

The Development of Assessment Instrument for Learning Science to Improve Student's Critical and Creative Thinking Skills

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Abstract. This study aims to develop assessment instrument for learning science, describe its validity and effectivity for improving students' critical and creative thinking skills. This study was conducted by adapting Borg & Gall's development research model, with seven steps consisting of preliminary studies, planning, initial product development, limited trials, initial product revision, main field test, and final product revision. The purposive sampling technique was applied to choose eleventh grade students in the city of Bandar Lampung, Indonesia as research sample. The instrument used is in the form of written tests and portfolios. Data analysis techniques used validity and reliability test and grain parameter test. The results showed that the instrument have a high category on the aspect of language, construction, and content based on expert and practitioners validation. Moreover, it is also effective to improve the students' ability to think critically and creatively with enhancement 28.8% and 35.1% for written tests, as well as 25.3% and 32.2% for portfolio. Hence, this assessment instrument is highly recommended to be used in science learning.

Keywords: Assessment for learning science, critical and creative thinking skills, research and development.

INTRODUCTION

Education is a learning process for individuals to achieve higher knowledge and understanding of specific objects and another. That knowledge and understanding can be obtained formally or informally which results in each individual having a mindset, behavior and morals that are in accordance with the education they obtained. One of the formal education facilities is schools. Students get education from school through teachers, so the importance of the teacher's ability to teach at school. The ability of teachers to do and utilize assessments, process evaluations, and learning outcomes is needed to find out whether or not the learning objectives that have been set in the school are achieved. The teacher's ability can be used to repair or improve the learning process that has been done by the teacher so that students can truly understand and be able to apply what they already know, students must be trained to work to solve a problem, find everything for themselves, and strive to realize his ideas. One of the abilities that are important for students today is the ability to think critically and creatively, which is the ability of students to solve problems 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.

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. In this study students' critical and creative thinking skills can be trained using written assessment techniques, learning outcomes become a measure of the achievement of the objectives of the learning process.

Based on the results of preliminary research of high school students in Bandar Lampung, cognitive assessment instruments used in the form of assessments that tend to test more aspects of memory that can not be used to train higher thinking skills, especially the ability of critical thinking and creative students. Moreover, in solving fluid problems that demand reasoning and analysis in solving them. In addition, the assessment is only given at the end of the chapter or the end of the lesson material. The assessment process that has been carried out so far only emphasizes the mastery of concepts which mostly include low-level

cognitive domains C1 (introduction), C2 (understanding), C3 (application), with objective and subjective written tests as a measuring tool. Improving students' critical, creative thinking skills and the teacher lacks the ability to develop assessment instruments. So that students are less trained in solving contextual problems, demanding reasoning, and creativity in solving a problem. According to Anderson and Krathwohl, (2010) Critical thinking ability occupies a dimension of analysis and evaluation, 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 solution to problem. 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. Creative thinking indicators better used consist of four aspects of critical thinking skills namely fluency, flexibility, originality and elaboration.

Critical and creative thinking are two very basic abilities because both can encourage students to always 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. Assessment is the process of collecting, interpreting and using evidence to make decisions about student achievement in education (Harlen, 2007). According to Boekaerts and Corno (2005) and Glasson (2005) Assessment can broadly be used to determine the level of achievement of learning outcomes known as assessment of learning (AoL), and to improve the learning process known as formative assessment or assessment for learning (AfL). 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 (Bell and Cowie, 2001). 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 in the hope of getting more effective results. To train students' critical and creative thinking skills, assessment is needed for learning that can improve classroom learning. The instruments that used are written assessment and portfolio assessment. Portfolio assessment is an assessment that can measure the overall level of students' abilities, even in their characteristics, portfolio assessment is an assessment that demands the collaboration between teachers and students. Portfolio assessment is not just a collection of students' work, but the most important is the selection process based on the

criteria and the collection of students' work from time to time.

