Development of Test Instrument Based Realistic Mathematics Education to Improve High Order Thinking Skills

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Abstract. Based on result of PISA 2015 in mathematics showed that characteristics of learning mathematics Indonesia students still used to the Lower Order Thinking Skill. Based on it, developed test instrument becomes important. This Research aims to develop and produce a test instrument based on realistic mathematics education to improve the high order thinking skills for grade VIII students. The type of research is a development research (Research & Development), where this research using the ADDIE model. ADDIE consist five stages: Analysis, design, development, implementation and evaluation. This research was conducted in one of the junior high schools in Medan. The result showed that the quality of test instrument had been successfully developed from validity aspect, practicality aspect and effectiveness aspect.

1. Introduction
Challenges in this 21\textsuperscript{st} century that require student to develop competitive skills that focus on develop high order thinking skills. The most recent revision in the 2013 Curriculum focused on improving two major parts of the curriculum, namely content standards and assessments standards. The assessments standard are carried out by adapting international standards assessments models gradually which mean assessment of learning outcomes focuses more on higher order thinking skills.

Based on TIMSS and PISA assessments, Indonesia still has very low scores, which means that Indonesia students as human resources are not yet at the good stage. To increase the quality of education, it can be improved through the quality learning, one of which is the learning process that has learning resources, learning implementation plans, student activity sheet and questions that are used as good student assessment instrument. To improve the quality of learning in Indonesia, it can be started as early as possible, one of which is by training students to use questions that require high order thinking so that Indonesian students are also able to compete with other countries in TIMSS and PISA assessments and improve student abilities according to the 2013 Curriculum, where learning in the curriculum has referred to TIMSS and PISA.

From the result of observations made by researchers on student of junior high school Muhammadiyah 47 Sunggal make the evidence stronger that students’ high order thinking skill are still low. The ability of students at level of analyzing was in the sufficient category by 74\%, but at the evaluation level was in the very low category by 40\%, and the ability to create was in the low category.
by 43%. With the overall average ability of students in the less category by 52.33%. Beside that, the test instruments used by the teacher to students had not required students to think at high level. In this case, learning activities are needed that can improve students’ high order thinking skills. One of approach that can improve student’s high order thinking skills is a realistic mathematic education. Based on the problems mentioned above, it be urgency for to have teaching materials innovations, one of the innovation that can done is developing instrument test based realistic mathematics education.

2. Theoretical Review

2.1. Test Instrument

The test instrument is a tool used by a person to collect information about the achievement of students in the learning process which has certain standards so that it can be used widely, the results of which can be used as a basis for decision making. The aims of test instrument from Basuki’s and Hariyanto’s 2014 statements consist four point: (1) Obtaining feedback on learning outcomes, (2) improving the curriculum and education programs, (3) increase student motivation, (4) carry out diagnosis and remedial. The characteristics of a good test according to Arikunto’s 2013 can be said to be good as a measuring tool that must meet the requirements of the test, there are validity, reliability, objectivity, practicality, and effectiveness.

2.2. High Order Thinking Skills

One of the taxonomies known in education is Bloom’s taxonomy. According to Bloom’s revised taxonomy, cognitive processes can be divided into two, there are low order thinking skill and high order thinking skill. Low order thinking skills level involve remembering (C1), understanding (C2), and applying (C3), while in high order thinking skills level involve analysing (C4), evaluating (C5), and creating (C6) (Anderson and Krathwohl, 2001: 30). According to Brookhart’s (2010:5) statement, high thinking level means the ability of students to connect learning with other things that have never taught. High order thinking skills require a person to apply information to reach possible answers in new situations (Heong, et al, 2001: 121). High order thinking occurs when someone acquires new information and is stored in memory and associates and rearranges and expands the information to achieve goals or find possible answers in confusing conditions (Lewis and Smith. 1993: 136). HOTS is a higher way of thinking than memorizing facts, presenting facts, or applying rules, formula and procedures. HOTS require that we do things based on fact. We have to understand them, connect facts, categorize, manipulate, put into new things, and apply them to find solutions to new problems (Thomas and Throne, 2009: 1). Indicator of high order thinking skills refers to revision Bloom’s taxonomy namely, analysing (C4), evaluating (C5) and creating (C6).

2.2.1. Characteristics High Order Thinking Skills Problems

According to Resnick’s statement (1987:34) defines the characteristics of high order thinking skills, namely non-algorithmic in which the direction of determining the answer is not specific. Problems that involve high order thinking process tend to be complex and have many solutions, so it can be said that the HOTS type of questions is one of them is an open-ended, involves opinions and interpretations in solving problems, and involves mental work such as elaboration and various kinds of things and requires high consideration an effort. High level questions require student to do something more than just memorize previously learned information. An important characteristics of high level question is that questions require more that remembering (Jacobsen et al, 2009: 175)

2.3. Realistic Mathematic Education

Traffer’s statement “Realistic mathematic education is a teaching and learning theory that views mathematics is a human activity that connected to reality”. According to Gravemeijer’s statement (1999:6), realistic mathematic education is a learning and teaching approach that uses reality as a starting point in the teaching and learning process that aims to support students in build and
reinventing mathematical concepts through interactive contextual problems. Realistic mathematic education activities in classroom, starting from realistic problems and giving students the freedom to be able to describe, interpret and solve these realistic problem in their own way according to their initial knowledge. Realistic mathematic education is an approach in mathematic learning that emphasize the meaningfulness of science based on the philosophy of mathematics as an activity. Mathemetic realistic education includes both components, namely horizontal and vertical mathematics.

