



THE CHARACTERISTICS AND DEVELOPING AN ASSESSMENT INSTRUMENT OF HIGH ORDER THINKING SKILL (HOTS) ITEMS WITH 4-D MODELS

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Abstract

The 21st century learning aims to develop and improve the process of high order thinking in students, including when solving mathematical problems. This research will discuss the characteristics and developing an assessment instrument of HOTS (high order thinking skill) items. The method used is research and development method with 4-D models (define, design, develop, disseminate). Scoring in Politomus scale was used and analyzed by Partial Credit Model 1 Parameter Logit (PCM 1-PL). Results of the research is 20 test items there are 17 items that qualify as a good items views of validity and reliability. Results based the criteria of Infit Mean Square is 1.00 and a standard deviation of 0.17 indicates test items fit with Partial Credit Model (PCM). Reliability items indicated by Cronbach's Alpha coefficient was 0.79 with the very reliable category. Test items validity based on the empirical analysis showed there are 17 valid test items with 12 test items as good categorized 5 test items as good enough category.

Keywords: Characteristics, Items, High Order Thinking Skill.

INTRODUCTION

The development and improvement of high order thinking processes are the main objectives of the 21st century learning. The real impacts felt at this time include improving the speed of production flexibility, increasing service to customers and increasing revenue (Lasi et al., 2014; Rubmann et al., 2015; Schmidt et al., 2015; Neugebauer, 2016). This is stated in Core Competencies (KI) in the domain

of knowledge or KI 3 in mathematics subjects, namely understanding, applying, and analyzing the factual, conceptual, procedural knowledge based on their curiosity to solve problems. So that, in general mathematics learning aims for students to have mathematical skills that must be possessed, especially in the development of reasoning, communication, and problem solving faced in the daily life of students.



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Mathematics is a logical means of communication, short and clear, can be used to present information in various ways, improve the ability to think logically, accuracy and spatial awareness, giving satisfaction to the challenging problem solving effort, which requires high order thinking skills (Cahyanti, 2016).

Problem solving is a process of thinking using the knowledge and skills that have already owned to solve the unresolved problems. Polya stated that there were four steps taken in solving the problem, namely understanding the problem, planning the solution, solving the problem according to the plan and checking the steps that had been done. In these four steps, students' high order thinking skills are used optimally (Lailly & Wisudawati, 2015). This can be seen from the description of problem solving steps that really require the students to describe the problems, find ideas in solving problems, find other possible alternatives and then choose an alternative that can be accepted logically to be applied in solving the problems. This is in line with the opinion of Changwong (2018), that problem solving will require the ability to think critically. It is a requirement for students to have ability of high order thinking because it trains in developing the sharpness in analysis, the ability to evaluate, and the ability to create new ideas. To train the students to do the high order thinking the challenging items are required which can guide the students to develop new ideas by using the prior knowledge.

HOTS is a skill that students to be able to have and develop after participating in learning mathematics in class (Ahmad et al., 2018). Mastery

of HOTS learning is an important factor that needs to be mastered as described in the study (Hadi, 2021). The increase in HOTS ability is seen from the results shown by PISA. PISA defines mathematical literacy as: the formulation, use and interpretation of mathematics in various contexts (OECD, 2017). The program is designed over a three year period in world assessment. PISA results show that Indonesia is still included in the score below the average. Stated in the research that the results of the PISA study explained that students ability in mathematics was still lacking (Amalia et al., 2021). Kemdikbud (2013) which stated that the low achievement of students Indonesia is caused by many test material in PISA that is not contained in the Indonesian curriculum.

Bloom's Taxonomy is the basis for high order thinking (Ariyanto & Mardiyana, 2020). One of important skills needed in facing global competition in the 21st century is the ability to think at a higher level or known as higher order thinking skill (Saïdo & Siraj, 2018). The basis of this thinking is that some types of learning require more cognitive processes than others, but have more general benefits. The thinking process describes the stage of thinking that must be mastered by students, namely thinking skills from low order thinking skill (LOTS) to high order thinking skills (HOTS). LOTS is a thinking skill that only requires someone to remember, understand and apply a formula or law. Whereas HOTS is an analytical, evaluation and creative thinking skill. Evvy & Wangge (2016) defines high order thinking is giving complex thinking, no algorithm for completing

a task, some of them are unpredictable, using an approach that is different from the existing task and different from the examples that have been given.

