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**Submission date:** 04-Jul-2024 12:25AM (UTC+0500)

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**Word count:** 2710

**Character count:** 14261

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## Development of Higher-order Thinking Test Instrument on Fluid Material for Senior High School Students

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**Abstract.** This study aims to produce valid and reliable HOTS physics questions based on Borg and Gall development model. The data collection instruments used consisted of questions grids, question sheets, and validation sheets. The data analysis techniques used were item analysis consisting of validity, difficulty level, and discrimination index analysis, and reliability test. The results of this development are 15 valid questions out of 25 items developed. Of the 25 items, 3 items were declared difficult, 20 items had a moderate level of difficulty, and 2 other items were relatively easy. Also, these questions were stated to be reliable through the Cronbach Alpha value of 0.78. The results of this study indicate (1) the instrument is declared valid by the experts with the value of 4.5 and (2) this instrument is declared reliable through the reliability tests on stage one and two respectively with the obtained value of 0.74 and 0.76 which is included in the high-reliability level. Thus, based on the results of the research, the HOTS instrument on fluid material is classified as valid and reliable.

### 1. Introduction

The key to the progress of a nation is education. At present, the world is facing the 21<sup>st</sup>-century era where there is fierce competition for the quality of human resources [1, 2]. The quality of human resources of a nation is determined by the level of education of the nation and based on the guidelines and norms [3]. So that the nation needs to prepare its generation to have both soft and hard skills for students from elementary school to high school [4, 5], besides that, character education is also very important for students [6]. Improving the quality of education can be started with improving the quality of learning. Improving the quality of learning can begin with setting appropriate learning goals [7,8].

The Ministry of Education and Culture (2018) have released the average score of the National Examination (UN). There is a decline in the average national examination score in 2018, especially in physics which is 5.35. This data shows that student learning outcomes in physics are still relatively low. There must be efforts to improve student learning outcomes [9, 10] suggested for teachers and prospective teachers to be able to improve the higher-order thinking ability in working on problems or in making questions since the HOTS absorption is still relatively low proved by the decline of the average national examination score. According to the Ministry of Education and Culture, one of the factors that cause the problem is the unfamiliarity of higher-order thinking skills (HOTS) [7, 10].

According to [11], HOTS can be learned, taught, and improved. Therefore, higher-order thinking can be realized in various ways [12], 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. By giving HOTS questions to students, students will indirectly train themselves to analyze, evaluate and create [2, 13].



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Also, 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 [14, 15].

The fluid material is chosen because the sub-topics are complex and its characteristics are very suitable to be developed into HOTS. Based on the 2013 curriculum, fluid is one of the main chapters of physics that should be taught to the tenth-grade high school students.

Previously, development research on HOTS physics had been carried out, but the research is only limited to the development of higher-order thinking abilities in physics. There had been no development in the form of HOTS questions that examined one material, especially fluid material.

## 2. Method

This research uses the Research and Development (R&D) method. This research is to produce HOTS instruments on fluid material. This research uses the Borg and Gall Research and Development (R&D) method [16, 17]. This 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. Borg and Gall in [15, 16] permit to limit the research steps. Due to time and cost limitations, the Borg and Gall Model is only up to the fifth step. This research was conducted in several stages [20]. The first stage is the design and development stage carried out from November to December 2018. The evaluation stage was carried out from January to February 2019 at SMAN 3 Palembang in the 2018/2019 academic year.

## 3. Results and Discussion

This research aims to develop a HOTS instrument on fluid material for high school students. Based on the research data, it can be said that the instrument has met the requirements of good instruments, namely valid and reliable. According to [7] a good question instrument must be valid and reliable. Validity is the accuracy of a measuring instrument or instrument in measuring what will be measured [9]. Reliable means understanding according to [8]. It is the consistency of measuring instruments in measuring the data. The reliability test shows that in the second test, the students' scored higher than the first test. Several factors influence the results of the validity and reliability tests. According to [10, 21, 22], the factors that influence the reliability are the number of items from the instrument itself, the number of respondents in the trial process, and the process of administering the test. Meanwhile, according to [11, 23], 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, the subjectivity in scoring the instrument, and the ability of students in answering and completing instrument questions. The research results are described as follows:

### 3.1 Experts Validation Stage

Researchers have produced 15 multiple choice questions after going through the analysis and design stages. 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 experts also validated the questionnaire at the one-to-one stage, as well as at the small group trial stage. From the assessment of the two questionnaires, the researchers 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 result obtained at this stage was the revision of 3 test items, namely items 3, 13, and 19. Item 3 was revised because the sentence was too long. The revision of two other items related to the need to

add supporting illustrations to the problem. These suggestions were conveyed by students through the questionnaire given.

### 3.3 Small-Group Trial

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 to revise the questions, as well as questionnaires that indicate the level of readability of the questions. The question that needed to be revised was item 19 because the question sentences were too long. The results obtained from the questionnaire were 85.5% which showed that the questions were highly feasible.

### 3.4 Field Test Stage

At this stage, the revised questions 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. Analysis of the items carried out next was the level of difficulty test. The last item analysis was discriminating index analysis which resulted in 5 questions were categorized as poor whereas the other 15 questions were categorized as good. The questions were also stated to be reliable after a Cronbach Alpha reliability of 0.879 was obtained.

**Table 1.** Analysis of HOTS Questions on Fluid Material

Basic Competencies	Theory	Problem Indicator	Cognitive Level
<b>STATIC FLUID</b> Applying static fluid laws in everyday life.  Plan and conduct experiments that utilize the properties of static fluids along with the presentation of results and their physical significance	The First Law of Hydrostatics	Present a simple drawing of a U pipe experiment. Students are asked to investigate the difference in height and explain it using physics principles why that can happen.	C5
		Present images and experimental results data (determine the density of liquid substances). Students are told to determine how much density of oil.	C4
	Hydrostatic Pressure	Present statements regarding the fact of fluid. Students are asked to see the causal relationship.	C4
		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. Students are asked to analyze the pressure when the volume of water decreases.	C4
	Pascal's Law	Give a picture of 3 vessels of different shapes and contents with the same volume of water. Students are asked to see the cause-effect relationship.	C5
		Present an image of a hydraulic pump. Students are asked to observe the picture and then analyze how the pressure is happening on the	C4



	hydraulic pump.	
Meniscus	State the relationship of cross-sectional area and force. Students are asked to analyze the causal relationship	C4
	Present a picture of flowing water phenomenon on taro leaves. Students are asked to study the phenomenon using physics concepts and principles.	C5
	Present a picture of the meniscus. Students are asked to determine how large is the angle.	C5 and C4
	There is a statement regarding concave meniscus. Students are asked to determine the cause and effect relationship.	C4

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#### 4. Conclusion

Based on the results of the study, it can be concluded that: 1) the instrument is declared valid based on the results of expert validation with the average percentage of 86%, 2) the HOTS test instrument obtained high validity and reliability values. Out of 25 questions developed, 15 questions are declared as valid and reliable. The reliability test was carried out twice in the testing stage The result obtained was 0.74 within a high-reliability category in small-scale trials and 0.76 in field trials within a high-reliability category.

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