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Development of instrument for assessing students' critical and creative thinking ability

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Abstract. The purpose of this study was to develop instruments to measure critical thinking ability and creative students in the topics of physics simple harmonic motion. The research method used was research development with application of procedures including research and data collection, planning, and initial product development. The participants of the study were thirty-four tenth grade students and five physics teachers of physics who were selected randomly from schools in the province of Lampung. The data collected by using test and analyzed in quantitative descriptive. Initial data showed that students' critical and creative thinking ability were still low and instruments to assess students' critical thinking skills and creative students was not yet available. Most of assessment conducted focused on memorization. Thus, the researchers developed a draft of instrument in the form of the test description based on criteria that encouraged students' activity in understanding the concepts, strategies and decision/solution in dealing with problems. The development of the instrument was conducted considering real-world phenomena in the form of pictures and stories, description of the situation, and verbal presentation.

1. Introduction

The primary purpose of education is to improve and develop students' ability. Various factors might contribute to this purpose, one of which is the ability of teachers to perform and utilize assessment, process evaluation, and learning outcomes [1]. Such ability is necessary to understand the application of intended learning objectives that have been set in the curriculum. In addition, the ability lead to improve the learning process performed by the teacher so that learners can understand and apply what they already know. To do that, learners should work to solve a problem, discover by themselves, and try to implement their ideas. In this case, critical and creative thinking ability play important role in reaching the educational goals successfully.

Critical and creative thinking ability is important abilities for the learners to solve the problems encountered [4]. Thus, these abilities are important for all students, especially high school students. However, based on PISA result reported by the Organization for Economic Co-Operation and Development (OECD), Indonesia ranks 69th out of 76 countries [12]. The result indicates that the average of Indonesian students still have problems in terms of the three cognitive aspects, namely knowing, applying, reasoning

According Ministry of National Education and Culture, assessment of learning outcomes performed by educators is the process of collecting information/data about learners' learning achievement in



various aspects such as attitude, knowledge, and skill in a planned and systematic ways to monitor the process and learning progress and to improve learning outcomes through assignment and evaluation of learning outcomes [13]. Based on these opinions, it could be concluded that the assessment can provide stimulation to students to develop students' critical and creative thinking skills.

Problems that occur in one of schools in Lampung Province are cognitive assessment instruments used in the form of questions that tend to focus on memorization. Meanwhile problems that encourage students' critical thinking skills and creative learners are not applied. Therefore, students' thinking ability is still low. In addition, it has been exaggerated by teachers' lack of ability to design its instrument designed specifically to improve students' critical and creative thinking skills. Thus, the teachers are in need of guidance to develop the instruments.

The test instrument developed was a test instrument description. The developed test items used image, graphic, and tables which led students to reach taxonomy of educational goals and involve higher-level cognitive processes [11]. The purpose of this study is to develop the design of physics instrument on simple harmonic motion material to measure students' critical and creative thinking ability.

1.1. Assessment Instruments

Assessment is the process of collecting and processing information. In education, assessment means the process of collecting and processing information to determine achievement of students' learning outcomes. To do this, teachers need instruments in the form of questions to assess cognitive, affective, and psychomotor aspects. One way to understand characteristics and quality of learning outcomes are through assessment. Therefore, teachers can understand exactly what students have achieved. Assessment is the process of collecting, interpreting and using evidence to make decisions about student achievement in education [7]. Assessment, in general, can be used to determine the level of achievement of learning outcomes known as the assessment of learning (AoL), and to improve the learning process known as the formative assessment or assessment for learning (AfL) [17]

Assessment of learning is an assessment used to find out what students know, to indicate whether it has met the standards, and to make comparison among students [5]. Assessments is designed to inform teachers to modify their learning activities, differentiate, and understand how students approach learning. In this study, to develop students' critical and creative thinking skills, an assessment of learning is needed that can improve learning in the classroom [6]. Teachers should use assessment to plan lessons, identify student needs in learning and re-teach materials which are not understood by students.

1.2. Critical and Thinking

Critical thinking is a cognitive activity related to the use of mind [4]. Based on Bloom's cognitive dimensions, critical thinking skills occupy the dimensions of analysis (C4), synthesis (C5), and evaluation (C6). It appears that these dimensions are derived from Bloom's old taxonomic system. If matched with Bloom's Bloomfield taxonomy revised by Anderson and Krathwohl [2], then critical thinking skills occupy parts of analysis (C4), and evaluation (C5), because, in the revised version, the synthesis dimension is integrated into the analytical dimension. While creative thinking is a mental activity that fosters original ideas and new understandings. Creative thinking is a habit of the mind trained by paying attention to intuition, animating the imagination, revealing new possibilities, creating stunning perspectives, and generating unexpected ideas [6]. Creative thinking is a mental activity that produces something new that results from development.

2. Methodology

The selected research and development model was developed by the Borg and Gall model which consisted of ten development steps: (1) collecting research and information; (2) planning; (3) developing draft; (4) implementing field trials; (5) revising trial results; (6) re-implementing field trials; (7) results of refined products; (8) field implementation test; (9) refining the final product; and (10) dissemination and implementation [3]. This article only reports three steps: research development from research and

information gathering, planning, and early product development. The research steps are presented in Figure 1 below.