In the opinion of Cottrell (2005) critical thinking is cognitive activity, which is related to the use of the mind. The ability to think critically is best measured and assessed in certain learning contexts, not in general. While the ability to think creatively is a mental activity that fosters original ideas and new understandings (Jonshon, 2009). The use of assessment instruments in the opinion of Klenowski (2009) as assessment for learning is needed to improve 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". The results 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 the assessment instruments that have been carried out is to determine the validity and effectiveness of assessment instruments for science learning to improve the critical and creative thinking skills of high school students in Static Fluid 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 for science learning to improve the critical and creative thinking skills of high school students in static fluid material?
- 2) how is the effectiveness of assessment for learning Science instruments to improve the critical and creative thinking skills of high school students in Static Fluid material ?

RESEARCH METHOD

This study adapted the development research model from Borg and Gall which consisted of ten development steps. However, in this study seven

development steps were used consisting of preliminary studies, planning, initial product development, limited trials, initial product revisions, main field tests, and final product revisions. Data from the validity assessment of written test instruments and portfolio assessments are shown from the results of the assessment of experts in assessing aspects of content, construction, and language in the assessment instrument. Data collection instruments used were through validation questionnaires filled by experts and practitioners, and data from the effectiveness assessment indicated by the results of increasing the average score of students for three meetings by being given an initial test (pretest) and then given treatment (treatment), and given a final test (posttest).

The sampling using purposive sampling technique. The research sample to obtain needs analysis data was taken from 36 students. Product trials in this study were 36 class XI students using the questions of critical and creative thinking skills, and the main field test in this study were 72 class XI students. Validity instrument questions, which are in the form of expert questionnaires in assessing aspects of content, construction, and language in assessment instruments in the form of written tests and portfolios. Furthermore, the effectiveness of the instrument can be seen from the results of the use of questions about the ability to think critically and creatively in three meetings in class XI students.

Data analysis of validity results of assessment instruments in measuring the ability to think critically and creatively 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 (Purwanto, 2010) in Table 1 below.

Table 1. Criteria for Instrument Validity Evaluation Results

Average Score	Avaluation 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)

The overall validation results are shown in the aspects of language, construction, and content/material of written assessment test instruments and a portfolio of critical and creative thinking abilities, after being declared valid and can be used limited trial after revision. Data analysis to determine the effectiveness of assessment instruments for learning science to improve students' critical and creative thinking skills, namely assessing using guidelines for scoring students'

critical and creative thinking skills based on their respective indicators. Data from the results of testing instruments that have been developed to assess the ability to think critically and creatively are then calculated the average score obtained by students in working on the questions. The test results are then converted into qualitative data to determine the level of critical and creative thinking skills (Lewy, 2009) as shown in Table 2.

Tabel 2. Critical and Creative Thinking Ability Level Categories

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

RESULT AND DISCUSSION

Assessment instruments for science learning to improve critical and creative thinking skills that have been developed are then tested to experts and practitioners who master static fluid material and experts in the field of instrument development. In the opinion of Gelerstein (2016) expert tests were conducted to examine the suitability of the relationship between questions and test objectives. The initial stage development was made as many as

15 multiple choice questions of critical thinking skills, and 12 questions about the ability to think creatively on fluid material for the test questions instrument, while for portfolio instruments were made in lab work and papers. The results of the questionnaire testing the validity of test instruments and a portfolio of critical and creative thinking abilities can be seen in Table 3 below.

Tabel 3. Recapitulation of the results of filling out the Questionnaire for Validation Test

Aspect tested	Percentae of Aspect Question	Portofolio Percentage	Quality Criteria
Content	82 %	72 %	Valid
Construction	82 %	74 %	Valid
Language/culture	83 %	73 %	Valid
Average total score	82 %	73 %	Valid

The results of expert validation from written test instruments and portfolios developed from language aspects were 82% and 72%, construction aspects 82% and 74%, and aspects of content or material by 83% and 73% and as a whole obtained the results of expert validation scores from all three aspects that is 82% and 73% with valid criteria, meaning that written test instruments and portfolios can be used

in advance. Limited trials to determine reliability, level of difficulty, and different power of written test instruments that have been revised previously. The results of showed that questions for critical and creative thinking are very reliable with R score 0,74 and 0,71, respectively. Level of difficulty and different power of item test are shown by table 4.

