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Development of HOTS (higher order thinking skills) test instruments for the concept of fluid and harmonic vibrations for high schools

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Abstract. The thinking ability of Indonesian students is still relatively low, this can be seen from the ranking of Indonesia based on the results of TIMSS in 2015. To improve students' thinking abilities and provide reinforcement to students' abilities, one of the efforts is to equip students with higher-order thinking skills by using questions HOTS is based on the Borg and Gall development model. A Higher Order Thinking Skill (HOTS) instrument has been developed that is subject to a valid and reliable fluid subject in high school using the Borg and Gall development model. This study aims to: 1) produce HOTS physics questions based on a valid and reliable Borg and Gall development model. The trial was carried out in SMAN 3 Palembang with class X MIA 1 students as research subjects. The data collection instruments used consisted of questions grids, question sheets, and validation sheets. The data analysis technique used is item analysis consisting of validity, difficulty level, and different power analysis, and reliability testing. The results of this development are 15 valid questions out of 25 items created. Of the 25 items, 3 items were declared difficult, 20 items had a moderate level of difficulty, and 2 other items were relatively easy. In addition, these questions are also stated to be reliable with a Cornbach's Alpha value of 0.78. The results of this study indicate (1) data collection as a validation test with an expert lecturer of 4.5 which is very valid. (2) a reliable test in the initial field test stage obtained an average score of the reliability of stages one and two respectively 0.74 and 0.76 with a high level of reliability. Thus, based on the results of the research data it was found that the instrument about HOTS fluid material developed was classified as valid and reliable.

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1. Introduction

The key to the progress of a nation is, firstly education, secondly education, and thirdly education. At present the world is in the 21st century, where in this century there is a fierce competition that is the competition for the quality of human resources [1]. The quality of human resources of a nation is determined by the level of education of the nation itself. So that the nation needs to prepare its generation in order to have both soft and hard skills skills for students from elementary school to high school [2]. Improving the quality of education can be started from improving the quality of learning. Improving the quality of learning can begin with setting appropriate learning goals [3].

Indonesia's Ministry of Education and Culture released the average value of the National Examination (UN). Where there is a decline in the average UN score in 2018 especially in physics which is 5.35. This data shows that student learning outcomes in physics are still relatively low. With the facts that there must be efforts to improve student learning outcomes. Teachers and prospective teachers to be able to improve the ability to think at a high level in working on problems or in making questions,



this is because the HOTS absorption of students is still relatively low. This is evident in the average UN score that has decreased. Because according to [5] one of the factors that causes the average value of physics UN is that there are high-minded problems or Higher Thinking Order Skills (HOTS) that cannot be done by students.

HOTS can be learned, HOTS can be taught to students, with HOTS the skills and character of students can be improved [6]. Therefore, high-level thinking can be realized in various ways, states that one of the ways that can be used to train students to have high-level thinking skills is by giving students higher-order thinking questions or HOTS [7]. By giving HOTS questions to students, students will indirectly train themselves to analyze, evaluate and create. In addition, [8] states that HOTS questions can encourage and stimulate students to learn and hone their thinking skills. When students are accustomed to answering HOTS-standard problems, students already have more abilities where when he faces a problem he will solve it scientifically based analysis [9].

In this study, a study of fluid material will be taken, the fluid material is chosen because the sub-topics are complex and its characteristics are very suitable to be developed into a matter of HOTS. Based on the 2013 curriculum that fluid is one of the main chapters of physics taught to high school students in grade X.

Previously, development research on HOTS physics had been carried out by Herbert [10], but his research was only limited to the development of higher-order thinking abilities in physics (PysTHOTS). There had been no development in the form of HOTS questions that examined one material, especially fluid material. Therefore the researcher took the topic "Development of Higher Order Thinking Skill (HOTS) Questions of Sriwijaya University Physics Subjects on High School"

2. Method

This research uses the Research and Development method, this research is to produce instruments about HOTS physics subject matter of fluid in high school. This research uses the Borg and Gall Research and Development (R&D) method [11]. Development research consists of ten stages (1) research and information gathering, (2) planning, (3) product development, (4) initial field testing, (5) major product revisions, (6) main field testing, (7) operational production revisions, (8) operational field tests, (9) final field tests, and (10) dissemination and implementation [11]. Utomo [12] permitted to limit small-scale research including research steps. Due to time and cost limitations, this research is only up to the fifth step, namely 1) data collection, 2) planning, 3) product development, 4) initial field trials, and 5) major product revisions [13]. This research was conducted in several stages. The first stage is the design and development phase carried out in November to December 2018. The evaluation phase was carried out from January to February 2019 at SMAN 3 Palembang in the 2018/2019 school year.

3. Results and Discussion

This research is a research development that is the development of the instrument of Higher Order Thinking Skills (HOTS) in the subject of physics subject matter of fluid in high school. In its development, this question instrument uses the Borg and Gall development model which consists of five stages including; data collection stage, planning, product development, initial field trials, and major product revisions.

