Development of HOTS-Based Instruments with a Science Literacy Approach to Measure Students' High-Level Thinking Ability

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Abstract. This research develops multiple open choice reasoning instrument with HOTS (High Order Thinking Skills) learning approach to measure high level thinking ability of class X of Karangpandan high school students on harmonic motion material. The purpose of this study is to develop open reasoning multiple-choice instruments based on HOTS with a scientific literacy approach, to test the validity and reliability of HOTS-based instruments, to test the discrimination power and level of difficulty of HOTS instruments and measure the ability of high-level thinking in class X students on harmonic motion material. The type of research used is R&D by Borg and Gall. The HOTS instrument developed consists of cognitive levels of analysing, evaluating and creating. HOTS instruments have been tested for content validity and empirically that produced 14 items that were declared as valid. The instrument showed high discriminate power and sufficient level of difficulty. The results of high-level thinking skills of students can be categorized as very less as 1.60%, less as 74.60% and sufficient as 23.80%.

1. Introduction
The rapidly developing world requires humans to keep moving of the times in all aspects of life. One aspect that is continually touched by humans is the aspect of education. This also happened in Indonesia by making improvements to the 2013 curriculum by the ministry of education. In the HOTS (High Order Thinking Skills) Module states that this improvement is done by providing relevant subject matter in depth and compiling assessment standards [1].

Permendikbud (ministerial regulation) No. 59 of 2014 concerning the 2013 curriculum for Senior High Schools / Madrasah Aliyah in Appendix 1 states that the 2013 curriculum was developed based on internal and external challenges. The internal challenge faced is to strive for the abundant productive age human resources to be transformed into human resources who have competence and skills through education. External challenges include globalization and various environmental issues, technological and information advancements, the rise of creative industries, culture. These challenges require that the 2013 curriculum be refined so that human resources in Indonesia are able to face challenges in the future.

Special attention must be focused in learning on the ability to think. A study stated that the government cooperates with the department of education development which aims to make students have creative and critical thinking and knowledge to compete on an international level [2]. HOTS was introduced for this purpose. HOTS was implemented at an early stage, showing that an important aspect in creating the younger generation in the 21st century is to focus on language skills and thinking skills.
Scientific approach is an approach in the learning process that integrates science skills that is finding out for yourself the facts and knowledge associated with learning material. The scientific approach emphasizes more on students as learning subjects that must be actively involved [3]. Students must be actively involved in the learning process using relevant learning models applied in school. The application of a scientific approach with several learning models such as problem-based learning and project-based learning can be an opportunity for teachers to apply learning at the HOTS level [4].

The purpose of HOTS (High Order Thinking Skills) is that students can think that they must develop themselves to prepare themselves in facing real life. Students can use the knowledge they have in real life more than just simple learning from facts and content. This knowledge is aimed at through higher-order thinking processes more easily directed to apply that knowledge and to overcome or solve new problems that arise with deep conceptual understanding[5].

Understanding of higher-level thinking needed in accordance with competency standards and learning objectives can be divided into three categories, namely high-level thinking as a transfer that means students not only remember but also understand the concept of what has been learned, then think of high-level as critical thinking skills and think high level as problem solving.

The instrument used to measure higher order thinking skills is the ability to think that is not recall, restate or recite. HOTS questions in the context of the assessment are used to measure the ability to transfer one concept to another, process and apply information, look for links from various different information, use information to solve problems and examine ideas and information critically.

Harmonic motion material is difficult to understand by students because the learning process does not involve students to carry out activities directly [6]. This indicates the need for an approach that contains literacy that can involve students doing activities directly. Literacy that suits this problem is scientific literacy.

According to PISA (Program for International Student Assessment) Science literacy (science literacy) is the ability to use scientific knowledge to identify problems and draw conclusions based on evidence in order to understand and make decisions about nature and changes made to nature through human activities [7].

Natural Science learning, especially physics, needs to develop critical, analytical, and clear-thinking skills accompanied by high self-control. The development of this thinking ability needs to be measured by instruments. Measurements with physical instruments are carried out on harmonic motion material. Making instruments in this subject matter is appropriate in measuring students' thinking abilities based on HOTS. This is due to the demands of basic competencies that require students to have high-level thinking skills to master this material. This instrument is applied to students who have learned through the scientific literacy approach. In addition to harmonizing the learning atmosphere of harmonic motion material learning in Karangpandan High School, according it has a certain level of difficulty because the learning process does not involve student activities directly, so learning with the scientific literacy approach becomes the solution.

The above description, in outline, is the basis of thought in this study under the title “Development of HOTS-Based Instruments with a Science Literacy Approach to Measure Students' High-Level Thinking Ability on harmonic motion material”.

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2. Methodology

According to Borg and Gall (1983) there are research and development steps consisting of 10 steps, according to Figure 1.

![Figure 1. R&D Research Steps According to Borg and Gall](image)

a. **Preliminary Research and Information Collection**

Preliminary Research and Information Collection includes a needs analysis and literature study. This is done by observing the field and examining relevant research results.

b. **Planning**

Planning carried out in this study is to determine the research objectives. The general goal is to develop HOTS instruments with a scientific literacy approach.

c. **Initial Product Development**

The product of this research is an instrument in the form of open reasoning multiple-choice based on HOTS with the cognitive stages of analyzing, evaluating and creating that is used in learning with a scientific literacy approach in the classroom. The steps of HOTS problem compilation are analyzing the Basic Competencies that HOTS questions can make, compiling outlined materials, selecting contextual stimuli, writing questions in accordance with the outlined materials, making scoring guidelines (rubrics) and answer keys.

d. **Initial Trial**

After the product was tested for content validity, the HOTS instrument was tested on 36 students in the school to determine reliability, item validity, discrimination power and level of difficulty. The item validity test uses product moment correlation, while the reliability test uses Alpha Cronbchor theory.

e. **Major Product Revisions**

The initial trial results contained 14 items that had met the instrument's eligibility test criteria empirically and represented 6 question indicators that had been revised in terms of sentence construction and were ready for field trials.

f. **Field trial**

The product is subjected to field trials on larger research subjects. This research was tested on 63 students of class X who used learning with science literacy at Karangpandan Public High School. from the results of field trials, then the students' higher-order thinking skills were measured. Students' high-level thinking skills are measured using a category belonging to which is very less, less, sufficient, good and very good [8].

