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Development of HOTS Assessment Instruments on Static Electricity Materials for High School Level

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Abstract

This development research is motivated by the lack of Higher Order Thinking Skill (HOTS) assessment instruments at 3 Public High School in physics subjects, especially static electricity. One of the efforts to assist teachers in knowing the development of students' higher-order thinking skills is by developing the HOTS assessment instrument. This study aims to develop a valid and practical HOTS assessment instrument for class XII static electricity at SMA N 3 Padang and to analyze the reliability of the items using the 4-D model research and development (R&D) method (four-D models) developed by Thiagarajan. , consists of 4 stages: (1) define, (2) design, (3) develop, and (4) disseminate. However, this research is limited to the development stage due to time and cost constraints. The research results on needs analysis show that the static electricity material developed follows the 2013 curriculum seen from Basic Competencies, along with its indicators. Validation analysis with three validators obtained 88.32% results with very valid category; practicality analysis obtained 95.55% results with very practical category; and reliability analysis the question obtained is 0.24, which is categorized as low. The implications of this research are to assist teachers in developing HOTS assessment instruments on other materials.

Keywords: Development; Evaluation; HOTS; Instrument

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INTRODUCTION

The development of technology and information in the 21st century has significantly impacted society. People's culture and lifestyle are greatly affected by electronic devices that make access to information easy. Information that is completely open and widely available to be used as a necessity, even used for economic, trade and educational purposes. Education is currently synonymous with very diverse innovations, ranging from the use of books to notebooks as writing media for learning so that it is very much noticed by the world openly (Trisnawati & Sari, 2019).

Technological advances and changes provide new awareness that Indonesia is no longer independent. Indonesia is in the midst of a new, open world, so people are free to compare life with other countries. After the publication of Indonesia's 40th rank out of 42 countries through TIMSS, currently, it is felt that there is a lag in the quality of education, both formal and informal education. (Hadi & Novaliyosi, 2019).

Learning in science is expected to deliver students fulfilling 21st-century skills. The skills needed are 4C skills which stand for critical thinking skills, collaboration skills, communication skills, and creativity skills. Critical thinking is the skill of understanding a complex problem and connecting information with one another (Noprinda & Soleh, 2019). So that various perspectives will emerge and find solutions to a problem. Critical thinking skills are important for students to have in the swift currents of the digital era. Critical thinking skills as a provision for students to become better learners (Budiman & Jailani, 2014).

In learning physics, students are required to categorize critical thinking skills, including higher-order thinking skills, to understand the concepts and principles of physics. However, the assessment instruments needed to determine the level of students' abilities and develop students' abilities are still lacking. Teachers only rely on textbooks so that students feel less challenged in working on physics questions and are not active in developing higher-order thinking skills. In line with the opinion (Brookhart, 2010) that it is important to give HOTS questions to students. This is because HOTS questions can improve the quality of education (Brookhart, 2014). However, students think that the HOTS questions are difficult to solve (Abdullah, Abidin, & Ali, 2015; Chinedu, Olabiyi, & Kamin, 2015). This is because stu dents rarely get HOTS questions during class learning. The findings of Khan and Inamullah (2011), students were only given questions at the LOTS level; even questions at the evaluation stage were never given to students. This is in line (Sangpom, Suthisung, Kongthip, & Inprasitha, 2016); students are accustomed to being taught by providing explanations, formula rules, and memorization theory. Physics learning is not only designed to give birth to physicists or scientists but is also designed to help students think critically about new things they encounter based on the knowledge that is believed to be true (Mundilarto, 2012). So, learning physics can help students develop themselves into individuals who have a scientific attitude and think critically, able to process phenomena with the knowledge gained about how to understand the phenomena around them.

