P-ISSN 2746-9034
Indonesian Physics Education Research
Volume 01, No. 1, December 2020, pp. 43-52

DEVELOPMENT OF HIGH ORDER THINKING SKILL TEST INSTRUMENTS ON OPTICAL MATERIALS

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Abstract

This study aims to develop HOTS (Higher Order Thinking Skill) test instruments that are able to measure the level of students' critical and creative thinking skills in optical material. The research method used is the ADDIE Research and Development method (Analysis, Design, Development, Implementation, & Evaluate). The research subjects used students from Medan An-Nizam Private High School T.P 2018/2019. The study produced 20 items of test instruments consisting of multiple choices and essays showing that HOTS thinking skills (Higher Order Thinking Skill) from the study sample amounted to 39 people were 18% of students had creative thinking skills, 23% of students had Creative-Critical thinking skills, 54% of students had skills critical thinking, and 5% of students with superior skills are critical.

Keywords: Development of HOTS Test Instrument, Optical Material, ADDIE Method.

Nowadays, there are so many efforts made by the government as a form of improving the quality of education in schools, such as making improvements in teaching and learning. Various types of new concepts and insights regarding the teaching and learning process in schools have emerged and developed very rapidly following the development of Science and Technology. The teacher as personnel who occupies a very strategic position in the context of developing human resources who are really required to keep abreast of the development of new concepts in the world of education.

According to Kusuma, et al. (2017: 26) most Indonesian students still have low abilities when viewed from a cognitive aspect (knowing, applying, and reasoning). This statement is also in accordance with the PISA reported by the organization for the OECD (Organization for Economic Co-operation and Development), that Indonesia is ranked 64th out of 65 countries. This finding should be a trigger for educators to familiarize students with completing or using LOTS (Lower Order Thinking Skill) which is then upgraded to HOTS (Higher Order Thinking Skill) in students. These are all necessary so that students can be more critical and creative in solving a problem.

A preliminary study conducted by researchers directly over a period of 3 months at An-Nizam Medan Private High School in the form of observations, interviews and student learning outcomes data. From the observations it was found that physics learning by utilizing the laboratory was minimal. Furthermore, from the results of interviews conducted by researchers, it was found

that the test items given by the physics teacher were generally questions with an understanding of low-level thinking skills (LOT) and high-order thinking skills (HOT). In addition, if there are higher order thinking questions given by the teacher, the items are only in the form of cognitive skills without paying attention to students' thinking process skills.

Student learning outcomes data show results that are not much different from the results of observations and interviews that have been conducted. The learning outcome data in one of the classes that the researcher will test, XI MIA 1, has very significant learning outcome data but tends to be the same as each other. Because students tend to discuss in the process of solving physics problems. So that there are some students with learning methods that can increase when conducting experiments to tend to be passive in the teaching and learning process. This is what makes students less fond of learning physics and often thinks that learning physics is a difficult lesson. As a result, students at these schools do not have an improved way of thinking.

Furthermore, the results of observations also show that in learning Physics students often experience difficulties in solving problems in the form of everyday life phenomena. So, to overcome this, the educators adjust their problems to the level of ability of students who are still familiar with LOTS (Lower Order Thinking Skill). While basically students are actually able to use HOTS (Higher Order Thinking Skill) in solving physics problems, but they are not familiar with the test.

There are many studies that have developed students' higher order thinking instruments. One of them has been done by Kusuma et al (2017). This research has developed indicators for student learning using higher order thinking. The results of this research are (1) In the analysis ability indicator (C4), the ability to analyze knowledge, conceptual knowledge analysis, procedural knowledge analysis, and metacognitive knowledge analysis has been developed; (2) For the ability evaluation indicator (C5) a factual knowledge evaluation ability, conceptual knowledge evaluation, procedural knowledge evaluation), and metacognitive knowledge evaluation have been developed; (3) While the indicators of creating (C6) have succeeded in developing conceptual knowledge creation, creating procedural knowledge, and creating metacognitive knowledge.

