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Developing Mathematics HOTS Test Items in Essay

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Abstract. This research aimed to develop Mathematics HOTS test items in essay type in improving mathematical communication of tenth grade Science students in Senior High School. Research Development was applied as the research method. The Research Development used in this research was Thiagarajan, Semmel and Semmel model consisting of defining, designing, developing, and disseminating in developing qualified mathematics learning test instrument. In this research, the expert judgements by mathematics lecturer and teacher were conducted toward the developed instruments. There were field trials conducted for empirical validity. The field trials involved tenth grade Science students in 11 State Senior High School. Data analyzing technique used qualitative analysis to interpret the result of the expert judgments and quantitative analysis to test item validity and instrument reliability containing the developed test items. Furthermore, among seven HOTS test items for mathematical communication skill that were written, there were resulted three HOTS test items for mathematical communication skill which were valid, reliable, and practical.

1. Introduction

Education plays a role in building and improving the quality of human resources, therefore education must build intelligent, creative and innovative people. [1] Such as knowledge of pedagogical content, as given or using only logical arguments to support claims about the existence and role of this domain [2]. The quality should always be developed and improved considering the existence of this globalization, where science is very rapidly developing. Improving the quality of education from various aspects of the learning process should be started from the purpose of the goal and strategy to the assessment instrument of learning outcomes.

After learning mathematics, students must be able to think and reason mathematically, solve problems and be able to communicate what they learn. Teachers as facilitators should be able to facilitate students in learning mathematics so that competence or ability can be achieved well. In addition, the teacher should use strategies that encourage students to think high level, the tests made by teachers must also facilitate the development of high Order Thinking Skills/HOTS. Higher order thinking problems can encourage students to think deeply about the material being studied [3].

Competencies that students must have after learning mathematics, among others; able to think and reason mathematically, solving problems and communication [4]. Teachers as facilitators should be able to facilitate students in learning mathematics so that competence or ability can be achieved well. HOTS cannot be directly taught to students. Students must be exposed to these learning activities support HOTS development [1]. In addition, the teacher should use strategies that encourage students



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to perform high order thinking skills; the tests made by teachers must also facilitate the development of high Order Thinking Skills/HOTS. Higher order thinking requires students to apply newly acquired knowledge and use that knowledge in solving problems in new situations [3].

According to Husna Nur Dini [5] through high order thinking students can distinguish ideas or ideas appropriately, argue well, be able to solve problems, be able to construct explanations, are able to hypothesize and understand complex things to become clearer, where this ability clearly shows how students learn. High-level thinking is that thinking is not always algorithmic and complex which often results in multiple solutions [6]. Therefore high order thinking skills can improve mathematical literacy skills. Competence in mathematics is not only limited to the ability to count, but also how to apply mathematics in everyday life in solving a problem, the ability to communicate an idea, which shows the student's mathematical thinking process. Mathematical literacy requires a person's ability to solve problems in everyday life.

According to Husna Nur Dini [5] through high order thinking students will be able to distinguish ideas or ideas in a clear, well-argued, able to solve problems, able to construct explanations, be able to hypothesize and understand complex things to be more obvious, where this ability clearly demonstrates how the learners reason. Solving problems requires higher order thinking, which requires students to interpret, analyze or manipulate information [7]. Therefore high order thinking skills can improve mathematical literacy skills. Math skills are not only limited to counting ability, but also how to apply mathematics in everyday life to solve a problem, how to communicate it, so it can be seen how the student's mathematical thinking process. Mathematical literacy takes some time in completing daily life. Kemdikbud [8] stated that the low achievement of Indonesian students in TIMSS (Trends in International Mathematics and Science Study) can be caused by many test materials that are not yet in the Indonesian curriculum. In Indonesia, students are less trained in solving contextual problems, which require reasoning, argumentation, and creativity in solving them. From these results demonstrate the importance of the role of teachers in enhancing the skills of mathematics and high student Thinking skills [9]. In 21st century learning, there is a change in the competencies needed by students. Students in the 21st century are required to be able to analyze environmental problems around them and not only memorize concepts [1]. The fact that is happening in the school, test questions tend to be more just to test the aspect of memory when some standards of competency (SK) and basic competencies (KD) on the subject of mathematics can be developed about HOTS [10].

