Development of Instruments to Train Critical and Creative Thinking Skills in Physics Assessment for High School Students' Learning

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Abstract. This study aims to develop assessment instruments, describe the appropriateness of assessment instruments that fill the elements of validity, practicality, and effectiveness of assessment instruments in training the critical and creative thinking skills of high school students. The research method used a development research model developed by the model of Borg & Gall. In this study, 7 steps were used consisting of research and information gathering, planning, initial product development, limited trials, initial product revisions, field trials, and final product revisions. The sampling technique used was purposive sampling technique, namely the high school students of class X in Tanggamus. The instruments used are validation instruments, practicality tests, and critical and creative thinking skills, and test instruments for critical and creative thinking skills. Test instrument analysis techniques use validity and reliability analysis, different levels of difficulty and power. The validation results of three expert lecturers and three expert practitioners stated that the assessment results of the development were feasible to be used in the high category (72%) for aspects of language, construction, and content. Assessment instruments resulting from practical development are used in physics learning with an average score in the very high category (83.3%). Assessment instruments are used in learning as assessment for learning, students who have the ability to think critically and creatively with good categories reach 56.5% and 57.4%. Thus, assessment instruments for critical and creative thinking skills that have been developed effectively train students to have good critical and creative thinking skills, so that assessment instruments can be used as an assessment for learning for students.

1. Introduction

The success of education has a goal to improve human resources. One of the factors that influence this success is the teacher's ability to conduct and utilize assessment, process evaluation, and learning outcomes. This ability is indispensable to know whether or not the learning objectives have been established in the curriculum. The ability of teachers to do and utilize assessment, process evaluation, and learning outcomes can be used to improve or improve the learning process that the teacher has done so that students can truly understand and be able to apply what they already know, students must be trained to solve a problem, find everything for themselves, and try hard to realize their ideas. The ability to think critically and creatively is an ability that is important for students to be able to solve the problems which faced. Thus, the development of thinking skills, both critical thinking, and creative thinking is an important thing to do and needs to be trained in students starting from elementary education to secondary education. However, based on the PISA reported by the Organization for

Economic Operation and Development (OECD) Indonesia is ranked 69th out of 76 countries [1]. These results indicate that the average Indonesian student still has a low ability when viewed from the cognitive aspect (knowing, applying, reasoning). Physics is a branch of natural science or science. Science is related to how to systematically know about a natural phenomenon. To explain this phenomenon, scientists build concepts and theories that often use abstract symbols so that they become difficult to understand. This makes most students dislike physics lessons at school. The ability to think critically and creatively is needed for the advancement of higher physics learning, in order to train students' abilities, an assessment is needed. Assessment encourages students to construct, organize, analyze, synthesize, interpret, explain, and evaluate information into new knowledge.

Based on the results of preliminary research of high school students in Tanggamus, cognitive assessment instruments used in the form of assessments tend to test more aspects of memory, while assessments that train students' critical and creative thinking skills are not widely available. Plus the teacher lacks the ability to develop assessment instruments. So that students are less trained in solving contextual problems, demanding to reason, and creativity in solving a problem. Critical thinking ability occupies a dimension of analysis and evaluation [2], an indicator of critical thinking ability consists of focusing on questions, analyzing arguments, assessing source credibility, making deductive and inductive conclusions, assessing definitions, defining assumptions and making decisions in problem-solving. While creative thinking is a mental activity that fosters original ideas and new understandings, students are expected to have a mind that is trained by paying attention to intuition, enlivening the imagination, expressing new possibilities, making perspectives and generating ideas. better, creative thinking indicators used to consist of four aspects of critical thinking skills. They are fluency, flexibility, originality, and elaboration [3].

Critical and creative thinking are two very basic abilities because both can encourage students to look at every problem faced critically and try to find answers creatively so that new things are better and useful for students. So it is necessary to develop assessment instruments in training students' critical and creative thinking skills. [4] Assessment for learning is a process used by teachers and students in recognizing and responding to student learning in order to improve their learning in the learning process. Assessment for learning assists teachers in describing student learning progress and informs decisions about the next steps in learning. Assessment for learning can be used by teachers and students to modify the way of learning or how to teach it, so it hopes that can get more effective results. To train students' critical and creative thinking skills, assessment is needed for learning that can improve classroom learning. The teacher should use assessment to plan lessons, identify students' needs in learning and re-teach material that is not well understood by students.