Based on the results of preliminary studies and referred to the above will be developed a test instrument HOTS (Higher Order Thinking Skills) in critical thinking skills and creative thinking skills in optical materials. Through this development, students will be able to find out the level of HOTS (Higher Order Thinking Skill) thinking skills of students in studying for Optics material in class XI at An-Nizam Medan Private High School.

METHOD

This type of research is the research and development of the ADDIE method (Analysis, Design, Development, Implementation, Evaluate). The population used in the study were all students of class XI and class XII of An-Nizam Medan T.P Private High School 2018/2019. The small class test sample as a test of the feasibility of the test instrument (item validation) in the study consisted of class XII MIA T.P 2018/2019 which consisted of 21 students. While the sample of the large class test in the study consisted of class XI MIA 1 and class XI MIA 2 with a total number of 39 students. The research design used was the design according to the ADDIE research method, namely (1) designing a test instrument with optical subject matter indicators in accordance with the syllabus and lesson plans used by the school; (2) designing test instruments with HOTS (Higher Order Thinking Skill) indicators in accordance with the literature; (3) communicating the test instrument design based on material indicators and based on HOTS (Higher Order Thinking Skill) indicators; (4) discussing and evaluating the test instrument with the validator team until the questions are valid; (5) giving the valid test instrument to the sample as a test of the implementation of the test instrument ability.

RESULT AND DISCUSSION

Result

Analysis Stage

At this stage, analysis of data on preliminary observation activities, analysis of material selection and qualification of materials, analysis of preparation for making HOTS instruments, and analysis of literature studies for product assessment were carried out. The results of this analysis will later be considered in later stages. At this stage of the analysis, the constraints that may arise in the development of the test instrument are identified.

The results of the analysis of preliminary observation activities resulted in the conclusion that from the point of view of learning physics activities in the classroom, they rarely did experimental activities in the laboratory. In terms of the implementation of the evaluation, the questions created and developed by the teacher tended to only modify the questions in the physics textbook used. From the student side, it was obtained from the learning outcomes data, that the average student score was above the “KKM” and students were used to solving problems at all levels. The results of this analysis indicate that the selection of the research sample in the school concerned is due to the fact that students are familiar with a variety of questions.

Analysis of the selection of physics material and material qualifications is carried out by discussing with physics teachers and expert lecturers. The results of the analysis can be concluded that the material chosen is optics with a focus material on the discussion of optics, namely Reflection, Refraction, Diffraction, and Interference material, Snellius's Law, and Optical Instruments. In addition, the form of the HOTS test that was developed was a multiple choice test totaling 15 questions and an essay test totaling 10 questions. The preparation for the HOTS instrument began by analyzing the syllabus used in schools to determine the test instrument indicators.

Further analysis of literature study that produced a product assessment test instrument. The literature study was conducted by researchers by collecting information about the characteristics of high-order thinking skills (HOTS) items. The collected literature is in the form of books, journals, and to attend seminars that support the development of higher order thinking skills (HOTS) test instruments.

Design Stage

The formulation of the design of the HOTS (Higher Order Thinking Skill) test instrument is carried out by developing the items through correspondence between the optical material that has been determined by the constituent indicators and the type of problem based on the HOTS (Higher Order Thinking Skill) indicator.

Table 1. Test Instrument Indicator Components

Test material indicator	Critical thinking skills test indicators	Higher Order Thinking Skill Criteria	Number of items
• Analyze the law of reflection and the law of refraction	Inference	C4 = 5; C5 = 3	5 Question
• Explore the applications of reflection and refraction in everyday life	Know the Assumptions	C4 = 5; C5 = 3	5 Question
• Analyze the workings of optical devices using the properties of reflection and refraction of light by mirrors and lenses	Argument Evaluation	C4 = 5; C5 = 3	5 Question
Total number of items			25 Question

With the above-mentioned indicators, the instrument was developed with the provisions of 15 multiple-choice test questions and 10 questions test essai. Furthermore, the assessment criteria are prepared for each type of test. According to Sugito and Ibarahim (2015: 2) assessment is the process of determining good, bad, beautiful, not beautiful decisions and so on, regarding the

development of student learning outcomes based on measurement data. The measurement result data can be determined by the principle of objective assessment. Selection of the type of assessment used in assessing each answer from the sample tested by the HOTS (Higher Order Thinking Skill) test instrument using the type of placement assessment (Placement). The assessment criteria are as shown in Table 2. below.