3. Result and Discussion

The test instrument was tested to determine the instrument's suitability. This test is done by content validity test and empirical validity test. The content validity test was tested by two validators, while the empirical validity test used product moment correlation, the reliability test used Alpha coefficient, discrimination power and the level of difficulty. The results of the test of the instrument's content validity were stated to be very good. The results of the empirical validity test of those 20 developed items stated that 14 items were valid, the instrument was declared as reliable, the discrimination power
of 5 of 14 items were fixed, 4 of 14 items were accepted but need revision, 4 of 14 items were accepted, and 6 items were discarded.

Instrument reliability was calculated using the Cronbach Alpha equation. The results of the first trial calculation obtained a value $r_{\text{count}} = 0.752$ based on the reliability value criteria for Alpha scores, the test is declared as reliable and can be used to measure students' higher-order thinking skills.

Difficulty level analysis of the questions is needed to find out the questions in the easy, medium, and difficult categories. The analysis level of difficulty is needed to find out that the questions in the easy, medium, and difficult categories. The results of the analysis of 14 questions tested, there are 6 medium questions and 8 items that are classified as difficult.

| Discrimination power | Number of the question | Total question |
|----------------------|------------------------|----------------|
| Approve              | 2, 16, 18, 19          | 4              |
| Approve but need revision | 4, 7, 9, 17          | 4              |
| Revised and fixed    | 1, 5, 8, 10, 11, 13    | 5              |
| Discarded            | 3, 6, 12, 14, 15, 20   | 6              |

The instrument developed was in the form of a grid of instruments, HOT-based open reasoning multiple-choice questions, answer keys and scoring and assessment guidelines. The number of questions used to measure students' higher order thinking skills consists of 14 questions from 6 developed indicators. The questions include the cognitive level of analysing, evaluating, and creating [9]. The format of the HOTS instrument that was developed uses the format according to the HOTS preparation module compiled by the Directorate of High School Development of the Directorate General of Primary and Secondary Education of the Ministry of Education and Culture.

The study was conducted at Karangpandan High School with 14 items used to measure students' high-level thinking skills. Analysis of students' high-level thinking skills was analysed[10]. The results of high-level thinking skills of students throughout the indicators can be seen in Table 2.

| Students’ score | Frequency | Percentage | Ability       |
|-----------------|-----------|------------|---------------|
| $80 \leq N \leq 100$ | -         | 0%         | Very good     |
| $60 \leq N < 80$  | -         | 0%         | Good          |
| $40 \leq N < 60$  | 15 students | 23.80%    | Sufficient    |
| $20 \leq N < 40$  | 47 students | 74.60%    | Less          |
| $N < 20$         | 1 student | 1.60%      | Very less     |

General factors that influence the lack of high-level thinking skills of students are as follows:
a) The required time to work on open reasoning multiple choice instruments based on HOTS is less.
b) Data from interviews with physics teachers stated that students in doing physics problems mathematically were still lacking.
c) Harmonic motion material learning with the scientific literacy approach is less effective because the hours of physics in one sample class are carried out after the physical education subjects.
d) HOTS- based open reasoning multiple choice instrument is a new instrument applied in learning physics in class X Karangpandan High School.
4. Conclusion

Based on the results of the analysis and discussion, it can be concluded that:

a. Characteristics of open reasoning multiple-choice instruments based on HOTS

The final product questions developed in the form of open reasoning multiple-choice instruments based on HOTS are complete with outlined material consisting of title, subject matter, basic competencies, material, semester/class, question indicators, cognitive level and number of questions. This instrument is also equipped with a question card, answer key which is accompanied by a scoring guideline, a scoring guideline[11].

b. Instrument validity and reliability

This instrument consisted of 14 items with the stages of cognitive analysis, evaluation, creation which was declared valid by content validity and empirical tests[12]. The HOTS open reasoning multiple-choice instrument developed was stated to be reliable $r_{count} > r_{table}$ with $r_{count} = 0.752$. Alpha coefficient value or $r_{table}$ is 0.329.

c. Discrimination power and level of difficulty

The different test items with the category were 8 items, 6 items were differed and 6 items were removed. The problem was improved by revising the sentence construction. This instrument has a difficulty level in the medium category of 11 items and 9 items in the difficult category.

d. Students' High-Level Thinking Ability

The overall assessment and analysis results of the indicators of students' higher-order thinking skills have an average value of 33.83 which means that they fall into the poor category. The percentage of students who have the ability to think at a high level is very less by 1.60%, less by 74.60%, sufficient categories by 23.80% and 0% for good and very good categories.

5. Conclusion

Firstly, HOTS-based open reasoning multiple-choice instruments are needed for physics materials so that students are accustomed to dealing with HOTS-based problems. Secondly, more respondents are needed to produce high reliability. Thirdly, HOTS instrument variations are needed on the basic competencies of the material, which can be made as HOTS instruments to measure students' higher-order thinking skills. The fourth, Special follow-up is needed to measure students' high-level thinking skills on solving the problem they face because the students' high-level thinking skills still can be categorized as less. For the last but not the least, hopefully, in the future there will be further research to reveal the effectiveness of the instruments developed.

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