Critical thinking is cognitive activity, which is related to the use of the mind [5]. The ability to think critically is best measured and assessed in certain learning contexts, not in general [6]. While the ability to think creatively is a mental activity that fosters original ideas and new understandings [7]. The use of assessment instruments as assessment for learning is needed to train students' thinking skills, especially the ability to think critically and creatively. This also agrees with the research entitled "Assessment for Learning revisited: an Asia-Pacific perspective" [8]. The results obtained show that assessment for learning which is a process to identify learning progress has been proven to be able to help develop students' thinking skills.

The purpose of developing assessment instruments that have been done is to determine the validity, practicality, and effectiveness of assessment of critical and creative thinking skills as assessment for learning in physics learning of high school students in simple harmonic motion material. Based on these objectives, the formulation of the problem in this study was prepared as follows.

1) how is the validity of assessment instruments critical and creative thinking skills as assessment for learning in physics learning of high school students on simple harmonic motion material?
2) how is the practicality of assessment instruments critical and creative thinking skills as assessment for learning in physics learning of high school students on simple harmonic motion material?
3) how is the effectiveness of assessment instruments critical and creative thinking skills as assessment for learning in physics learning of high school students on simple harmonic motion material?

2. Research Method

This study uses the Borg and Gall development research model consisting of 10 development steps [9]. But in this study, 7 steps were used which consisted of research and information gathering, planning, initial product development, limited trials, initial product revisions, field trials, and final product revisions. Data from the validity assessment results are shown from the results of the expert test assessment in assessing the content aspect of the problem, the construction of the problem, and the language in the question. The data collection instrument used was a validation questionnaire filled by the lecturer validator, practicality assessment data shown by the practicality questionnaire on the questions in the form of qualitative data, while the data from the effectiveness assessment indicated by the results of the average score of students during the first two meetings in the process the development of students' critical and creative thinking skills and the average score at the last meeting in working on the all of problem in the form of quantitative data.

The sampling technique used purposive sampling technique, namely the sample was chosen based on the considerations of the researcher. The research sample to obtain the needs analysis data was taken from 35 students and 6 high school science teachers using a questionnaire. Product trials in this study were 35 class X students using questions of critical and creative thinking skills, and field trials in this study were 70 class of x grade students. The validity of the questions was in the form of questionnaires to test experts in assessing content aspects, construction of questions, and language in the problem. Practical instruments consist of practical use observation sheets about critical and creative thinking skills in assessment. Before using practicality observation sheets have been validated by experts and declared valid. Furthermore, the effectiveness instrument can be seen from the results of the use of questions about the ability to think critically and creatively in the two initial meetings and the last one meeting in the class of X grade.

Data validity analysis in train the critical and creative thinking skills of high school students was obtained from the validator in the form of quantitative data. The scores obtained are then processed into values categorized according to the evaluation criteria [10] in Table 1 below.

Table 1 Criteria for Instrument Validity Evaluation Results

Average Score	Evaluation Criteria
25% – 40%	Invalid (may not be used)
41% – 55%	Less valid (may not be used)
56% – 70%	Quite valid (may be used after a major revision)
71% – 85%	Valid (may be used with minor revisions)
86% – 100%	Very valid (very good to use)

All validation results are shown in the aspects of language, construction, and content/material of the test instruments for critical and creative thinking skills, after being declared valid and can be used in limited trials after revision. Analysis of data from the practicality of the questions was carried out descriptively. The practicality of critical and creative thinking skills in terms of the results of the practicality questionnaire results in eight questions. The practicality of the problem is determined by calculating the average score from each aspect, then changing the mean score to a value with the criteria. The reference for changing scores to a scale of five [11] can be seen in Table 2 below.

Table 2 Score Conversion Assessment Statement of Practical Quality Score

Achievement level	Qualification
81 – 100%	Very good
61 – 80%	Good
41 – 60%	Good enough
21 – 40%	Less good
0 – 20%	Not good

Data analysis result of the instrument practicality test consists of 8 items, it states about how the instruments of critical and creative thinking skills are used in the assessment. Data analysis to determine the effectiveness of test instruments for critical and creative thinking skills as assessment for learning in physics learning of high school students is by assessing using guidelines for scoring students' critical and creative thinking skills based on their respective indicators. Data from the test results of test instruments that have been developed to assess critical and creative thinking skills then calculated the average score obtained by students in working on the questions. The test results are converted into qualitative data to determine the category of critical and creative thinking skills [11] as in Table 3.