A test is a systematic and objective tool or procedure for obtaining the desired data or information in a precise and fast way [11]. Test results of mathematics learning as a data collection tool aims to determine the achievement of students mathematics learning competency. The test was made by the teacher following quality test criteria. Each test or assessment carried out by the teacher must measure the learning material and apply HOTS elements [12]. Quality tests can encourage students to have a high level of thinking skills. The teacher's ability to develop tests needs to be continuously developed to improve the quality of education and human resources. Besides, higher order thinking skills have a relationship with teacher cognitive learning [13].

Based on the description above, this study will develop Hots math test items in the form of descriptions, to improve the mathematical communication skills of class X students. This research was conducted in the school which is the pilot project HOTS, which produces a form-shaped test device to improve the ability of mathematical communication.

2. Methodology

2.1. Types and Data Sources

This research is research development. This development research refers to Thiagarajan, Semmel and Semmel development models [14] consisting of four stages:

- 1) Define, design, develop, and disseminate. The development activities of authentic assessment instruments in this study only reached the third stage of development. The define stage includes preliminary analysis, material analysis, student work analysis, and competency achievement indicator formulation.
- 2) The design stage includes the selection of formats and the preparation of instruments.
- 3) The development stage includes expert validation and empirical validation.

4) Deployment stage.

The subjects tried in this study were high school students grade X as many as 140 students (4 classes), SMA N 11 Yogyakarta. The number of test items developed was 7 HOTS descriptions to improve mathematical communication skills.

Before testing, Before the test is tested, the test is analyzed for its theoretical validity. Validation was carried out in relation to the contents and constructs of the tests being developed. After the test was tested on a limited scale, students' answers were analyzed to obtain empirical validation. This validation aims to determine valid test items and reliable instruments. Once a valid and reliable test item is obtained, the test device is tested again on a broad scale; this step is taken in order to obtain a valid and reliable HOTS test device. The result of the development of HOTS question is a question device consisting of a grid and HOTS question in the form of a description that meets valid and practical criteria.

2.2. Data Analysis

2.2.1. Product Validity Analysis

The validity assessment aspect is performed by the validator, if the data analysis results do not meet the valid category in this study is considered to revise the test instrument before testing.

2.2.2. Product Practicality Analysis

The practicality aspect of the developed product consists of data on teacher assessment results and student assessment. In general, the analysis of the data is done by grouping the data and then performing the average score calculation.

2.2.3. Product Effectiveness Analysis

The results of the mathematical communication skills test are said to be completed individually if it reaches the Minimum Completion Criteria (KKM) set by the school which is 75.00. Classical completeness is achieved if at least 75% of students achieve individual completed criteria, so it can be said that mathematical test instruments are effective. In addition to classical completeness, test results are also analyzed based on each indicator of mathematical communication ability. The table of the criteria for mathematical communication skills is shown in Table 1 below:

Table 1. HOTS Criteria (Mathematical Communication Capability)

Score	Criteria
$80,0 < \bar{M} \leq 100,0$	Excellent
$60,0 < \bar{M} \leq 80,0$	Good
$40,0 < \bar{M} \leq 60,0$	Enough
$20,0 < \bar{M} \leq 40,0$	Less
$0,0 < \bar{M} \leq 20,0$	Very lacking

An effective test if the average score of every aspect of critical thinking skills as a whole has at least reached the "good" criteria.