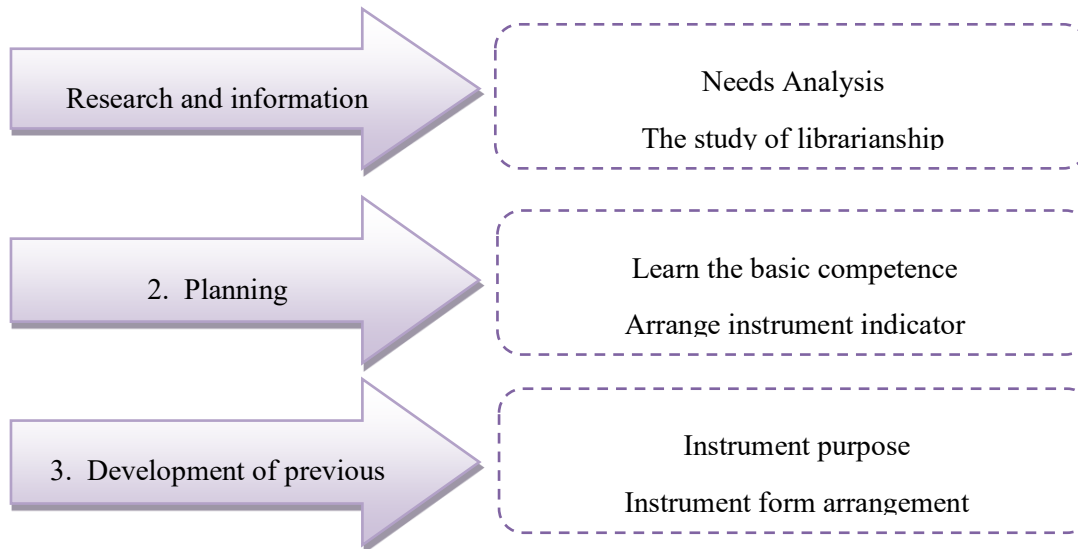


Figure 1. Steps of Development

Research development in this article is

2.1. Research and information gathering

This research and gathering of information is the first step in this research to map the problems that is studied and to bring up the idea of the product to be developed. Form of research and data collection in the form of field needs analysis and literature review. Necessary analysis were performed by providing needs analysis to 34 high school students of class X and five physics teachers who were selected randomly from schools in Lampung Province. The literature review conducted by reviewing several books and research results are relevant to the development of the research.

2.2. Planning

At the planning stage, basic physics competence analysis was conducted such as determining some basic competencies whose phenomenon were found by students easily. Subsequent processes was to develop indicators of assessment instruments adapted to indicators of critical and creative thinking skills. The next steps were to create natural phenomena in the form of pictures and stories, presentation of the problem (description of the situation), and presentation of statements and experimental table data that could be presented in accordance with the basic competence sequence.

2.3. Early product development

The early product development stage determine the purpose of the assessment instrument is to train students' critical and creative thinking skills. The parts planned in the planning phase are designed in such a way that they became design products at this stage. The test instrument should contain some good test instrument parameters. The assessment instrument to be developed was used to help students to practice their critical and creative thinking skills, the following is the assessment instrument design can be seen in the following figure:

