, although it is classified as high. The problem arises because they do not understand the meaning of the problem and are less able to analyze the right solution to solve the problem in the problem.

Problem Solving Ability

The aspect observed in this indicator is the students' ability to find the right solution in order to solve the problem. Students' ability to solve problems in the problem obtained a percentage of 63.36%. This happened because they were unable to find information related to problem solving, forgot the initial concept and could not determine the right solution used to solve the problem.

Ability to Draw Conclusions

The aspect observed in this indicator is the ability to think that utilizes the knowledge gained from learning to be able to produce an understanding or conclusion. Students' ability to draw

conclusions obtained a percentage of 61.75%. This is because many students do not make conclusions from the problem solving they have done. This can be caused by forgetting or not.

Ability to Provide Argumentation/Explanation

The aspect assessed in this indicator is how students can explain how to get answers from problem solving so as to get the correct final result. The achievement obtained by students is only 51.11%. This achievement is classified as low. This is because they are only able to work on solving problems based on algorithms. But they were not able to explain every step of the solution.

From the four indicators of students' critical thinking skills, it can be concluded that the average critical thinking skills of prospective teacher students are presented in the following table.

Table 6: Students' Critical Thinking Ability

Critical Thinking Ability Indicator	Percentage	Category
The Ability to Formulate Problems	71,22%	High
Problem Solving Ability	63,36%	Fair
Ability to Draw Conclusions	61,75%	Fair
Ability to Provide Argumentation / Explanation	51,11%	Low
Average	62,89%	Fair

Thus it can be concluded that the percentage of students' critical thinking skills is 62.89% which is in the moderate category. This is in line with the students' ability to solve HOTS questions also in the moderate category.

CONCLUSION

Based on the results of data analysis and discussion previously described, it can be concluded that the HOT-based mathematics learning assessment instrument developed has valid criteria, the majority difficulty index is difficult, the majority differentiating index is good and the reliability index is high. So that it has met the criteria of a good quality instrument and it can be used to measure the HOTS abilities of prospective teacher students. When viewed, the HOTS ability of students who take mathematics learning courses PGSD FKIP Bung

Hatta University is in the medium category. This result is in accordance with the level of critical thinking skills which is also in the medium category.

From the conclusions obtained, it is suggested to the next researcher to develop HOTS-based instruments on other mathematics materials.

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