According to Collins (2014), the HOTS involves logic and reasoning, analysis, evaluation, creation, problem solving, and also judgment. This means that while using this type, students have honed their cognitive abilities in the aspects of understanding, applying, and analyzing (Hyder & Bhamani, 2017). This is also in line as expressed by Minarni & Napitupulu (2020) that the HOTS math problem is a form of non-routine questions (the problems which solution is not known directly) in the process of solving, the students must have high motivation, enthusiasm and desire to solve it because the solution of the given problems cannot be known directly and require several processes. Various methods are used to develop the high order thinking skills including critical thinking, creative thinking, and problem solving (Zainal, 2012). In a process of Mathematics learning if a student uses high order thinking skills then the learning would be a meaningful learning, because from the process of problem solving the students are able to analyze, evaluate and even create the solutions to the problem itself. However, using HOTS as teaching problem materials during learning in class is still rare; while Indonesia achievements in mathematics subject at international reputation are also even low (Tonra et al., 2019).

In 1994, Anderson & Krathwohl refined the cognitive domain of Bloom Taxonomy under the name of Bloom's Taxonomy Revision which consists of six levels: remembering,

understanding, applying, analyzing, evaluating and creating. Anderson's revision is often used in formulating the learning goals which are often known as C1 through C6. Anderson & Krathwohl states that the indicators for measuring the high order thinking skills include analyzing (C4), evaluating (C5), and creating (C6) (Dhewa, 2017).

Krathwohl uttered the characteristics that must be contained in HOTS items such as: C4/analyzing, the newly obtained information and then create a smaller structure to get the related pattern or relationship; find the difference and recognize the cause-effect which is occurred from an action; make a formulation of the problem in the form of question. C5/evaluating, assess the problem solving, ideas, and method by using the proper criteria or by the exiting standard to find the effectiveness; create a temporary presumption, critic and conduct the test to the presumption; accept or reject the statement based on the predetermined criteria. C6/creating, create the general conclusion from an idea or ideal point of view to something; design alternative way to find the problem solving; classify the element or part become a new structure that has never existed before.

To prepare the HOTS items required some operational verbs in accordance with the characteristics. Analyzing/C4 includes specify the aspect of each element with keyword: compare, examine, criticize and test. Evaluating/C5 make your own decision have keyword: evaluation, assess, reject, decide, choose, support. Creating/C6 is create your own idea or opinion with keyword: construct,

design, create, develop, write, formulate.

According to Ghasempour et al. (2012), the criteria of the problems that can stimulate high order thinking activities including: (1) the problems must be based on the analysis of current student knowledge content, so that students will not be able to solve the problems without extending their knowledge and skills base, (2) the problems which are irregular in structure (ill-structured problem), (3) the problems which require collaboration for the completion, (4) the problems which are authentic based on students experience, if the problems are not be based on the students current experience, then the problem will be authentic if it relates to the students future plans and the career which is expected by them, and (5) the problems which can enhance the lifelong learning and independent learning. In line with the above matter, Rohmah (2015) states the guidelines for items that demand high order thinking, namely the material that will be asked is measured by the behavior in accordance with Bloom's cognitive domain, which is analyzing, evaluating, and creating.

Rohmah (2015) states the criteria for items that require high order thinking, namely the asked material is measured by the behavior in accordance with Bloom's cognitive domain, namely analyzing, evaluating, and creating (C4-C6). Then, in order to make the items can guide students to do the high order thinking, each item is always given a basic question (stimulus) in the form of sources/ reading material as information such as: reading texts, paragraphs, drama texts, fragments of novels/ stories/

fables, poetry, cases, pictures, graphics, photos, formulas, tables, lists of words/ symbols, examples, maps, films, or voice recordings.

METHODS

The method used is research and development method with 4-D models (define, design, develop, disseminate). The research that prepare the measurer instrument of Mathematics higher order thinking skills (HOTS) of the students in geometry material. This research will produce a product in the form of HOTS items. The define step includes front-end analysis, learner analysis, task analysis, concept analysis, and goal formulation. The design includes the selection of learning tools, the selection of formats, and making the initial design. The develop includes expert assessment and field testing and the disseminate which is the dissemination stage.

Empirical validity is obtained from object test results. In this research, the QUEST program is used to analyze the validity of the items, the reliability, the level of difficulty of the items, as well as the criteria for passing and dropping items. This study used item analysis in a Polytomusic four categories. The test results were analyzed according to the Partial Credit Model (PCM) 1-PL.

Determination of the overall fit of the item with the model is based on the average value of the Infit Mean Square and its standard deviation. If the infit Mean Square value is 1.0 or close to it with a variance of 0.0 or if the INFIT t value is close to 0.0 and the variance is 1.0 then the overall test item is declared fit with the model.

