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The development of mathematics higher order thinking skills instrument for grade VIII junior high school

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Abstract. 21st-century learning activities require higher order thinking skills including critical and creative thinking. High-level mathematical thinking skills are tools to train and improve higher order thinking skills in mathematics. This study aimed to produce products in the form of a high level mathematical thinking skills instrument of grade VIII based on Bloom's Taxonomy containing C4 (Analyze), C5 (Evaluate), and C6 (Creating) questions. Indicators of higher order thinking include analyzing, organizing, differentiating, and linking. Evaluating is judging, checking and criticizing. While creating is generalizing, designing, and producing. This research was conducted at three junior high schools in Jakarta that consisted of 41, 36 and 36 students respectively. The sample of this research was grade VIII students. The study was conducted during the even semester in 2017. Data collection method used higher order thinking skill test of the eight grade students then analyzed data with the calculation of validity, reliability, difficulty level, and discrimination power. The result showed that the instrument was valid, reliable, the difficulty level was moderate, and the discrimination power was moderate so the problems in this instrument could be used by teachers to measure students' high order thinking skills.

1. Introduction

An international study measuring the student's performance in mathematics and natural science, Trend in Mathematics and Science Study (TIMSS), showed that in 2015, Indonesia ranked 45 out of 50 countries. Based on the data of mathematics content and cognitive domain, the percentage of Indonesian participants with the correct answer in a matter of understanding was higher than that of in the matter of application and reasoning. Moreover, the results of Programme Internationale for Student Assessment (PISA) test showed that in 2015, Indonesian students ranked 62 out of 70 countries in mathematics with an average score of 386. Indonesia's score was 386 in mathematics. This value is below the international average, 493. This shows that Indonesian students' higher order thinking skills in mathematics is still below expectation. The curriculum used in Indonesian education is the Curriculum 2013 Revision 2017 (K13 2017). The K13 2017 intends to promote higher order thinking skill (HOTS), literacy and character education [1]. The aim is to improve students' problem-solving skills so that they are able to overcome difficulties in their learning activities and everyday life. Qualified teachers are the key to achieving this goal [2].

Higher order thinking process is a mental activity that involves multifaceted, creative, and unconstrained thinking that leads to useful solution [3–6]. Learners generally have a variety of abilities. The ability to think creatively and critically are both the ability to create a diverse way of completion and produce the right answer to a difficult problem. These skills result in valid explanation, decision, performance, and product within the context of existing knowledge and experience and they promote continued growth in these and other intellectual skills [7].



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The studies on improving critical thinking skills have used a variety of strategies and learning models such as problem-based approach [8], the application of writing strategy [9], collaborative approach work [10], and guided inquiry learning model [11]. Thinking skill is divided into two categories: higher order thinking skill (HOTS) and lower order thinking skill (LOTS). LOTS deals with regular implementation of mathematics formula in solving equations, while HOTS entails strategy and manipulation [12-13]. It is crucial that learners be introduced to problems that require analyzing, interpreting and manipulating of information and producing a correct solution. Bloom states that education should focus on mastery subject and the achievement of higher order thinking as oppose to the use of utilitarian that simply means learning as a means of transferring words [14]. The instrument in this study was formulated based on the Bloom's taxonomy on the ability of higher order thinking skills that requires a high level problem solving skill.

2. Method

This study used research and development method to produce and develop higher order thinking skills instrument for the students. This study was conducted using formative research proposed by Tessmer [15] which was modified as shown in the flowchart.

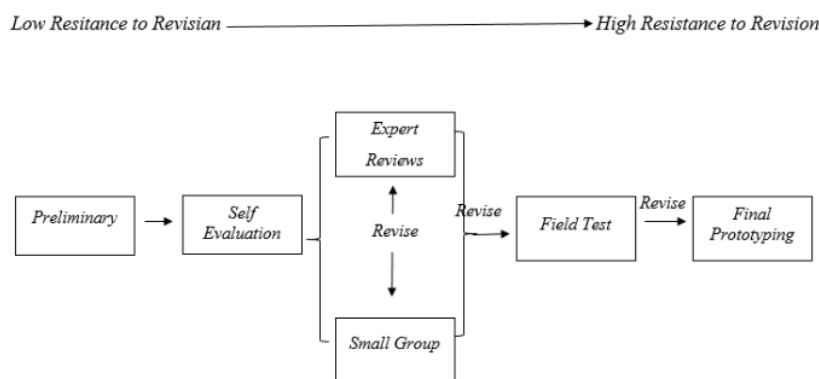


Figure 1. Flowchart of formative research design.