Table 3 Critical and Creative Thinking Ability Level Categories

Students score	Level of thinking ability Critical and creative students
100 – 76	Very good
75 - 51	Good
50 - 26	Enough
25 – 1	Less

3. Result and Discussion

Critical and creative thinking test instruments that have been developed then tested on three lecturers of Physics Education in teacher training and education faculty who are master in simple harmonic motion material and are experts in the field of instrument development. Expert tests were conducted to examine the suitability of the relationship between questions and test objectives [13]. The initial development stage was made as many as 14 questions about critical thinking skills, and 12 questions about the ability to think creatively on simple harmonic motion material. The results of the questionnaire of validity on the test instruments for critical and creative thinking skills can be seen in Table 4.

Table 4 Recapitulation of the results of filling out the Questionnaire for Validation Test

Aspects tested	Average Score Percentage	Quality Criteria
Content	72 %	Valid enough
Construction	71 %	Valid
Language / culture	72 %	Valid
Average Total Score	**72 %**	**Valid**

The results of expert validation from test instruments developed from the aspect of language by 72%, construction aspects 71%, and aspects of content or material by 72% and in total obtained the results of expert validation scores from the three aspects of 72% with valid criteria, meaning the test instrument can be used with repairs first. The trial is limited to know the reliability, the level of difficulty, and the different power of the previously revised test instruments. The results of limited trials can be seen in Table 5, Table 6, and Table 7.

Table 5 Reliability Test Results About Critical and Creative Thinking Ability

Test	**R Score**	**Criteria**
Critical Thinking Ability	0,82	Very high
Creative Thinking Ability	0,68	High

Table 6 Results of Test of Difficulty Level and Differences in the Problem of Ability Critical Thinking

Number of tests	Difficulty		Difference Power	
	Score	**Criteria**	**Score**	**Criteria**
1	0,71	Medium	0,35	Accept without revision
2	0,63	Medium	0,25	Accept with revision
3	0,53	Medium	0,33	Accept without revision
4	0,42	Medium	0,28	Accept with revision
5	0,72	easy	0,38	Accept without revision
6	0,29	Hard	0,45	Good
7	0,55	Medium	0,23	Accept without revision
8	**0,41**	Medium	**0,00**	**Reject**
9	**0,59**	Medium	**0,20**	**reject**
10	0,51	Medium	0,35	Accept without revision
11	0,71	Easy	0,25	Accept with revision
12	0,59	Medium	0,30	Accept without revision
13	0,58	Medium	0,48	Good
14	0,71	easy	0,33	Accept without revision

Table 7 Results of Difficulty Test Level and Problem Difference Creative Thinking Ability

Number of Tests	**Difficulty**		**Difference power**	
	Score	**Criteria**	**Score**	**Criteria**
1	0,73	Easy	0,30	Accept without revision
2	0,72	Easy	0,28	Accept with revision
3	0,29	Hard	0,30	Accept without revision
4	0,42	Medium	0,30	Accept without revision
5	0,59	Medium	0,33	Accept without revision
6	**0,57**	**Medium**	**0,03**	**Reject**
7	0,72	Easy	0,20	Accept without revision
8	0,39	Medium	0,23	Accept without revision
9	0,75	Easy	0,28	Accept without revision
10	**0,29**	**Hard**	**0,05**	**Reject**
11	0,60	Medium	0,28	Accept with revision
12	0,59	Medium	0,25	Accept with revision

The questions tested consisted of 14 critical thinking skills questions and 12 creative thinking skills questions. Reliability values were 0.82 with very high categories and 0.68 with high categories. The results of the limited trial showed that in all the critical thinking ability problem 64.2% of the questions were in the medium category. Judging from the different strengths, 2 items were rejected, 3 items were received with revisions, 7 items were received without revision, and 2 items were good. In the matter of the ability to think creatively seen from the level of difficulty as a whole 50% of the questions included in the medium category. For different power, 2 items were rejected, 6 items were received with revisions, and 4 questions were received without revision. 6 questions received with repairs were revised first and then included in the main questions to be tested. Thus, the questions that will be used for field trials are 12 questions about the critical thinking skills and 10 questions about the ability to think creatively.