2.3.1. Characteristic of realistic mathematic education
Lange’s (1987: 75) reveal five characteristic of realistic mathematic education as follows (1) using a real context, (2) using models or mathematization, (3) using student contributed (4) interaction between student and teacher, (5) integration and intertwining with other topic.

2.4. Research and Development ADDIE models
This development model adopted by Robert Maribe Branch (2009: 2) who developing instructional design with ADDIE approach, which stands for analysis, design, development, implementation and evaluation. Branch said that "creating product using ADDIE process remains one of today’s most effective tools. Because ADDIE is merely a process that serves as a guiding framework for complex situations, it is a appropriate for developing educational product and other learning resources.

3. Research Method
This research used Research & Development type with the ADDIE model. The aim is to produce teaching materials and these product with valid, practical and effective. This research was conducted at junior high school Muhammadiyah 47. The subjects in this study were students of class VII-2 as the individual test and the small class (development test) and student of class VIII-3 as the implementation class. The object of this research is a test instrument developed based on realistic mathematics education to improve the high order thinking skill of grade VIII student of junior high school Muhammadiyah 47.

This ADDIE development models refers to five stages, namely: (1) analysis, (2) design, (3) development, (4) implementation, (5) evaluation.

The analysis stage is the stage of pre-design product development by identifying product in accordance with the goals of learners, learning objectives, and identifying learning. In this stage, researcher analyze important to developing product. The stage analysis have five steps, namely (1) gap analysis, (2) determining objectives, (3) student learning analysing, (4) determining available resources, and (5) compiling a work plan.

The Design stage aims to design product base on the result of the analysis above. In this study, researcher designing a test instrument based realistic mathematic education to improve high order thinking skills. The step in design stage are (1) hold the necessary, (2) set development goals, (3) set strategy testing.

The development stage is the stage of making a test instrument to produce a product development which is then carried out by an expert validator test. The aim in this stage is produce final form test instrument after get revision based on expert validator. In development stage are (1) produce a product, (2) one to one trials (student), (3) teacher trial, and (4) small class trial. The result of the responses from the first step, if it is declared valid and practical, it can be continued to the next step, if the response is not valid and not practical then the product must be repaired and retried it is declared practical.

The implementation stage is field trials (real class) where the activity product trial with the aim of measuring the quality of the test instrument from practically and effectiveness aspect in the implementation of class. The trial results are used as the basis for refinement product. The trial will stop if all indicators of effectiveness and practicality on the test instrument are met to produce the final product.
The evaluation stage is carried out both before and after implementation. Revisions are made in accordance with the result of evaluation or unmet needs for the product being developed. At this stage, evaluation can be carried out based on input obtained during the development process. All procedures performed can be summarized in the table below:

| Analysis | Design | Develop | Implementation | Evaluation |
|----------|--------|---------|----------------|------------|
| Identify the reason for a gap | Product verification and proper testing model | Generate and validate product | Preparing learning environment and engage student | Assess product quality, before and after implementation stage |
| Gap analysis | Hold the necessary inventory | Produce a product | Prepare the teacher | Determine evaluation criteria |
| Determining objective | Set development goals | One to one trials | Prepare the student | Choose an evaluation tools |
| Student learning analysis | Set strategy testing | Teacher trial | Small class trial | Do an evaluation |
| Determining available resources | Compiling a work plan | |

The data analysis technique used in this study was examined through three aspects. The first aspect is validity aspect with consists of data analysis from expert validator result, item analysis and High order thinking skill test analysis with formula

\[ N = \frac{T_d}{T_m} \times 100 \]

Information:
N : Score value
Td : Total value obtained
Tm : Maximum total value
To determine the category of students high order thinking skill, the value it can be converted into qualitative from by paying attention to the assessment guidelines written by Susanti (2014: 53).

| Score         | Category    |
|---------------|-------------|
| 90 ≤ Score ≤ 100 | Very Good   |
| 75 ≤ Score < 90  | Good        |
| 55 ≤ Score < 75  | Enough      |
| 40 ≤ Score < 55  | Less Good   |
| Score < 40      | Not Good    |

The criteria of High Order Thinking Skills has category not good if the score less than equal 40, the less good category if score between 40 and 55, the enough category if score between 55 and 75, the good category if score between 75 and 90 and the last, very good category if score between 90 and
100 Students are said to have achieved the mastery level of High Order Thinking Skill if 80% of the total student who have taken the High Order Thinking Skill test have reached KKM (\( \leq 75 \)) classical completeness.