RESULTS AND DISCUSSION

In the preparation of the HOTS item, the writer must be able to determine the behavior and attitudes that will be measured and formulate the teaching material that is used as the basis of the question as a stimulus in certain contexts in accordance with the expected behavior. Not all materials that require students to think high are found in the textbooks, so the compiler must be able to develop teaching materials, the skill in writing the questions, and creativity in order to be able to produce the HOTS items. HOTS the highest level of thinking allows students to process so much information effectively and efficiently (Tan & Halili, 2015). The following are the steps for preparing HOTS items.

1. Analyzing the Basic Competency that can be made as HOTS items

The compiler firstly chooses the basic competencies that will be made as HOTS items, by referring to KI 3 and KI 4 in the domain of knowledge and skills.

2. Preparing the Reference of HOTS items

The preparation of the reference of HOTS items aims to assist in making the framework of the HOTS items. In general, the reference is needed to select the subject matter related to the basic competencies that will be tested, and formulate the question indicators, as well as determine the cognitive level according to the levels of C4 to C6.

3. Selecting The Contextual Stimulus

The apperception in the form of stimulus that is used should be interesting, contains novelty, and contains the current information so that it encourages the students to read the

stimulus. The contextual stimulus means the stimulus that is in accordance with the reality in daily life and information contained in the surrounding environment or local area. Heong et al. (2011) states that HOTS are defined as the widespread use of the mind to find new challenges.

4. Writing the Items in Accordance with the Reference

The question items are written according to developing a reference that has been compiled using the stimulus that is in accordance with current information and local wisdom.

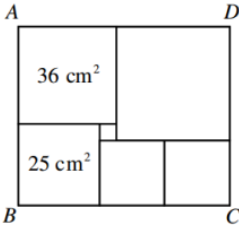
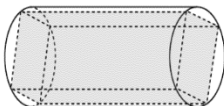
5. Creating the Scoring Guidelines (Rubrics) or Answer Keys

Each written HOTS item should be completed with a scoring guide or answer key. The scoring guidelines are made for the description questions. Students must understand, analyze each other, categorize, manipulate, create new ways creatively, and apply them in finding solutions to new problems (Riadi, 2016). Conklin (2012) states the characteristics of higher order thinking skills encompass both critical thinking and creative thinking.

Geometry problems with the HOTS category that have been developed are shown in the following table 1.

Research on item development starts from the definition to the dissemination stage with some limitations until a valid and reliable test item product is obtained based on data analysis. The analysis of the test items carried out in this study includes empirical validity. Empirical evidence support for the fulfillment of empirical validity based on analysis using the QUEST program is presented in table 2.

Table 1. HOTS-type geometry problems

Problem	Type
 An ABCD rectangle composed by six squares, as shown in the picture. If the area of two squares respectively are 36 cm^2 and 25 cm^2. By comparing each known area, then the circumference of ABCD rectangle is ... cm. 44 46 50 52	Analyzing (C4): Specify the aspect of each element
 A rectangle consists of 4 smaller squares, and the area of each small squares are 6 cm^2, 15 cm^2, and 25 cm^2 as shown in the picture. By selecting one area reference of the proper square, then the area of shaded area is ... cm^2 7 10 15 16	Evaluating (C5): Make your own decision
 As a carpenter, Mr. Dhani is very agile in cutting the wood to be desired shape. Mr. Dhani will make the table legs in the shape of cuboid, but he does not have a wood which is ready to be made as table legs. Mr. Dhani remembers that he has a piece of wood in the shape of cylinder with radius 10 cm and height 60 cm. Then, Mr. Dhani will make the cuboid by cutting that piece of wood according to the dotted line as shown in the picture. By designing the cylinder, then the farthest distance occurred between two vertex in the cuboid is ... m. $10\sqrt{37}$ $20\sqrt{10}$ $20\sqrt{13}$ 70	Creating (C6): Create your own idea/opinion

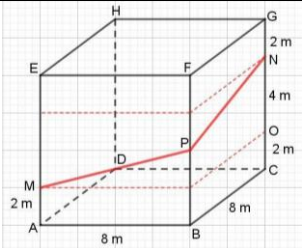
Problem	Type
 An ant is crawling on ABCD.EFGH cube with edge 8 m, where ABCD as the basic field. The ant crawls start from M point located 2 m above A and stop in N point located 2 m above G. By constructing the cube, then the shortest distance taken by the ant is ... m. $4\sqrt{17}$ $8\sqrt{2}$ $8 + 4\sqrt{5}$ 12	Creating (C6): Create your own idea/ opinion