3. Results

Table 2. Relationship between HOTS Indicators and Mathematical Communication Capability Indicators

No	HOTS indicators	Mathematical Communication Capability Indicators
1.	identify and associate relevant information from a situation/issue	Connect real objects, images and diagrams into mathematical ideas
2.	make an appropriate conclusion based on the information of a situation/ problem,	Explain ideas, situations, and mathematical relationships or text with real objects graphic images or algebraic shapes
3.	Finding consistency/ inconsistencies in an operation/product,	Can declare the events of daily life into symbols or mathematical languages
4.	assess a relevant operation/product based on criteria/standards,	Listen to discussions and write about mathematics
5.	ideas/strategies to solve a problem,	Reading with the understanding of a written mathematical presentation
6.	using the right ideas/strategies to solve a problem,	Conjecture compose arguments, formulate definitions, and generalize
7.	develop or create new alternatives to solve a problem	Re-disclose a mathematical description or paragraph in its own language

The results showed that:

3.1. Valid

The results of the validation of the experts, it is known that the appropriate mathematical communication skills test items are used are shown in the following table:

Table 3. Expert validation results on question items developed

Criteria	Item Number	Description
Worth using	1, 2, 3	In accordance with the item indicator on mathematical communication capabilities and HOTS
Not Worth using	5	Not compliant with HOTS
Not Worth using	6, 7	Not in accordance with Mathematical Communication Capability Indicators

From the table above it appears that only 3 questions match the indicators of mathematical communication capabilities and HOTS criteria (points 1, 2 and 3) while point 5 does not match hots criteria and point 6, 7 does not match the indicator of mathematical communication ability.

Empirical Validity

Table 4. Validity and reliability of question items

Question Item	Validity	Reliability
1	0,764	
2	0,748	0,786
3	0,768	

3.2. Practical

From the analysis of student responses and the results of interviews with math teachers and some students can be concluded that the test questions developed are stated as practical.

3.3. Effectiveness

Table 5. Percentage of each Mathematical Communication Capability Test Indicator

No.	Mathematical Communication Capability Indicators	Percentage
1	Connect real objects, images and diagrams into mathematical ideas	90,1
2	Explain ideas, situations, and mathematical relationships or text with real objects graphic images or algebraic shapes	85,22
3	Can declare the events of daily life into symbols or mathematical languages	86,44
4	Listen to discussions and write about mathematics	84,1
5	Reading with the understanding of a written mathematical presentation	84,05
6	Conjecture compose arguments, formulate definitions, and generalize	83,57
7	Re-disclose a mathematical description or paragraph in its own language	79,41

From table 5, it can be concluded that the students' mathematical communication skills are complete, meaning that the test items developed are effective.

3.4. Trial results

In order to reveal the students' mathematical communication skills, the answers of students were analyzed. The results were shown in Table 6.

Table 6. Analysis of each indicator of mathematical communication skills

Indicators	Item Score			Total Score	Criteria
	1	2	3		
Connect real objects, pictures, and diagrams into mathematical ideas	81	95,2	94	90,09	High
Explain ideas, situations, and mathematical relations relationships or text with real objects graphic images or algebraic shapes	75,5	93,2	87	85,22	High
Can declare the events of daily life into symbols or mathematical languages	81	92,7	85,5	86,44	High
Listen to discussions and write about mathematics	81,3	88,8	82,1	84,04	High
Reading with the understanding of a written mathematical presentation	81,1	87,1	83,9	84,06	High
Conjecture compose arguments, formulate definitions, and generalize	80,2	88,2	82,3	83,57	High
Re-disclose a mathematical description or paragraph in its own language	73,4	81,8	83	79,40	High

Development of HOTS test items to improve mathematical communication skills of class X SMA students, learning materials to solve contextual problems related to angular trigonometric ratios in various quadrants and related angles, through the stages of making test grids, compiling questions and asking validation experts to see the suitability of the items with the achievement of indicators of mathematical communication skills and HOTS criteria. The analysis of the answers to the test questions and the results of the interviews resulted in 3 (three) HOTS test questions that were valid,

reliable, practical and effective to improve the mathematical communication skills of class X SMA IPA students.

4. Conclusions

The development of HOTS question points to facilitate mathematical communication capabilities is carried out by establishing basic intelligence, achievement indicators, creating grids, fielding questions, expert validation, revision and trial of question and analysis and interview items. In the development of this item about mathematical communication capabilities, 3 (three) question points are produced that meet HOTS criteria, valid, reliable, practical and effective.

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