The second aspect is practicality. Practicality is obtained through a questionnaire given to teacher and students. The criteria established to state that students have a positive response is at least 50% of the number of statement items in each aspect and the teacher gives a positive response to at least 75%. The third aspect is effectiveness which consists of completed learning, attainment of indicator, time of learning and student positive responses.

4. Result and Discussion

This development research aims to produce test instrument base realistic mathematics education to improve high order thinking skills and describe the result. The result and discussion of this study are described based on the stages of development by ADDIE as follows.

4.1. Analysis

At the analysis stage, it consist of gap analysis, determining objectives, student learning analysing, determined available resources, and compiling a work plan. The result in this stage, research find the reality that learning is still teacher centred learning, the test instrument used by the teacher not require higher order thinking, student not used to solving problem that require higher order thinking, student have low scores in high order thinking test. From the observation, researcher found and determined the aims. The aims what researcher take are developing test instrument and using realistic mathematics education during learning, which is the treatment can improve high order thinking skills. The characteristic of students are passive, they tend to just listened what teacher said. Student junior high school grade VII range in age 13-14 years, if we linked with the cognitive stage, then students are at the stage of formal operational. Student at this age still need concrete objects in learning mathematics. Therefore, it is very appropriate if learning is related to their daily lives and presents learning that can require students to construct. School using 2013 Curriculum’s, material adjusted with curriculum and basic competencies as base for development. Based all analysis step above, researcher compile a work plan to be carried out at a later stage.

4.2. Design

At design stage, researcher design what is needed in the study, namely test instrument and supporting materials which are learning plan and activity worksheet both of which base realistic mathematic education. Other than that, researcher made answer keys and scoring guidelines. The strategic test by used researcher are test instrument assessment sheet, the form of response questionnaire student and teacher, and a validation questionnaire and high order thinking test which is a test post question.

4.3. Development

After design stage completed then goes to development stage. In this stage, the test instrument is ready to be tested to expert validators. The product was declared valid, the product ready for testing at the one to one trial, teacher trial, and small class trial. In the one to one trial, the product is tested on three students who have high, medium, and low abilities. After that, the product was tried out on teacher, and finally tested in small class on 12 students who had high, medium and low abilities.

| Criteria       | Result | Category     |
|----------------|--------|--------------|
| Validity       | Validator 1 | 91% | Very Valid |
|                | Validator 2 | 83% | Quite Valid |
|                | Validator 3 | 88% | Very Valid |
| Practically    | One to one | 87.5% | Practice |

Table 3. Result of Development Stage
Based on table above, the development have two criteria measurement, they are validity and practically. The validity criteria have three validator, the result of validator 1 is 91% with very valid category, the result of validator 2 is 83% with quite valid category, and the result of validator three is 88% with very valid category. The practicality criteria have three step, step 1 is one to one, the result is 87.7% with practice category, step 2 is teacher response, the result is 87,5% with practice category, and step 3 is small class step, the result is 83,3% with practice category. That mean the research phase can be continued.

4.4 Implementation

At this stage, the product is ready for use/tested in real class by implementing learning according to the learning plan using realistic mathematics education using activity worksheet and test instrument that have been designed.

**Table 4. Effectiveness Result**

| Criteria               | Result    | Category      |
|------------------------|-----------|---------------|
| Individual Completeness| 86,11%    | Complete      |
| Classical Completeness | 93,33%    | Complete      |
| Indicator Completeness | 86,3%     | Complete      |
| Students Responses     | 87,6%     | Positive      |
| Time                   | Does not exceed the usual learning time |

Based on table above, the effectiveness result have five criteria measurement. The result of individual completeness criteria is 86,11% with category complete, the result of classical completeness criteria is 93,33% with complete category, the result of indicator completeness is 86,3% with complete category, the result of student responses is 87,6% with positive category and the result of time criteria is does not exceed the usual earning time. From all of effectiveness result that means the test instrument is fulfill the effectiveness.

At this stage it is also measured how about increased student’s high order thinking skills after learning with the product developed. The measurement of the increase in the result of pre test and post test result is given using n-gain formula as follow

**Table 5. n-gain Result**

| Test   | Result | n-gain | Category |
|--------|--------|--------|----------|
| Pretest| 52,78  | 0.74   | High     |
| Post test | 86,11  |        |          |

Based on table above, pre test and post test scores are much different. The n-gain result seen from pretest and post test result. The pretest result is 52,78 and the post test result is 86,1. From the different result, the calculating n-gain result is 0,74 with high category. That means, there is an increase in high order thinking skills by implementing learning using test instrument based realistic mathematics education.
4.5 Evaluation
The evaluation stage is carried out at each stage of development by the researcher. The evaluation is in
the form of input such suggestions like comments and revisions at each stage. The evaluation includes
measurement validity, practicality and effectively.

5 Conclusion
After measuring the three aspects, namely validity, practicality and effectively, it concluded that the
test instrument based realistic mathematics education has fulfilled the three requirements. Furthermore,
there is an increase in high order thinking skills by implementing learning using test instrument based
realistic mathematics education.

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