According to Bloom's Taxonomy which has been revised, cognitive processes are divided into high-order thinking skills (HOTS) and lower upper (LOWS). Low-level thinking skills involve the ability to remember (C1), understand (C2), and apply (C3). Meanwhile, higher-order thinking skills involve analysis and synthesis (C4), evaluating (C5), and creating or creativity (C6). (Royantoro et al., 2018:374), (Nurhayati et al., 2019 :14), (Saraswati & Agustika, 2020 :258). Low-level thinking skills of students only remember and understand a problem without having to solve and find solutions to the problem. So low-level thinking skills cannot be used in learning at this time. Meanwhile, for higher-order thinking skills, students must understand, analyze, and solve or find solutions to a problem in physics learning. Applying a suitable learning model in the classroom can improve students' thinking skills, one of which is HOTS (Sambite et al., 2019:141). To be in line with learning, a HOTS assessment instrument is needed to see the level of students' thinking abilities. Therefore, this study aimed to develop a HOTS assessment instrument on valid and practical static electricity and analyze the reliability of the developed items.

METHOD

This research uses the method of research and development (*R&D*). Following the problems found in schools, a solution to this can be done by developing this HOTS assessment instrument to provide opportunities for students to be more active in developing their critical thinking skills (Yanti et al., 2016:20).

The procedure stage in this study is the 4-D model shown in Figure 1.

