Developing Test Instruments for Measurement of Students’ High-Order Thinking Skill on Mathematics in Junior High School in Makassar

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Abstract. This study aims to determine the procedure and to assess the quality of test instrument development to measure students’ high-order thinking skill on mathematics in Junior High School in Makassar. The type of this research is a Research and Development with formative research model through 4 phases: preliminary, self-evaluation, prototyping and field test. The research subjects were the students of class VIII Junior High School in Makassar. The results of the instrument validity test was valid because in CVI (Content Validity Index) and CVR (Content Validity Ratio) the total average score was 1 with category very appropriate or at the interval 0.68 - 1.00. The result of student response test is 68.5% on positive category because more than 50% students responded positively. The reliability test indicated that the total average score was 0.923 with very high category (reliable) because it was at the interval 0.80<r_{11}≤1.00. The analysis of level of difficulty indicated that the total average score was 0.41 with medium category because it was at the interval 0.31-0.700. The average score of the analysis of differentiator power was 0.30 with sufficient category because it was at the interval 0.20<Δp≤0.40, and the analysis of measuring high-order thinking skill denoted that there were 14.71% included in good category, 38.24% in sufficient category, 32.35% in less category, and 14.71% in very less category that it produced the total average score 40.39 in sufficient category because 40 < (x) total score ≤60. Therefore, it is concluded that the students’ high-order thinking skill at Junior High School in Makassar Makassar was in sufficient category.

Keywords: Test Instruments, High-Order Thinking, Mathematics

1. Introduction
Mathematics is a lesson training students to develop and improve logical, critical, and creative thinking. The education curriculum in Indonesia places mathematics as a compulsory subject that must be given to elementary until high school students [1]. Mathematics is the study of interrelated patterns and relationships, ways of thinking with organizational strategy, analysis and synthesis, art, language, and tools to solve practical and abstract problems [2]. Mathematics is basically a systematically organized and structured science that can help people to do an activity through generative, dynamic and active processes. Mathematics as a science is very important to lean by students because it can develop the high-order thinking skill.

High-level thinking skill is a critical thinking process and creative thinking ability. High-order thinking skills ability to solve problems/make decisions on new situations by connecting
interconnected information, manipulating and transforming new and old knowledge and experiences for critical and creative thinking [3]. To measure the high-orderthinking skills requires an instrument to train students' thinking skills that include logical, systematic, critical, and creative thinking.

The survey results of Trends International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA) measures the ability students of 15 year olds in literary reading, math, and science. At PISA in 2015, Indonesia ranks 69 out of the 76 countries studied. Trends in International Mathematics and Since Study (TIMSS) Report in 2015 that Indonesian students of junior high school are ranked only 36 out of 49 countries in terms of performing scientific procedures, Indonesia's score in mathematics was 386. This indicates that ability of Indonesia's students on mathematical to solve problems complex involving high-level thinking processes, such as critical thinking and creative thinking was still relatively low.

The result of the analysis indicated that the questions made by teachers at Junior High School in Makassar is more dominated by questions measuring the low level skill that is remembering (C1), understanding (C2) and applying (C3) levels and less questions found measuring the high-order thinking skill, analyzing (C4), evaluating (C5), and creating (C6).

It is necessary therefore to develop a measurement tool to measure students' critical and creative thinking by developing the measurement tool/instrument so as to measure the students' high-orderthinking skill. Several studies related to the development of test instruments to measure high-order thinking skills have been undertaken by [4]–[8]. The research is also to improve students' reasoning and critical thinking skills.

High-level thinking is a thinking activity that does not simply state the facts, but the more important is what to do to the facts. So the first thing to do is to understand the facts, then connect the facts, categorize the facts, manipulate the facts and use them in new situations to obtain new solutions to problems [7], [9]. High-order thinking skill is a non-algorithmic and complex way of thinking to solve a problem (task) different from the existing examples by using different and unpredictable approaches [5]. Another opinion suggests that high-order thinking skill is a skill an ability when one be able to connect new information and old information in his memory, then connecting the information and submitted them to obtain the expected answer [6], [10]. Based on the opinions of the experts above, it can be concluded that the high-order thinking skill is an ability to solve problems/make decisions by associating new and old knowledge by connecting existing facts, then manipulating and converting and then using them together to obtain completion of the new situation.

2. Research Method

The type of this research is a research of developing Research and Development with formative research model through 4 (four) phase that is preliminary, self-evaluation (curriculum analysis, analysis of students, material analysis) and design, prototyping (validation, evaluation and revision) and field test (field trials). The development procedure [5] in this study are as follows:

![Figure 1. Procedure of Test Instrument Development](image)

The experimental subjects used in this research are students of grade VIII Junior High Schools
(SMP) in Makassar. The test instrument is mathematics test for grade VIII of SMP that meets the criteria of Blooming Taxonomy of type of analysis, evaluation, and creative.