Table 2. Test Assessment Scoring Guide

Test	Number of Item	Scoring
Multiple Choice Test	15 Question	15
Essay Test	10 Question	100
Total Score		115

Development Stage

The instrument that has been developed is then performed construct validation. Validation is performed by 3 experts that aims to validate the test instrument first before being applied to the sample. In this phase, the validator will provide advice and feedback to further refine the test instrument developed by researchers.

From the results of the validation by the experts, there were items that were corrected because they did not match the predetermined indicators. In addition, there are five questions that was rejected, because it does not correspond with the material and indicators that have been developed previously. The results of this validation then become a reference for improvement before testing in small and large classes.

Implementation Stage

Small Class Sample Data

The small class test sample as a test of the feasibility of the test instrument (item validation) in the study consisted of class XII MIA T.P 2018/2019 which consisted of 21 students. Table 3 and table 4 below present the results of testing multiple choice instruments and essays in small classes.

Table 3: Multiple Choice Questions Data Analysis on Small Class

Validity Test		Level of difficulty	Discriminating Power		Reliability test	*SEM**
Test Item	Value		Test Item	Value		
2, 5, 7, 10, 12	Uncorrelated	0,26-0,75 (moderate)	2, 5, 7, 10	Not good	0,589 (moderate)	1,829
9, 11, 14	Very Low Correlation					
3, 4, 8, 13	Low Correlation		8	Good		
6, 10, 15	Medium Correlation		1, 3, 4, 6, 9, 11, 12, 13, 14, 15	Very Good		
1	High Correlation					

* *Standard Error of Measurement*

Table 4: Essay Questions Data Analysis on Small Class

Validity Test		Level of difficulty	Discriminating Power		Reliability test
Test Item	Value		Test Item	Value	
1, 6, 7, 9, 10	Low Correlation		1	Not good	
2, 4, 5, 8	Medium Correlation	0,26-0,75	3, 5	Medium	0,543
3	High Correlation	(moderate)	2, 4, 6, 7 8, 9	Good	(moderate)
			10	Very Good	

From the data above, it is found that there are several items that have a low value of prediction validity, this is indicated by a low correlation value. These results are then compared with suggestions from the validator before testing a large class. This result is consistent with the suggestion of the validator, for multiple choice questions corrections were made. As for the essay questions, according to the validator's input, invalid items will not be tested in large classes.

In general, from the data above, it is also found that the difficulty level scores for both multiple choice questions and essays are in the moderate category. According to Sugito and Ibrahim, (2015: 83) a good test is a test that is not too easy and not too difficult. In other words, the test that the researcher has developed is a good test. In addition, the reliability value of the test is also in the moderate range, meaning that the test is quite reliable in testing students' higher order thinking skills in optical material.

Large Class Sample Data

The large class test in the study consisted of class XI MIA 1 and class XI MIA 2 with a total number of 39 students. The instrument being tested is the result of improvements from the small class trial. At this stage, 20 item items were tested, consisting of 15 multiple choice items and 5 essay items. Table 5 and table 6 below show the results of the large class trials.

Table 5: Multiple Choice Questions Data Analysis on Large Class

Validity Test		Level of difficulty	Discriminating Power		Reliability test	*SEM**
Test Item	Value		Test Item	Value		
2, 5, 10	Uncorrelated		1	Not good		
7	Very Low Correlation		2, 5, 7, 10	Medium		
8, 11, 13	Low Correlation		8, 11, 13	Good		
1, 14	Medium Correlation	0,26-0,75 (moderate)			0,411 (moderate)	1,771
3, 4, 6, 9, 12	High Correlation		3, 4, 6, 9,12, 14, 15	Very Good		
15	Very High Correlation					