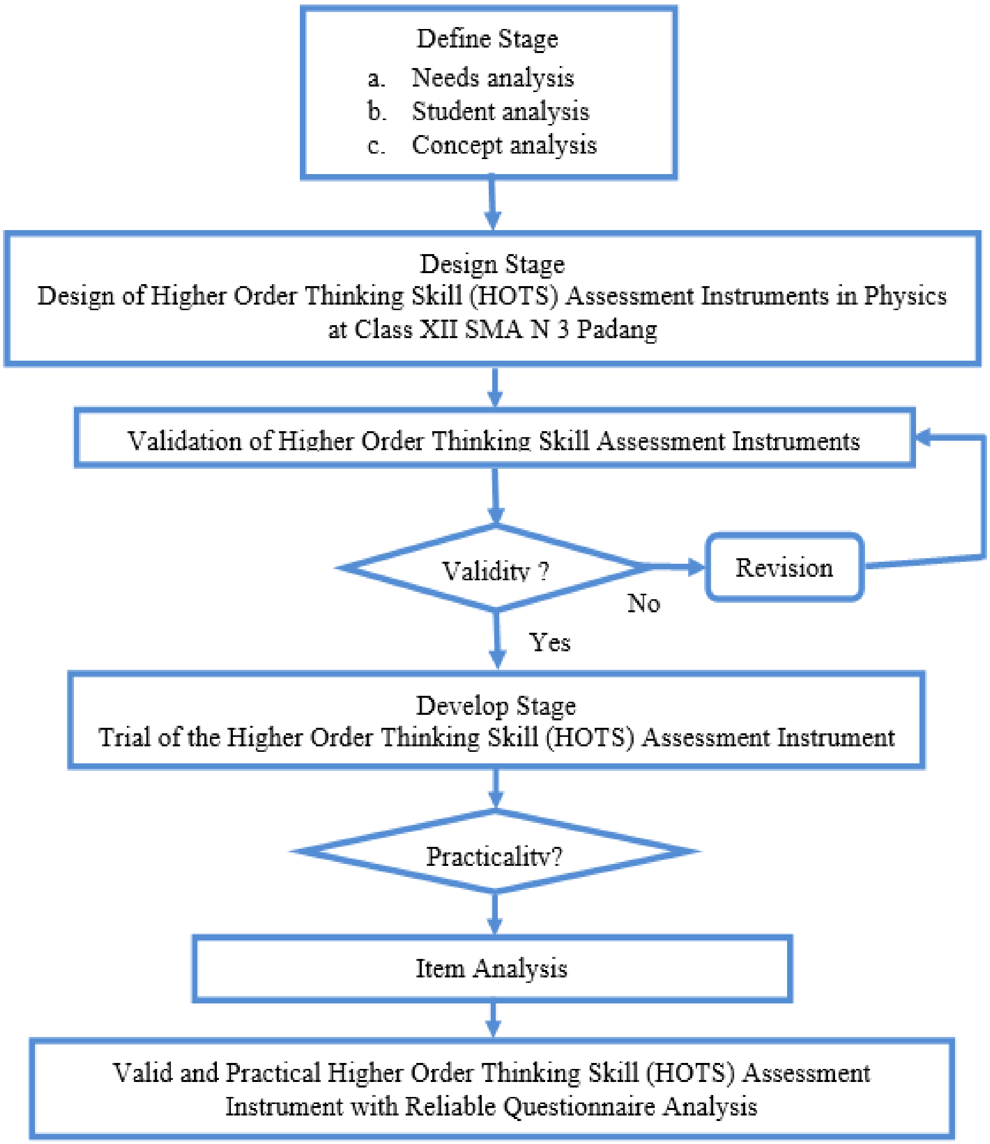


Figure 1 Stages of R&D performed

This study is limited to the development stage only in line with research (Fitri et al., 2021) due to time and cost constraints. The research instrument used in this study was an expert validation questionnaire with aspects of the feasibility of content and language and a teacher practicality questionnaire with aspects of ease of use and language use using a Likert scale. Furthermore, the data obtained were analyzed to see the validity and practicality of the HOTS assessment instrument. An analysis of the HOTS questions was carried out based on the test results to see the reliability of the questions. The analysis in this study is in line with that carried out by (Liana et al., 2020:103) to see the validity and reliability; only this study added practicality analysis on teachers, which is in line with the research (Fitri et al., 2021).

Expert Validation Assessment Analysis

Validator validation results in all aspects are expressed in percentages and categories, as shown in Table 1.

Table 1 Percentage validity

Percentage%	Category
81% ≤ final score≤ 100%	Very valid
61% ≤ final score≤ 80%	Valid
41% ≤ final score≤ 60%	Quite valid
21% ≤ final score≤ 40%	Less valid
0% ≤ final score≤ 20%	Not valid

(Riduwan, 2013)

Practical Data Analysis

According to (Riduwan, 2012), instrument practicality test data are expressed in the form of percentages and categories, as shown in Table 2.

Table 2 Percentage practicality

Percentage %	Category
81% ≤ final score ≤ 100%	Very practical
61% ≤ final score ≤ 80%	Practical
41% ≤ final score ≤ 60%	Quire practical
21% ≤ final score ≤ 40%	Less practical
0% ≤ final score ≤ S20%	Not practical

(Riduwan, 2013)

Reliability Data Analysis

A test is reliable if it gives the same results when used many times and in different situations (Riduwan, 2013). Reliability in this study is calculated using the formula *Alpha Cronbach*. Classification of item reliability values listed in Tabel 3.

Table 3 Classification of item reliability values

Range	Information
0.81-1.00	Very high
0.61-0.80	High
0.41-0.60	Enough
0.21-0.40	Low
0.00-0.20	Very low

(Riduwan, 2013)

RESULT AND DISCUSSION

The HOTS assessment instrument in physics subjects has been tested on class XII SMA N 3 Padang students. The HOTS assessment instrument developed contains material on static electricity. Based on the type of research used, namely development research or R&D using a 4-D model research procedure which consists of 4 stages, namely, define, design, develop and disseminate. Based on the research that has been done, this research is only carried out until the third stage, namely development (Fitri et al., 2021).

The stage of defining the HOTS Assessment Instrument

The definition stage aims to define and determine the conditions for learning. We see an overview related to the physics learning process at SMA N 3 Padang in this definition stage. Then analyze the problems that occur in the learning process. The definition stage is carried out in three stages: the needs analysis stage, student analysis, and concept analysis (Budiman & Jailani, 2014).

Needs analysis aims to find out the problems in SMA N 3 Padang. In physics learning, students are required to have critical thinking skills, which include higher-order thinking skills to understand the concepts and principles of physics. Based on the results of interviews at schools, it is known that the physics learning process is quite good with complete facilities used, including learning media. But to measure the development experienced by students after the learning process can not be seen optimally because the teacher's HOTS assessment instrument has not been maximized. Teachers have not been able to determine which students have reached the stage of higher-order thinking skills. In addition, the problem for physics teachers is the lack of sources of HOTS assessment instruments, so teachers often use the questions contained in textbooks.