3. Research Result

3.1 Test Instrument Development Process of HOTS

The test instruments development to measure high-order thinking skill passes through a series of development phases of formative research type from preliminary, self-evaluation, prototyping, to field test so as to produce a product. The preliminary phase is the initial phase or preliminary development process. At this phase, the researcher collects references about the test instruments to measure the high-order thinking skill. Bloom's Taxonomic Theory explains that high-order thinking skill is classified into three cognitive domains: analyzing, evaluating, and creating. In addition it determines the place of research trials.

The next phase is self-evaluation. At this phase the researcher conducts curriculum analysis, student analysis, material analysis, and designs and develops test instruments to measure high-order thinking skills such as grids, test questions, answer keys, and assessment guides, as well as other research instruments. Then the results of the development of high-level thinking skills tools are consulted with supervisors so as to produce Prototype I.

The next phase is the prototyping phase which includes assessment by experts, one-to-one, and small group. The developed test instrument is validated by the validator. The assessment results from the validator are then tested to the three students (one-to-one). It is intended to know the legibility of the questions and students’ assessment on the test instrument of high-order thinking skill. The results of the assessment from validator and one-to-one are then used to revise Prototype I which will result in Prototype II. Then Prototype II was tested on 6 students (small group). The results from the small group are then used to revise Prototype II which will produce Prototype III. Prototype III will then be used in field trials (field test).

The field test phase is a trial test in field where the test instrument that has been developed is given for a test to research subject, the students in Junior High School in Makassar. At this phase the data is obtained to measure the validity of each question, the questionnaire, reliability, difficulty level, and differentiator power and to know the results of high-order thinking skill.

4. Quality of Test Instrument

Quality of the developed instrument is validated both in content, construct and empirical. Content and construct validation was done by Ali in Mathematics and Measurement in education. Content validity test is done by using Content Validity Ratio (CVR) and Content Validity Index (CVI). The results show that there are 4 items to be revised because the CVR value generated ≤ 0.99. The items are number 1, 2, 5, and 12. This revision was done with the suggestion of validator and then re-validate the content to obtain the appropriate test instrument.

The result of the second content validity shows that the 15 items examined by validator have supported the content validity test. From the results of CVR (Content Validity Ratio) is then generated the value of CVI (Content Validity Index) which is the average of CVR of all items is 1, meaning that all items of the instrument are very suitable in measuring the high-order thinking skill.

5. Questionnaire Test of Students Respond

The result of questionnaire test of students response related to the test instrument of high-order thinking skill is presented in the following table:

| Test          | Positive Respond | Negative Respond |
|---------------|------------------|------------------|
| One-to-one    | 75%              | 25%              |
| Small group   | 62.5%            | 37.5%            |

Table 1. The Result of Student Respond Questionnaire
The table of students’ response in questionnaires above show that in the test of one-to-one obtained the average of student's positive response 75% and the average of student's negative response is 25%. In small group test the average of students' positive response is 62.75% and the average of students negative response is 37.5%. So the average of student's positive response is 68.5% while the average of students negative response is 31.25. So the student response in questionnaires meets the "achieved" criteria and there is no improvement/revision of the test instrument to be developed as more than 50% of the students who responded positively. Analysis of the instrument reliability test uses Cronbach's Alpha formula. The instrument reliability analysis of high-order thinking skill result in values of 0.923 and it is at "very high" level.

The analysis of difficulty level quantitatively, based on the result of the analysis of questionnaire items in terms of the level of difficulty of the test instrument of high-order thinking skill it is known that of the 15 items there are 3 items of easy categories, 6 items of medium category, and 6 items of difficult category. The average result of the difficulty level is 0.41. Thus the difficulty level of the developed test instruments has medium quality. Instrument items are said good when the test items have a difficulty level at the interval of 0.31-0.71. This indicates the items are not too difficult and not too easy.

The analysis of differentiator power of questions becomes one indicator of the HOTS quality questions that is developed. The result of the differentiator power analysis indicates that the average result of differentiator power is 0.30, with sufficient quality of developed differentiator power. Items of the Instrument can be said good when they have a differentiator power >0.20.

The result of data analysis to measure the high-order thinking skill above shows that from 34 students there are not students performing high-order thinking skill, 5 students (14.71%) included in category of having high-order thinking skill of good category, 13 students (38.24%) included in sufficient category, 11 students (32.35%) included in less category, 5 students (14, 71%) included in very less category. So the average the students high-order thinking skill is 40, 39 with sufficient category.

6. Conclusion

Procedures to develop the test instrument of high-order thinking skill follow four phases, (1) preliminary, (2) self valuation, (3) prototyping, and (4) field tests. The research result showed that the test instrument developed invalidity test of each question is valid because in CVI and CVR the total average score is 1 with the category very appropriate, the results of the questionnaire test the students’ response meet the criteria, the results of reliability test total average score is 0.923 with very high category (reliabel), the result of difficulty level analysis the total average score is 0.41 with the medium category, and the result of the difference power analysis the total average score is 0.30 with sufficient category and the result of analysis of measuring the students’ high-order thinking skill the average total score is 40.39 with sufficient category because 40 <x ≤60. Thus, it can be concluded that the test instrument of high-order thinking skill of the students of SMP Makassar is in sufficient quality.

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