Development of Open-Ended Problems for Measuring The Higher-Order-Thinking-Skills of High School Students on Global Warming Phenomenon

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Abstract. Higher-order-thinking-skills can not be developed directly, except by training which is employing open-ended problems for measuring and developing critics, creativeness, and problem-solving thinking-skills of students. This study is a research and development producing open-ended problems. The purpose of this study is to measure the properness and effectiveness of the developed product and to observe the profile of higher-order-thinking-skills of students on global warming phenomenon. The result of properness test of open-ended problems according to the experts is 92,59% on the first stage and 97,53% on the second stage, so we can assume that the product isvery proper. The result of effectiveness test shows the coefficient of correlation between student's midterm test scores and open-ended questions is 0,634 which is in the category of strong. Higher-order-thinking-skills of SMA Negeri 1 Salatiga students is in the category of good with the average achievement scores 61,28.

1. Introduction

An international study which measures the performance on mathematics and natural science for thestudent, Trends in Mathematics and Science Study (TIMSS), shows that in 2011, Indonesia's student was on the ranking 40 of 42 countries surveyed in the sciences. Indonesia score was 397 in Physics. This value is below the international average, 500. Based on the data of science content and cognitive domain, especially in physics, the percentage of Indonesian participant swith the correct answer in a matter of understanding are higher than that of in the matter of application and reasoning. Furthermore, anaspect of understanding and application is in the lower-order-thinking-skill,and aspect of reasoning is in the higher-order-thinking-skill [1]. Therefore, higher-order-thinking-skill of Indonesia's student is still low.

Higher-order-thinking-skill is the ability to solve problems where there is no algorithm that has been taught that requires justification or explanation. Also this problem has more than one solution to be accepted [2-3]. Higher-order-thinking-skill is the highest level in the hierarchy of cognitive processes [3]. Therefore according to Bloom's Taxonomy, higher-order-thinking-skill is one of the ability to analyze, evaluate, and create.

Higher-order-thinking-skill can not be developed directly and instantly. The test can be used as a tool to determine the profile of student's thinking skill and to train students for better thinking skills.

Teachers should use an open-ended problem to determine the student's thinking skill; this isa problem with more than one answer [4]. Open-ended problems consist ofmain concepts, processes, and skills beyond the specific instructions that can determine the students thinking skills [5]. Surf*et al.* [6] and Intrasite [7] revealed that the advantage of using open-ended problems is to encourage in developing the creativeness and analytic-thinking-skill. By using open-ended problems, the basic concepts can be explored, so the students do not only recall the certain facts but almost all possible facts to solve the problems. This gives a chance for the students to be asuccess in answering the open-ended problems, even they cannot remember a certain fact because there is always some alternative way of solving the problem in nature.

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2. Research Methods

This studyisconducted byresearch and development method that produces and develops open-ended problems for measuring higher-order-thinking-skill of students. This study is conducted using formative research proposed by Tessmer [8] and modified as shown in the following flow chart.

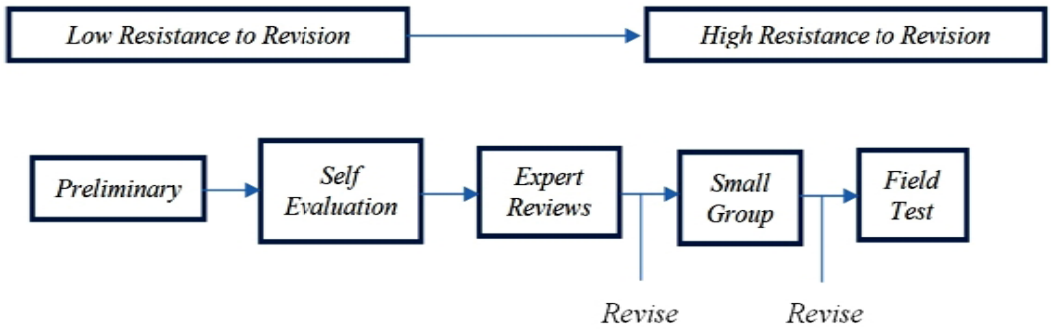


Figure 1. Flow chart of formative research design.