* *Standard Error of Measurement*

Table 6: Essay Questions Data Analysis on Large Class

Validity Test		Level of difficulty					Discriminating Power		Reliability test
Test Item	Value	Item 1	Item 2	Item 3	Item 4	Item 5	Test Item	Value	
5	Medium Correlation	0,62	0,70	0,71	0,45	0,62	1,2,3,4,5	Very Good	0,794 (High)
1, 2, 3, 4	Very High Correlation	(Moderate)							

From the data above, data on the validity, level of difficulty, discriminating power, and reliability of the HOTS instrument test were obtained. Both the multiple choice instrument and the question item essay which in the small class trial had low validity, after being corrected in the large class trial class it became better. There are 4 questions whose validity is very low in multiple choice questions. This shows that these items cannot measure high-order thinking skills. This low validity value can also be caused by the SEM value of 1.771.

From the table it can also be seen that the level of difficulty, discriminating power, and reliability of the tests developed. With the level of difficulty for multiple choice questions and essays on a moderate level, the difference power value of only 1 item was not good, and with the average reliability value of the two types of questions is good, it can be concluded that the test developed is good and can be used to measure students' critical thinking and higher order thinking skills.

Students High Order Thinking Skills

In addition to determining the feasibility of the test, the test instrument is also used to measure the ability of higher level thinking that is reflected through the critical thinking skills in students that the research sample. According to Rusyna, Adun., (2014) indicators of creative thinking skills, the balance between creative-critical, critical thinking skills, and superior critical thinking skills are as follows:

1. Creative Thinking, if critical thinking skills improve, problem-solving abilities will be doubled.
2. Creative-Critical Balance
    - Average creative and critical thinking styles.
    - Able to solve problems using certain skills of all thinking skills (brain skills).
    - To enrich thinking skills to have thinking techniques and learning to think (learning brain) requires mental arithmetic, knowledge of mind mapping, etc.

3. Critical Thinking, the ability to solve problems can be improved by increasing creative thinking skills.
4. Superior Critical Thinking
   - Learn quickly and effectively through a critical thinking approach.
   - Less able to generate unique ideas in problem solving situations but excel at evaluating ideas logically and rationally.
   - To sharpen creative thinking skills requires understanding and being able to change barriers to creative thinking by using several creative thinking approaches such as brainstorming and other techniques.

The results of the analysis of high-order thinking skills in the students sampled in this study are shown in Figure 1. Below.