Figure 1 shows that the research method consisted of several stages: (1) preliminary or preparatory phase, (2) self-evaluation including analysis and design stage, (3) expert reviews or properness test of the product, followed by small group or small-scale trials, (4) field test or large-scale trial, and (6) final prototyping instrument. The research subject from small groups in grades VIII was intended to provide advice on higher order thinking skills instrument. The research received the material about mathematics in grade VIII for the field test.

The purpose of this study was to produce and develop instrument, to determine the properness and effectiveness of the product, and also to determine the profile of higher order thinking skills of students on the topics of number patterns, Cartesian fields, relation and function, straight line equations, linear equations with two variables, Pythagoras theorem, circles, wake-up flat space, statistics, and probabilities. Properness test was done by giving product properness questionnaire to the experts and students. Product effectiveness test was done by calculating the validity, reliability, difficulty level, and the discrimination power. The profile of higher order thinking skills was determined by analysing the students' answers to the problems. Data from field tests were used to calculate the feasibility of the instrument.

3. Result and discussion

The result of this study included the design, properness, and effectiveness of instrument, and a profile of the students' higher order thinking skills. The developed higher order thinking skills instrument consisted of 20

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 problems description. These problems represented the indicators of the higher order thinking skill. The indicators of the higher order thinking skill were as follows: first, student could recognize and distinguish between the causes and the result of a complicated scenario; the student could analyse incoming information and divide it into smaller sections to find patterns and relationships; and the student could identify and formulate questions. Second, the student could describe the idea and the methodology of an evaluation by using match and standard criteria to ensure the effectiveness; the student could hypothesize, criticize, and do the test; and the student could accept or reject a statement based on predetermined criteria. Third, in creation, the student could make a generalization of ideas; the student could determine a way to solve the problem, and the student could organize the parts of something into a new structure that did not exist before [16].

Higher order thinking skills instrument was given to experts and students to measure the properness. The properness questionnaire was prepared with some aspects of the assessment criteria, i.e. the aspect of content, construct, language, time allocation, and instructions. The properness test of higher order thinking skills instrument of students was done by experts in one stage. It was conducted before the higher order thinking skills instrument was tested in a small-scale trial. The result about the properness of higher order thinking skills instrument is shown in table 1.

Table 1. The result of properness higher order thinking skills instrument.

No	Aspects Observed	Evaluator				I_i	V_a
		Validator 1	Validator 2	Validator 3	Validator 4		
1	Content	3	4	4	5	4	3,52
2	Construct	2,78	3,4	3,95	4,3	3,6	
3	Language	3	4	3,3	4,7	3,75	
4	Time Allocation	2	3	3	3	2,75	
5	Instruction	3	3	3	5	3,5	
Criteria							Quite Valid

The profile of students' higher order thinking skills instrument can be seen from the answers regarding the students' ability to analyze, evaluate, and create. The result for the field test of ability higher order thinking skills instrument is presented in table 2.

Table 2. Profile of higher order thinking skills.

Interval values	Frequency	Percentage (%)	Category
80 < Value ≤ 100	8	7,08	Very good
60 < Value ≤ 80	27	23,89	Good
40 < Value ≤ 60	37	32,74	Moderate
20 < Value ≤ 40	32	28,32	Low
0 < Value ≤ 20	9	7,96	Very Low
Amount of subject	113	100	
The average value		50	Moderate

Table 2 shows that the average value obtained by all of the students was 50 which was in the moderate category, so it could be concluded that in general grade VIII students had moderate ability in solving problems and understanding the problems that were not routine or higher order thinking skills. The score of the students in doing questions of higher order thinking skills is shown in figure 2. Figure 2 shows that the students' scores were normally distributed which meant that students were able to understand the problems that were not routine or higher order thinking skills.