Figure 1 shows that the research method consisting of several stages: (1) preliminary or preparatory phase, (2) self-evaluation that includes analysis and design stage, (3) expert reviews or properness test of product, (4) small group or small scale trials, and (5) field test or a large-scale trial. The research was done in SMA N 1 Salatiga who had received the material on the global warming phenomenon of physics learning, namely MIA 5.4 as a research subject of asmall group, MIA 1.4 and MIA 2.4 as a research subject of thefield test.

The purpose of this study is to produce and develop open-ended problems, to determine the properness and effectiveness of the product, and also to determine the profile of higher-order-thinking-skills of students on a material of global warming phenomenon. Properness test is done by giving product properness questionnaire to the experts and students. Product effectiveness test is done by calculating the correlation between the student's midterm test scores and open-ended problems. The profile of higher-order-thinking-skillsis determined by analyzing the student's answer to the problems.

3. Results and Discussion

The results of this study include the design, properness, and effectiveness of open-ended problems, also profile of student's higher-order-thinking-skills. The developed open-ended-problems are consists of 10 problems on a global warming phenomenon. These problems represent the indicators of the higher-order-thinking-skill. In fact, higher-order-thinking-skill of students consists of several aspects, *i.e.* the ability to analyze, evaluate, and create. Moreover, the ability to analyze, evaluate, and create can be represented by three indicators as follows; first in analysis, students can recognize and distinguish between the causes and the result of a complicated scenario, students can analyze the incoming information and share it into smaller sections to find patterns and relationships, and students can identify and formulate questions. Second, in the evaluation, students can give an assessment of the idea and the methodology by using match and standard criteria to ensure the effectiveness, students can hypothesize, criticize, and do the test, and students can accept or reject a statement based on predetermined criteria. Third, in creation, students can make a generalization of ideas or ways, students can determine a way to solve the problem, and students can organize the parts of something into new structures that have never existed before [2].

Open-ended problems are given to experts and students to measure the properness. Properness questionnaire prepared with some aspects of the assessment criteria, *i.e.* the aspect of content, construct, and language. Properness test of open-ended problems to measure the higher-order-thinking-skills of students is done by experts in two stages. The first stage did before the open-ended problem sare tested in a small scale trial. The second stage did before the open-ended problems are tested in a large scale trial. The test result about the properness of open-ended problems at the first stage is presented in Table 1 and the second stage is presented in Table 2.

Table 1. The result of properness test open-ended problems at the first stage.

No	Evaluator	Content		Constructs		Language	
		Score	in %	Score	in %	Score	in %
1	Validator 1	9	100	9	100	9	100
2	Validator 2	8	88.89	8	88.89	8	88.89
3	Validator 3	8	88.89	8	88.89	8	88.89
Average		8.33	92.59	8.33	92.59	8.33	92.59
Criteria		very proper		very proper		very proper	

Table 2. The result of properness test open-ended problems at the second stage.

No	Evaluator	Content		Constructs		Language	
		Score	in %	Score	in %	Score	in %
1	Validator 1	9	100	9	100	9	100
2	Validator 2	9	100	9	100	9	100
3	Validator 3	8	88.89	9	100	8	88.89
Average		8.67	96.29	9	100	8.67	96.29
Criteria		very proper		very proper		very proper	

The distributions of the student responses questionnaire are also performed in two stages. The first stage is done by small-scale trial participants and the second stage is done on a large scale trial participants. Student responses questionnaire to open-ended problems is given to the students after the test. The results of student responses are presented in Table 3.

Table 3. The result of student responses to open-ended problems.

	Acquisition of Score per Aspects (%)				
Respondents	Language	Display	Systematic	Function	Testimony
Small scale trials	83.04	79.46	77.68	89.28	77.68
Large-scale trial	83.33	82.41	79.40	85.95	78.24
Average	83.19	80.94	78.54	87.62	77.96
Criteria	Good	Good	Good	very good	Good

The results of properness test by expert and student responses show an average percentage > 80%, its means that the open-ended problems are very proper to be used to measure higher-order-thinking-skills on global warming phenomenon.

The effectiveness of open-ended problems can be seen from the score of students mid-semester test that is compared to the score obtained from open-ended problems. The correlation coefficient between the score of mid-semester test and open-ended problems with a level of error of 1% is 0.634, a strong category. The result shows that the open-ended problems can be used to describe the higher-order-thinking-skills effectively.