The practicality of assessment instruments for the ability to think critically and creatively is measured through product practicality questionnaires to physics teachers in high school. The field trial was conducted by filling out the practicality questionnaire for the use of instrument instruments for critical and creative thinking skills developed. Overall review based on the recapitulation table of the results of filling out the use trial questionnaire, the average score of respondents regarding the practicality test of the instrument is 3.3 or if it is converted to 83.3%, which means very high.

Regarding the use of instructions, 100% percentage of respondents' scores which means very practical because the use of instructions used in the instrument of critical and creative thinking skills is easier to understand, aspects of material content presented is 91.66% which means practical, content of the material presented Through the instrument it has been able to represent the components of KI and KD that will be presented, aspects of sentences and language, 75% percent of respondents' scores which means practical because the sentences and language used in the instrument of critical and creative thinking skills are more easily understood in detail. The form of the question, 75% of the percentage of respondents 'scores which means it is practical because the form of the questions used in the instrument connects between illustrations with material concepts in physics, forms of observation sheets, 75% percentage of respondents' scores which means practical to use because the observation sheet format includes assessment of activities student learning during the learning process. The indicator is assessed, 100% of the percentage of respondents' scores which means very practical because the indicators that will be assessed on the instrument of critical and creative thinking ability include the indicators listed in KI and KD as well as indicators of critical and creative thinking skills.

Assessment instrument of critical and creative thinking skills 75% percent of respondents scores which means very practical use after the learning process, improvement of learning outcomes, 75% percent of respondents scores which mean practical because the instruments of critical and creative thinking skills are able to measure student learning outcomes on cognitive aspects. This type of assessment can provide quality information about student learning [14]. The conclusions obtained through the questionnaire regarding practicality tests are very practical, detailed, and suitable for use.

Analysis results of critical and creative thinking test instruments tested were 22 items. The scores obtained from the test results are processed into values then. The values obtained from the results of this trial are analyzed and interpreted into the category of students' critical and creative thinking skills based on scoring guidelines on the ability to think critically and creatively. The number of students who have the ability to think critically and creatively according to their respective categories can be seen in Table 8 and Table 9.

Table 8 Students Critical Thinking Ability

Category	Total	Percentage
Very good	8	11,4 %
Good	37	52,9 %
Enough	21	30,0 %
Less	4	5,7 %
Total	**70**	**100 %**

Table 9 Students Creative Thinking Skill

Category	Total	Percentage
Very good	6	8,6 %
Good	34	48,6 %
Enough	25	35,7 %
Less	5	7,1 %
Total	**70**	**100 %**

Students who have the critical thinking ability category of all samples tested, the average student score is 56.5 which belongs to the good category. This critical thinking ability assessment instrument is specifically designed so that students' critical thinking skills are high so that students can face challenges in the future. One of the skills needed to face future challenges is critical thinking skills [15]. While the research results of students who have creative thinking ability categories from all samples tested, the average student score is 57.4 which belongs to the good category.

The development of assessment instruments for the ability to think creatively can measure the ability to think smoothly, originally, elaboratively and evaluatively well [16]. After students are grouped according to their respective categories of critical and creative thinking skills, then the whole question assembly is done and given back to students to see the effectiveness of the test instruments

that have been developed whether they are truly able to train students' critical and creative thinking skills in accordance with the criteria which has been set. The results of the overall field trial for each category can be seen in Table 10 and Table 11.

Table 10 Overall Instrument Testing Results in Critical Thinking Ability

First Average Score	Category	Final Average Score	Category
78,4	Very good	81,5	Very good
59,3	Good	70,1	Good
44,7	Enough	49,6	Enough
23,6	Less	25,0	Less

Table 11 Overall Instrument Testing Results Creative Thinking Ability

First Average Score	Category	Final Average Score	Category
79,7	Very good	84,4	Very good
62,4	Good	70,4	Good
47,1	Enough	49,9	Enough
23,3	Less	25,0	Less

Table 10 and Table 11 show that students who are grouped into criteria of critical and creative thinking are very good, good, sufficient, and lacking, have the same criteria when tested again through the problem of overall critical and creative thinking skills. Thus, the test instruments for critical and creative thinking skills that have been developed are considered effective in training students' critical and creative thinking skills in accordance with the level of ability that they have. The results of the table show that students who have creative thinking skills are very good, after working again on the ability to think creatively and still have excellent creative thinking skills. Likewise students who have the ability to think critically and creatively well, still have the ability to think critically and creatively well, students who have the ability to think critically and creatively enough, still have enough critical and creative thinking skills, and students who have less critical and creative thinking skills, still lack the ability to think critically and creatively.