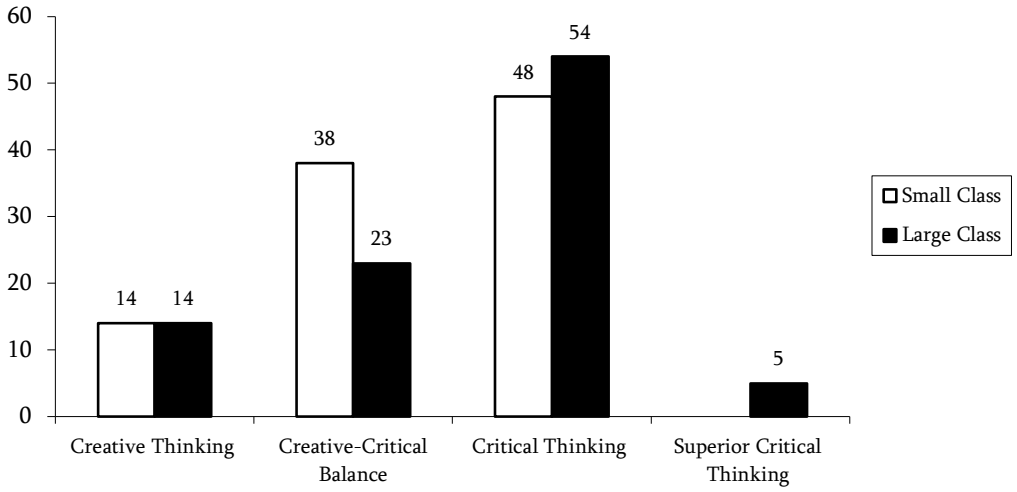

Figure 1. Students HOTS Data Analysis Results Diagram

Evaluation Stage

At the evaluation stage, the HOTS test suitability analysis was carried out on the characteristics of the items. This suitability is done by drawing conclusions on the data obtained by the researcher in testing its use. In the last trial conducted by researchers to class XI MIA students of An-Nizam Medan Private High School, it can be stated that 15 multiple choice items and 5 items that have been developed by the researcher are items that can be trusted in measuring high-order thinking skills (HOTS). This can all be seen from the total reliability value of the multiple choice items, which is 0.411 and the rebility of the essay items is 0.794. The total reliability is at the level of reliability sufficient to high reliability so it is true that these items are good questions to be used as a measuring tool for higher order thinking skills (HOTS) in Optical material.

Further evaluation of the factors that cause mismatches HOTS instruments with items. The discrepancy in the results of the correlation of the items which indicates that there are still items with a bad correlation, which is uncorrelated, is usually because students have answers that are similar to even the same in answering the questions. As a result, the correlation data between the answers of each student is not consistent with one another. In addition, this error can also be caused by the inaccuracy of the researcher in conveying his statements in developing the items. This statement can be stated because the SEM value is 1.771 on the multiple choice items.

Discussion

The results showed that a person's high-order thinking skills could be identified by testing 15 multiple choice items and 10 essay items that were developed in this study. Research by developing a HOTS (Higher Order Thinking Skill) test instrument that can be used as a good measuring tool is not an easy thing to do. This research really requires the accuracy of basic theory in the formation of instruments both the theory of the HOTS test instrument (Higher Order Thinking Skill) and the theory of physics lessons, in this case the theory of optical material. The data generated by this study ultimately shows that the HOTS (Higher Order Thinking Skill) test instrument developed in this study is a fairly good test instrument in its use as a measuring tool for high order thinking skills after tested in a small class.

However, after comparing the data with the results of the analysis of comments from 3 expert validators, it was stated that there were 5 essay items that could not be used as a HOTS (Higher Order Thinking Skill) test instrument. The reasons for this reduction are: (1) the item uses an image which is irrelevant to the theory of optical matter; (2) the items presented did not match the material to be tested, namely optical material; (3) items do not match the Higher Order Thinking Skill indicator that has been determined. The five items are item number 3, 4, 5, 6, and 7.

The results of the analysis of the second test were carried out in large classes with a total of 39 students. In this second test, the study produced classical data analysis, namely the total reliability of the multiple choice test of 0.411 with a SEM (Standard Error Of Measurement) value of 1.771 and a total reliability value of 0.794 for the essay test. In other words, 15 multiple choice test items and 5 essay items on this second test resulted in classical test analysis data which was quite reliable in its use as a measuring tool for students' higher order thinking skills (HOTS).

Although this research shows the success of a test where the classical test analysis data shows good data results, this research still has obstacles in its implementation. This obstacle arises

when the sample used in the research process is not taught using the appropriate learning model and student worksheets to improve students' higher order thinking skills, so the students will not be able to answer the questions developed by this study. As a result, the data from the analysis of classical tests will show fewer good data as a measuring tool for higher-order thinking skills.

CONCLUSION

Based on the results of data analysis that has been done, it can be concluded that,

a. Based on the results of the validation, measurement value of the level of difficulty, discriminating power, and the value of reliability test that can be relied upon is used to measure student's higher order thinking skill (HOTS) in the critical thinking skills in the material optics in question is a 15 item multiple choice questions and 5 essay questions.
b. Students' HOTS (Higher Order Thinking Skill) thinking ability in learning for Optics material in class XI at An-Nizam Medan Private High School has 18% of 39 students with creative thinking skills, 23% of 39 students with creative-thinking skills Critical, 54% of 39 students with critical thinking skills, and 5% of 39 students with superior critical skills; (2) The form of the test instrument

ACKNOWLEDGMENTS

I would like to express appreciation to Mr. Wawan Bunawan as a supervisor who has provided guidance and input to the author so that the study can done. Last but not at least thank you to my family for moral and financial support during this study.

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