Based on the research data, it can be said that the instrument about HOTS fluid material that has been developed has met the requirements of good instruments, namely valid and reliable. A good question instrument must be valid and reliable [14]. Validation is the accuracy of a measuring instrument or instrument in measuring what will be measured [15]. While reliable is the consistency of measuring instruments in measuring, the data obtained does not have a significant difference even if given in different time periods [14]. In the reliability test stage shows that in the second test the student's value is greater than the student's score on the first test. Of course there are several factors that influence the results of the validity and reliability tests. The factors that influence reliability are the number of items from the instrument itself, then the number of respondents used in the instrument trial process, as well as matters relating to the process of administering the test [15]. Meanwhile, things that can affect reliability are the breadth of the material from the instrument, the limits of questions on the instrument, the time required to complete the instrument and subjectivity in scoring the instrument, as well as the

ability of students in answering and completing instrument questions [16]. After conducting research in accordance with research procedures based on the development of Tessmer, obtained research results are described as follows.

3.1. Experts Review Phase

Researchers have produced 15 multiple choice questions after going through the analysis and design stages. And of the 26 items made, were validated by two experts namely two Physics lecturers in the Physics Education Study Program, Universitas Sriwijaya. From the validation stage, the researcher stated that the questions were valid. This is concluded from the calculation of the results of research conducted by researchers based on the formula Percentage of Agreement. In addition to the 15 items validated, the validator also validates the questionnaire at the one-to-one stage, as well as at the small group stage. From the assessment of the two questionnaires, the researcher concluded that the questionnaire could be used without revision.

3.2. One-to-one stage

At the one-to-one stage the questions were tested on a student who was not the subject of the study. The results obtained at this stage after the questions are worked on are revised 3 items, namely items 3, 13, and 19. Problem item 3 is revised because the sentence used is too long. While the revision of two other items related to the need to add supporting illustrations to the problem. These suggestions were conveyed by students in the questionnaire given. From this suggestion, the researcher gets material to revise the questions that will be tested at the small group stage.

3.3. Small Group

At this stage the questions were tested on 5 students who each represented high abilities, medium abilities, and low abilities. The results obtained at this stage are suggestions from students used to revise the questions, as well as questionnaires that indicate the level of readability of the questions. The question that needs to be revised is point 19 because the question sentences are too long. While the results obtained from the questionnaire given were 85.5% which showed that the questions were very legible.

3.4. Field Test Stage

At this stage the revised questions in the one-to-one stage and the small group stage were tested on 42 students. After being tested, the researcher analyzed each item with the help of the IBM SPSS Statistics 23. From the validity test, 15 valid questions were obtained from 25 questions created. Analysis of the items carried out next is the level of difficulty test, with the results of the questions made having a difficult category of 11.53%, questions with the medium category at 76.92%, and for the easy category at 11.53%. The last item analysis is the differentiation test, and the results of the test are 5 questions that have poor power difference. Whereas the other 15 questions have a good difference. The questions were also stated to be reliable after a Cronbach Alpha reliability test and a result of 0.879 was obtained.

Table 1. Analysis of fluid material concepts for HOTS questions.

Basic competencies	Theory	Problem Indicator	Level Cognitive
STATIC FLUID Applying static fluid laws in everyday life.	The Main Law of Hydrostatics	Presented a simple drawing of a U pipe experiment, students were asked to investigate the difference in height and explain with using physics principles why that can happen	C5

¹			
Plan and conduct experiments that utilize the properties of static fluids, along with the presentation of results and their physical significance		Presented images and experimental results data (determine the density of liquid substances). Students are told to determine how much density of oil.	C4
		Presented statements regarding the fact of fluid silence, students were asked to see the causal relationship.	C4
	Hydrostatic Pressure	A picture showing a finger phenomenon that keeps water in the straw is presented. Students are asked to investigate how stresses occur within a straw.	C5
		Presented an image of a glass containing water, one of the glasses of water volume decreases. Students are asked to analyze the pressure when the volume of water decreases.	C4
		Given a picture of 3 vessels of different shapes and inside containing the same volume of water. Students are asked to see how the cause-effect relationship.	C5
	Pascal's Law	Presented an image of a hydraulic pump. Students are asked to observe the picture and then students analyze how the pressure is happening on the hydraulic pump.	C4
		Given a statement regarding the relationship of cross-sectional area to style. Students are asked to analyze the causal relationship	C4
	Meniskus	Presented a picture of the phenomenon of water flowing on the taro leaves, students were asked to study the phenomenon using physical concepts and principles.	C5
		¹ A picture of the meniscus is presented. Students are asked to determine how large the angle	¹ C5 and C4
		There is a statement Regarding concave meniscus, students are asked to determine how the relationship cause and effect.	C4

4. Conclusion

Based on the results of the study of physics test instrument development high level thinking skills matter of harmonic vibration for high school that has been done, it can be concluded that: 1) The instrument tests high-level thinking skills for High School declared invalid. It is based on the results of expert

validation at the stage of an expert assessment (expert appraisal) conducted by two experts of experts to look at the level of validity on the content aspect, constructs and language with the results of the validation of 86% included in the category is very valid. 2) The high-level thinking ability test instrument for Class X high schools developed at the development testing stage obtained validity and reliability values. 15 valid questions were obtained from the 25 questions developed and reliability was carried out twice in the testing phase, namely in the pilot phase. Limited results 0.74 with a high reliable category and wide-scale trial phase of 0.76 with a high reliable category as well.

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