Table 2. Result of estimation of items and estimation of testimonials

No	Indicators	Item Estimate	Test Estimate
1	Mean and standard deviation	0.00 ± 0.64	0.04 ± 0.62
2	Adjusted mean and standard deviation	0.00 ± 0.45	0.04 ± 0.56
3	Separation index	0.50	0.84
4	Cronbach's Alpha	-	0.84
5	Average of the standard deviation of Infit Mean Square	1.00 ± 0.18	0.99 ± 0.40
6	Average and standard deviation of t	0.01 ± 1.17	0.08 ± 1.24

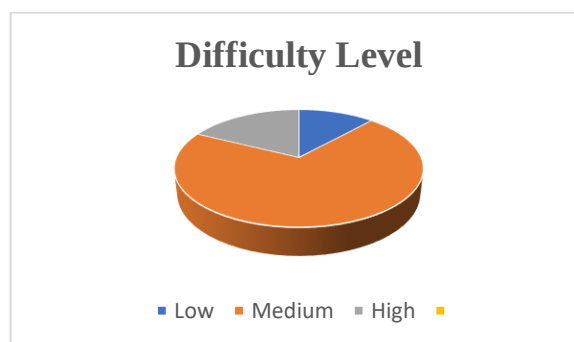
Table 2 shows that overall the test items fit with the model because the fit statistical requirements in the QUEST program when the test items analyzed have an Infit Mean Square average to 1.0 with a standard deviation of 0.0 or the average Infit t approaches 0.0 with a standard deviation of 1.0. The average of Infit Mean Square in research is 1.00 with a standard deviation (SD) of 0.18 and according to requirements in the QUEST program. Overall the items analyzed fit according to PCM-1PL.

The reliability of the test items estimated based on testi analysis expressed in the form of a Person Separation index of 0.84. The separation value shows very reliable. The reliability of the test questions according to the CTT (Classical Test Theory) with the QUEST program is indicated by the Cronbach Alpha index of 0.79 which indicates that the test questions made are very reliable. Wright and Masters which stated that the respondents reliability index of 0.79 is a good value for the expected

consistency on the logit scale for the answers on different sets of items that measure the same construct (Othman et al., 2014).

Estimates in determining the items that are accepted or rejected are seen based on results of the analysis using the QUEST program if the Infit

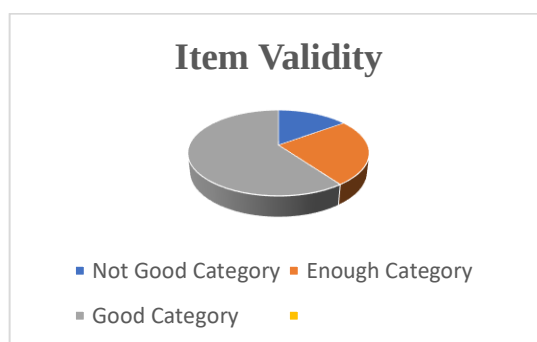
Mean Square of the item between 0.77 to 1.31. The results of the empirical data analysis based on PCM in research resulted in 17 items that fit the model and 3 items that did not fit the model. The three items that do not fit are items number 6, 11, and 19.



Picture 1. Difficulty level

Picture.1 shows the distribution of item difficulty levels. The level of difficulty in research obtained test items with an easy category of 2 questions, a medium category of 12 questions, and a difficult category of 3 questions. The item difficulty level

was determined based on the Difficulty Score in the QUEST program analysis and difficulty value has a standard deviation (SD) of 0.64. The standard deviation value shows the level of difficulty of the items in the range of -0.64 to 0.64.



Picture 2. Item validity

Picture 2 shows the distribution of item validity based on empirical data. Alpusari (2014) which stated that to test the validity of each item, the scores is in the item in question correlated with the total score. Determination of item validity based

on empirical data is seen from the Infit Mean Square and item difficulty level. The validity of the items tested was limited, the results obtained 3 test items as not good category, 5 test items as good enough category, and 12 test items as good categorized.

CONCLUSION

Based on the study above, it can be concluded that by analyzing the basic competencies in each subject, the compiler can develop the questions into the HOTS items category which corresponds to Bloom's cognitive domain namely analyzing, evaluating, and creating (C4-C6).

Based on empirical validity, there are 17 valid items with 12 items in the good category and 5 items in the enough category. The reliability value of the items is 0.79 with a very reliable category.

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