The results of the effectiveness test of this assessment instrument can be seen based on the average score of students during the first 2 meetings in the process of developing students' critical and creative thinking skills and the average score at the last meeting in working on the overall problem. The results are shown in Table 10 and Table 11 which is interpreted in Figure 1 and Figure 2.

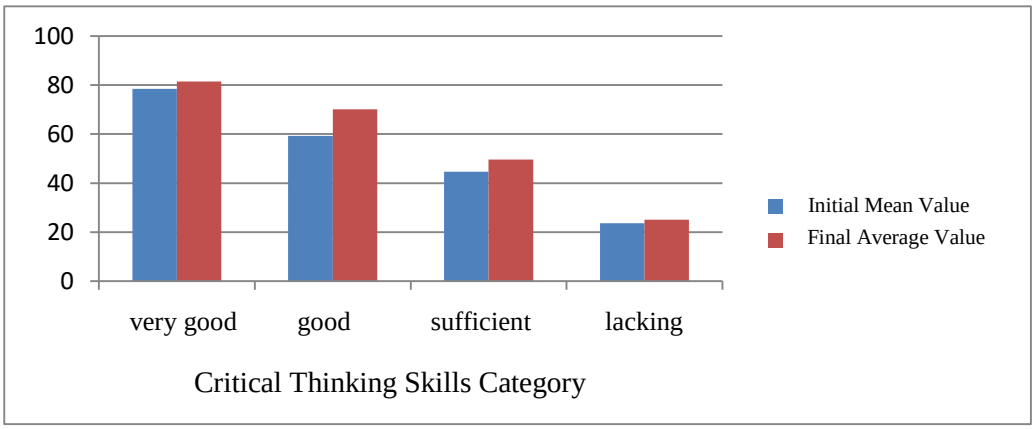

Figure 1 Initial Mean Value (First Meeting 2) and Final Average Value (1 Last Meeting)

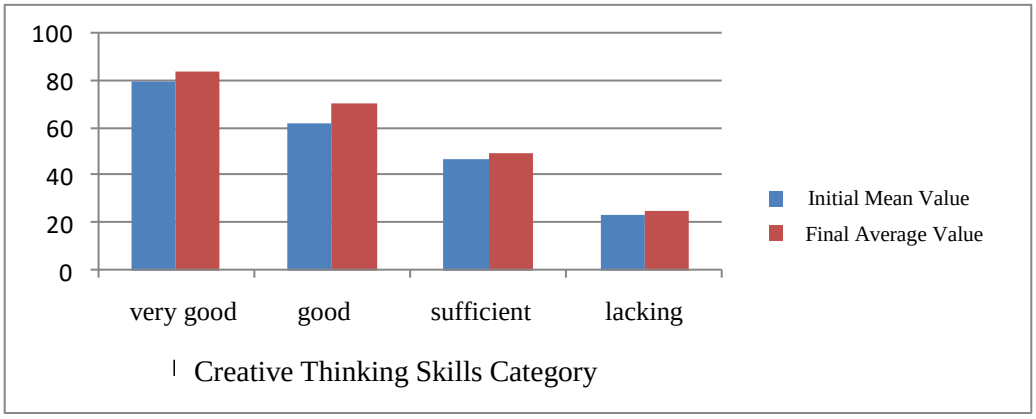

Figure 2 Initial Mean Value (First Meeting 2) and Final Average Value (1 Last Meeting)

These results indicate that the assessment of critical and creative thinking ability instruments that have been developed effectively train students' critical and creative thinking skills in accordance with their thinking abilities. The assessment should be able to measure all aspects that students know and students do, this indicates that the assessment used in learning is successful. Assessment is an assessment of student learning processes that can demonstrate learning success [17-19].

In this case, the use of assessment tools for critical and creative thinking skills is an alternative for teachers to train and determine the level of students' critical and creative thinking skills [20]. By working on the question of the ability to think critically and creatively, students can provide answers according to their thinking skills so that the teacher knows how well the students' level of thinking ability. This, of course, can help teachers to develop better test instruments for critical and creative thinking skills on other topics so that students can develop their thinking skills to be more optimal.

4. Conclusion

Based on the description in the discussion, it can be concluded that the assessment instrument of critical and creative thinking skills as assessment for learning is valid, practical and effective to be used in physics learning of high school students.

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