Profile of student's higher-order-thinking-skills can be seen from the answers and the obtained scores on open-ended problems where the ability to analyze, evaluate, and create can be observed from it. Ability profile in analyzing, evaluation, and creation are presented in Table 4, 5, and 6.

Table 4. Ability profile in analyzing.

Interval values	Frequency	Percentage (%)	Category
$75 < t \leq 100$	6	11.11	very good
$58.33 < t \leq 75$	18	33.33	good
$41.67 < t \leq 58.33$	16	29.63	enough
$25 < t \leq 41.67$	13	24.08	low
$0 < t \leq 25$	1	1.85	very low
The average value	56.17		enough

Table 5. Ability profile in theevaluation.

Interval values	Frequency	Percentage (%)	Category
$75 < t \leq 100$	25	46.30	very good
$58.33 < t \leq 75$	15	27.78	good
$41.67 < t \leq 58.33$	11	20.37	enough
$25 < t \leq 41.67$	3	5.55	low
$0 < t \leq 25$	0	0	very low
The average value	70,68		good

Table 6. Ability profile in creation.

Interval values	Frequency	Percentage (%)	Category
$75 < t \leq 100$	6	11.11	very good
$58.33 < t \leq 75$	20	37.04	good
$41.67 < t \leq 58.33$	21	38.89	enough
$25 < t \leq 41.67$	7	12.96	low
$0 < t \leq 25$	0	0	very low
The average value	57		good

The developed open-ended-problems raise very diverse student answers, so it can show the profile of student's thinking skill well. Table 4 shows that ability profile in analyzing is good enough. It can be seen from the student's answers that a large number of students can recognize and distinguish between the causes and consequence of global warming process, analyze information about the earth's climate which is unstable, begin to identify the patterns, and able to identify the problems that led Indonesia became contributor of greenhouse gases.

Table 5 shows that the ability to evaluate is good. It can be concluded from the student's responses. The students can give an assessment of the vegetarian community to ensure the effectiveness and benefits, make hypotheses the kind of greenhouse gasses which is most influential on global warming then do the testing, and accept or reject the opinion in stopping the global warming.

Table 6 shows that the ability in creation is good. It can be seen from the student's answers which show that a large number of students can generalize an idea in controlling the global warming, determine a way to overcome the problem of organic waste in Indonesia, and developing some ideas to create an alternative energy or environmentally friendly technology.

The results show that the best ability of students of SMA Negeri 1 Salatiga is the ability to evaluate, creative, andthen analyze. These results are not in line with research conducted by Istiyono *et al.* [9] which states that the best ability of high school students is the ability to analyze, evaluate, and then to create. Higher-order-thinking-skill can be measured by summing the scores obtained by students from aspects of the analysis, evaluation, and creation. Profile of higher-order-thinking-skill of students stated in Table 7 below.

Table 7. Profile of higher-order-thinking-skill.

Interval values	Frequency	Percentage (%)	Category
$75 < t \leq 100$	11	20.37	very good
$58.33 < t \leq 75$	17	31.48	good
$41.67 < t \leq 58.33$	23	42.59	enough
$25 < t \leq 41.67$	3	5.56	low
$0 < t \leq 25$	0	0	very low
The average value	61.28		good

The table shows that 20.37% of the students have a very good higher-order-thinking-skills, 31.48% of students have a good higher-order-thinking-skills, 42.59% students have a good enough higher-order-thinking-skills, and the other have a low good higher-order-thinking-skills. The average value obtained by all students is 61.28 in the category of good, so it can be concluded that in general, SMA Negeri 1 Salatiga has a good higher-order-thinking-skills.These results are in line with research that

has been done by Rahayu and Sonata [10] which states that a higher-order-thinking-skills of students of SMAN 18 Surabaya on Acid Alkali Titration material included in good categories. These results are also in line with the data from Balitbang Kemdikbud on the results of a national examination SMA/MA 2014/2015 stating that SMA Negeri 1 Salatiga has a good academic record.

4. Conclusion

The open-ended problems in measuring the higher-order-thinking-skills of high school students on global warming are very proper and effective. Higher-order-thinking-skills of the students of SMA Negeri 1 Salatiga are good, covering the ability to analyze good enough, the ability to evaluate is good, and the ability to be creative is good enough.

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