Tabel 4. Results of Difficulty Test Level and Problem Difference

No	Critical thinking				Creative thinking			
	Difficulty		Different		Difficulty		Different	
	Score	Criteria	Score	Criteria	Score	Criteria	Score	Criteria
1	0,70	Medium	0,35	Accept	0,58	Medium	0,33	Accept
2	0,92	Easy	0,33	Accept	0,48	Medium	0,41	Accept
3	0,45	Medium	0,33	Accept	0,33	Medium	0,33	Accept
4	0,67	Medium	0,33	Accept	0,39	Medium	0,33	Accept
5	0,46	Medium	0,5	Accept	0,51	Medium	0,2	Accept with revision
6	0,75	Easy	0,83	Accept	0,55	Medium	-0,03	Deny
7	0,5	Medium	0,83	Accept	0,51	Medium	0,25	Accept with revision
8	0,29	hard	0,83	Accept	0,55	Medium	0,12	Deny
9	0,70	Medium	0,5	Accept	0,61	Medium	0,37	Accept
10	0,70	Medium	0,83	Accept	0,43	Medium	0,33	Accept
11	0,70	Medium	0,83	Accept	0,59	Medium	0,2	Accept with revision
12	0,79	Easy	0,33	Accept	0,54	Medium	0,41	Accept
13	0,70	Medium	-0,31	Deny				
14	0,92	Easy	0,33	Accept				
15	0,96	Medium	0,13	Deny				

Based on Tabel 4, item questions consisted of 13 questions about critical thinking skills and 10 questions about creative thinking abilities. The results of the limited trial showed that in the overall critical thinking ability problem 75% of the questions were in the medium category. Judging from the different powers, 2 items were rejected, and 13 items were received. In the matter of the ability to think creatively seen from the overall level of difficulty 100% of the questions fall into the medium category. For different powers, 2 items were rejected and 10 items were received with revision first and then included in the main questions to be tested. Thus, the questions that will be used for field trials are 13 multiple choice questions of critical thinking skills and 10 questions of creative thinking abilities. The main field test was conducted in class XI IPA 1 and 2 Muhammadiyah Bandar Lampung High School as an experimental class with 36 students. The learning process begins by explaining to students about the learning process carried out namely assessment for learning science learning by doing practicum, then students work on the pre-test questions of critical and creative thinking. This pretest was intended to find out the students' initial critical thinking skills before treatment was used. Furthermore, learning is carried out with a percentage of the papers that have been made. Finally, student learning is also given a posttest to

determine the improvement of students' critical and creative thinking skills.

Portfolio assessment instruments tested in the form of lab reports, science process skills, papers and presentation skills. Practical Report Assessment is based on 8 aspects of assessment with 5 critical thinking indicators. Assessment of science process skills is based on 6 aspects of assessment with 5 indicators of critical thinking, assessment of papers based on 4 aspects of assessment with 5 indicators of critical thinking, presentation skills assessment based on 6 aspects of assessment with 5 indicators of critical thinking. The scores obtained are processed into values which are then interpreted into the category of critical thinking skills.

Analysis results critical and creative thinking test instruments were tested as many as 23 items and portfolio instruments in the form of practical reports and paper assignments and percentages. The scores obtained from the test results are then processed into values. The values obtained from the results of this trial are then 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 in the written test and portfolio can be seen in Table 5.

Table 5. Information of students' critical and creative thinking on writtent test and portfolio

Category	Response (%) on Critical thinking		Response (%) on Critical thinking	
	written test	portfolio	written test	portfolio
Very Good	13 (18,0%)	12 (16,7%)	14 (19,4%)	12 (17,1%)
Good	37 (51,3%)	35 (48,6%)	38 (52,7%)	35 (50,0%)
Enough	20 (27,7%)	23 (31,9%)	17 (23,6%)	20 (28,6%)
Less	2 (2,7%)	2 (2,8%)	3 (4,1%)	3 (4,1%)
Total	72 (100%)	72 (100%)	72 (100%)	72 (100%)