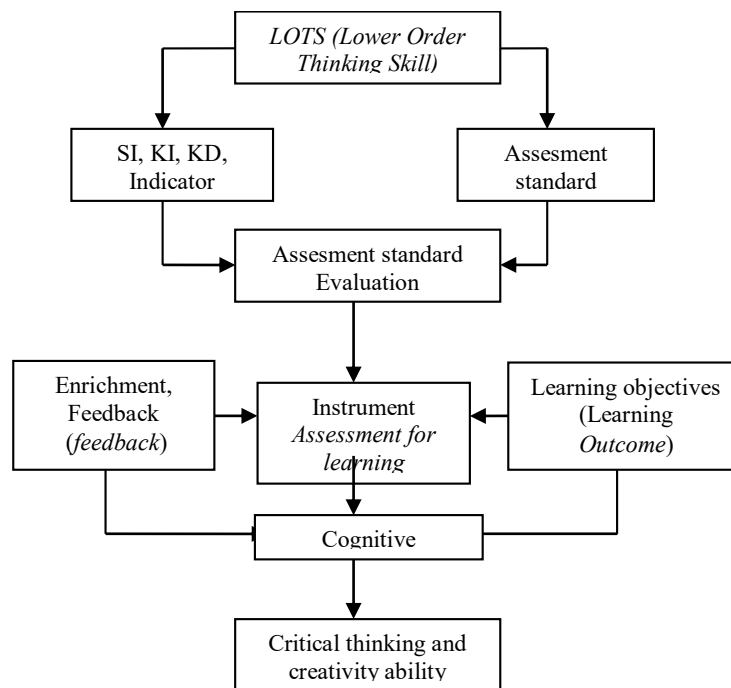


Figure 2. Assessment Instrument Design

3. Results and Discussion

The stages done in this research are that the research and information gathering stage are based on relevant theoretical studies. The information obtained is the need to develop a test instrument used to measure students' critical and creative thinking based on preliminary study conducted in one of the high schools in Lampung. According to preliminary study results, it was found that cognitive assessment instruments used to train students' critical and creative thinking skills have not been widely available. Most questions tend to measure aspects of memory or memorization that cannot be used to train students' thinking skills even higher. Moreover, in solving the problems of simple harmonic motion that requires reasoning and analysis in solving it, so need to develop assessment instruments to measure the ability of critical and creative thinking. So in the next stage, the researcher attempts to develop the instruments that will be developed, such as the question of critical and creative thinking based on indicators of the thinking stage. The type of test is a subjective test in the form of a description test.

The result of the initial product development is the design of the critical and creative thinking criteria of high school students on simple Harmonic Motion materials. The specific purpose of instrument design is that students can:

- a. investigate the concept of harmonic vibration on a simple pendulum swing;
- b. determining the restoring force on a simple swing;
- c. analyze the relationship of style and vibration in everyday life.

The developed instrument is in the form of a description test. The problem developed test adapted to indicators Basic Competence Motion Harmonist Simplified and Indicator Critical thinking and creative thinking. The indicators of critical thinking are: (a) Interpreting, (b) Analyzing, (c) Evaluating and (d) Inferring [4]. The general indicators used in the critical thinking are ability to understand either known or well-asked questions, to identify the relationships between the statements, questions and concepts provided in the questions, and to provide right explanation using right strategy in solving the problem, to complete and correct and students can make the right conclusions.

The test instrument for measuring critical thinking skills is a description test. It contains questions that lead to certain indicators of critical thinking ability. While some creative thinking skills are: (a) Fluency, (b) Flexibility (Dexterity), (c) Originality and (d) Elaboration [6]. Assessment instruments are

based on creative thinking skills, test instruments that are created to make students spark a lot of ideas, answers, problem-solving, able to generate varied answers, think something that never thought of others and develop an idea and detailing of an object making it more interesting [15].

The plan for the appraisal of assessment instruments was carried out with the first three meetings of prior learning process in order to develop students' critical and creative thinking skills. A final meeting was conducted to examine the problem as a whole with the objective of knowing the effectiveness of the developed test instrument whether effective in measuring ability think critically and creatively as an assessment of learning students [10]. The first meeting discussed the topic of the concept of harmonic vibration in the pendulum swing, in this meeting the process of teaching and learning with the aim that students can understand the topic discussed to work on the problem of critical thinking and creative skills that have been assembled as an assessment for learning.

After the learning was performed, the students were given some description questions to assess their thinking ability. The second and third meetings were still going through the same process as the first meeting, only the topics discussed was different. The second meeting discussed the restoring style and the third meeting discussed the relationship of style and vibration in everyday life. From these three meetings, the students' value in working on the critical thinking and creative thinking problem was given.

Based on the analysis, it could be said that the test instrument of critical and creative thinking ability was designed to build and train students' critical and creative thinking skills based on the indicators of problem made. The following are examples of problems that could improve students' critical and creative thinking skills in simple harmonic motion materials.



Figure 3. Picture on the left shows a hummingbird flapping its wings while sucking on nectar. Hummingbirds have a body mass of about two grams. This bird flaps its wing 80 times every second. Why does the hummingbird flap its wings? What do you think about it?

Students answered the question in various responses. To measure students' ability to answer the question, it considered analysis of natural phenomena created based on drawings and stories that led students to take decisions in solving the problem.

The results of research conducted by Treagust showed that learning using assessment sheet as an assessment for learning could improve students' ability in science learning. The use of test instruments as an assessment for learning is necessary to develop students' thinking skills [16]. This also agrees with research by Klenowski. The results obtained showed that assessment for learning, a process of identifying development of learning, was able to develop students' thinking ability [8]. Thus, the use of an assessment instrument of critical and creative thinking skills as an assessment for learning is able to develop students' thinking ability.

The use of critical thinking and creative thinking test instruments is one of the alternatives for teachers to determine the level of critical and creative thinking skills of students [14]. By working on the problem of critical thinking and creative students can provide answers in accordance with the ability to think so that teachers know how well the level of thinking ability of students. This, of course, can help teachers to better develop critical and creative thinking test instruments on other topics so that students can develop their thinking ability to be more optimal. The test instrument of critical and creative

thinking ability to be developed is considered effective in measuring students' critical and creative thinking ability in accordance with the level of ability they have.

4. Conclusion

Based on the results of research on the literature and analysis, it showed that the assessment instrument is still a rote or memory assessment instrument. Instrument assessment required by students can measure the ability of critical and creative thinking in the form of a description test with the criteria that can stimulate student activity in understanding the concepts, implementing strategies and tactics in solving problems. Development of instrument design is through natural phenomena in form of pictures and stories, presentation of problems (description of situations), presentation of statements and experimental table data so as to strengthen students' conceptual understanding and make correct decisions/solutions in solving problems.

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