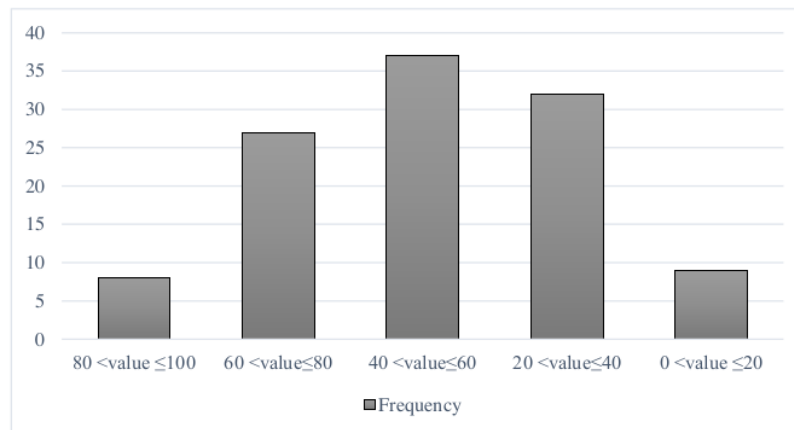


Figure 2. Scores of students in doing questions.

The result of validity test of higher order thinking skills was valid ($r_{xy} > r_{table}$) as shown in table 3.

Table 3. Validity test of higher order thinking skills.

Item	r_{xy}	r_{table}	Conclusion	Category
1	0,5193	0,1555	Valid	Moderate
2	0,5243			Moderate
3	0,5626			Moderate
4	0,4117			Moderate
5	0,5309			Moderate
6	0,5841			Moderate
7	0,6835			Moderate
8	0,6188			Moderate
9	0,6043			Moderate
10	0,6620			Moderate
11	0,7577			Good
12	0,7957			Good
13	0,7314			Good
14	0,7583			Good
15	0,7036			Good
16	0,6476			Moderate
17	0,6185			Moderate
18	0,6861			Moderate
19	0,7161			Moderate
20	0,5428			Moderate

As shown in table 3, as many as 15 items fell into the moderate category and 5 items fell into good category. As a whole, the instrument could be verified valid.

The result of the reliability test of higher order thinking skills instrument was reliable. The r value was 0.9219 and it fell into very good category.

The result of the difficulty level of the higher order thinking skills instrument showed that one item was hard, seventeen items were moderate, and two items were easy. This is shown in table 4.

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Table 4. The difficulty level of the higher order thinking skills instrument.

Item	Difficulty Level	Category
1	0,3938	Moderate
2	0,6615	Moderate
3	0,3368	Moderate
4	0,5170	Moderate
5	0,4963	Moderate
6	0,4904	Moderate
7	0,3931	Moderate
8	0,2904	Difficult
9	0,7887	Easy
10	0,7777	Easy
11	0,3374	Moderate
12	0,5736	Moderate
13	0,6134	Moderate
14	0,4729	Moderate
15	0,4808	Moderate
16	0,5863	Moderate
17	0,4882	Moderate
18	0,4226	Moderate
19	0,4652	Moderate
20	0,3285	Moderate

The result of the discrimination power of the higher order thinking skills instrument is shown in table 5.

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Table 5. Discrimination power test of higher order thinking skills.

Item	Discrimination Power	Category
1	0,3226	Moderate
2	0,4570	Good
3	0,3629	Moderate
4	0,2769	Moderate
5	0,4382	Good
6	0,5161	Good
7	0,5672	Good
8	0,4879	Good
9	0,3871	Moderate
10	0,4778	Good
11	0,6734	Good
12	0,6754	Good
13	0,5847	Good
14	0,5746	Good
15	0,5833	Good
16	0,5706	Good
17	0,4167	Good
18	0,4879	Good
19	0,6653	Good
20	0,3165	Moderate

Table 5 shows that there were five moderate items and fifteen good items. Therefore, it could be concluded that the instrument satisfied the discrimination power criteria.

4. Conclusion

The higher order thinking skills instrument used to measure grade VII junior high school students was moderate and effective. It was a valid, reliable, with moderate level of difficulty and moderate discrimination power. The students were able to understand the problem that was not routine or higher order thinking skills which included analysis, evaluation, and creation. This instrument can be used for junior high school to practice higher order thinking skills and provide references for teacher on the matter of promoting higher order thinking skills. These skills are important for students to compete in the national and international world, especially in mathematics.

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