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. Development of assessment instruments for the ability to think creatively can measure good thinking skills, originality, elaborative and evaluative (Tinio, 2003). The test results of students' critical and creative thinking skills were obtained from the mean posttest of critical thinking skills (76.2) and creative (78.4) greater than the average pretest scores of critical thinking skills (59.2) and creative (58.0), so that From the mean score, there was an increase in critical and creative thinking skills of 28.8% and 35.1% for test questions and 25.3% and 32.2% for portfolio instruments. Besides that, based on the results of the calculation, the mean n-gain values were 0.41 and 0.48 with the medium category. Thus, assessment for learning science instruments to improve critical and creative thinking skills that have been developed are considered quite effective

in improving students' critical and creative thinking skills in accordance with the level of ability they have. 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 students' learning processes that can demonstrate learning success (Habiby, 2016; Mueler, 2005; and Shwartz, 2006). 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 (Lombardi, 2008). The assessment for learning science instrument developed has the characteristics of critical and creative thinking, where the assessment for learning science instrument presents information so that students can solve problems, examine information critically and creatively, link concepts to other concepts, or seek truth from different information. The written test trains the ability to think critically and creatively by displaying contextual or realistic problems in everyday life, but

still based on the concepts of physics studied. In the opinion of Treagust (2001) questions in the form of statements contain problems to stimulate students to be critical and creative in solving the problem.

Assessment for learning science in this study provides further explanation and emphasis on the right concepts in solving problems in students. The student's answer shows students' understanding of the instrument. This is taken into consideration in designing the next learning in order to improve the quality of student learning, this is in the form of discussing many questions that are wrongly answered by students and accompanied by additional explanations to overcome misconceptions. In the matter of the ability to think critically and creatively, students are facilitated by giving feedback immediately during the process of the question and after the work on the question. The feedback given is the correctness of the answers, instructions on the location of the student's answer errors, assistance in working on the questions, and suggestions for improvement to improve the student's learning process.

According to Rofiah's opinion (2013), a test or instrument is said to be assessment for learning if it has two criteria. The first criterion is assessment carried out during the learning process and the second criterion, must meet one or more of the main objectives of assessment for learning, namely identifying students' strengths and weaknesses, assessing educators in planning learning, guiding students to improve performance and helping to increase responsibility for continuing learn. Increased scores obtained in this study because in learning students are given the opportunity to explore their abilities in conducting a problem orientation. Students are not only passive in following the fluid learning process, but are required to actively explore information by practicing and percentage. In addition students are asked to make practical reports and papers that can develop students' ability to think critically and creatively. Indicators of the ability to think critically and creatively have been effective in improving students' ability to learn.

In this study there are advantages of assessment for learning that can help students in learning through regular giving and accompanied by giving feedback immediately and can be completed with students' needs. 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 in the hope of getting more effective results (Cizek, 2010). At each meeting, the questions provided contain indicators that can improve students' critical and creative thinking skills.

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" (Klenowski, 2009). 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. Thus, the use of critical and creative thinking ability assessment instruments as assessment for learning that has been developed is able to improve students' thinking ability with the average acquisition of critical and creative thinking skills in the good category of students. Indicators of instruments of critical thinking skills that have been developed are identified into five categories (Nitko, and Brookhart, 2011) and indicators of creative thinking abilities in accordance with aspects of critical thinking skills (Munandar, 2002). By working on written instruments and a portfolio of critical and creative thinking skills, students can provide answers according to their thinking abilities so that the teacher knows how well the students' level of thinking ability. This of course can help teachers to develop better assessment for learning science instruments the ability to think critically and creatively on other topics so that students can develop their thinking skills even better.

CONCLUSION

Based on the discussion in the discussion, it can be concluded that the assessment for learning science instrument to improve students' critical and creative thinking skills is valid in the aspects of language, construction and content with the mean percentage of validation of written and portfolio tests of 82% and 72%, and assessment for learning science instruments. to improve students' critical and creative thinking skills, they were shown by average scores of 28.8% and 35.1% for written tests and 25.3% and 32.2% for portfolios.

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