Analysis of students is done by identifying the characteristics of their development of students. This analysis begins by knowing the students' age, academic ability, and language. Student analysis data can assist in the process of developing assessment instruments. In addition, student analysis needs to be carried out to determine the level of higher-order thinking skills because the selection criteria must follow the development of students. Based on the data obtained from the physics teacher, it is known that the students who are the subjects of the research are students of class XII aged between 17 to 18 years. At this age, students can think logically. But in reality, students who are research subjects are still lacking in sharpening themselves to think logically. Students also feel not challenged in working on physics questions that have been given by the teacher, so students' higher-order thinking skills have not developed. Furthermore, concept analysis aims to identify concepts, systematically develop concepts and link existing concepts to create assessment instruments to measure higher-order thinking skills on static electricity material. Based on the problem indicators on static electricity material, information from experiments on several charged points is presented. Students are asked to evaluate what happened during the experiment and conclude the position of the charged points so that student analysis is needed to solve the case.

The design stage of the HOTS Assessment Instrument

After carrying out the definition stage, proceed with the design stage. At this stage, the HOTS instrument design for physics learning is carried out following the HOTS question preparation guidelines by the Ministry of Education and Culture. The HOTS assessment instrument is designed to improve students' higher-order thinking skills in learning physics.

Question grid

The HOTS assessment instrument used on static electricity is a type of test in the form of a limited description. The grid will be made following the revised 2013 curriculum syllabus. The grid of questions made is in the form of a HOTS question assessment instrument grid on static electricity material. The question grid consists of identities such as education unit, subject, curriculum, class/semester, time allocation, number of questions, a form of question and author. Then there are basic competencies, material, class/semester, question indicators, cognitive level, question form and question number. To make it clearer, the question grid looks like Figure 2.

QUESTIONS HOTS

Education units : Senior High School
Subjects : Physics
Curriculum : 2013
Class/Semester : XII/ I (Odd)

Time Allocation : 90 Minute
Number of Questions : 10 Item
Question Form : Description
Writer : Athari Hany Milia

No	Basic competencies	Theory	Class/ Semester	Question Indicator	Cognitive Level	Question Form	Question Number
1.	3.2 Analyze electric charge, electric force, electric field strength, flux, electric potential, electric potential energy and its application in various cases	Coulomb's Law	XII/1	Information from experiments on several charged points is presented. Students can evaluate what happened during the experiment and conclude the position of the charged point.	Reasoning (L3)	Description	1
2		Coulomb's Law	XII/1	An illustration of the relationship in an equation is presented. Students analyze the form of the graph according to the illustration and then explain the relationship between the two equations.	Reasoning (L3)	Description	2
3		Capacitor	XII/1	A table of several capacitor materials and their relative permittivity is presented. Students can conclude what materials are used in an experiment.	Reasoning (L3)	Description	3
4		Electric Field Strength	XII/1	Presented an illustration of the description of a capacitor, students are able to analyze the reaction of one of the equations when the component is given a charge.	Reasoning (L3)	Description	4
5		Capacitor Circuit	XII/1	A table of several capacitors and their charges is presented. Students can predict the shape of the capacitor circuit image and the value of its replacement capacitor.	Reasoning (L3)	Description	5
6		Energy Stored In Capacitors	XII/1	An illustration of an experiment is presented on a capacitor connected to another capacitor. Students are able to predict the results of the experiment in one of the equations.	Reasoning (L3)	Description	6
7		Electric Field Strength	XII/1	An illustration of the characteristics and position of the unknown charge is presented, students draw and analyze the magnitude of the charge.	Reasoning (L3)	Description	7
8		Capacitor Circuit	XII/1	Some pictures of capacitors and their charges are presented. Students can prove that there is one capacitor according to the specified value.	Reasoning (L3)	Description	8
9		Capacitor Circuit	XII/1	Tables are presented with several prices for capacitor replacement capacity, students are able to parse and analyze which prices will appear in the experiment.	Reasoning (L3)	Description	9
10		coulomb's law	XII/1	Presented illustrations of natural phenomena. Students can conclude events in the illustrations.	Reasoning (L3)	Description	10

Ascertain,
Physics teacher

Armaili, S. Pd

Padang, August 2021
Editor

Athari Hany Milia

Figure 2 Question grid

Question Card

At the design stage, in addition to designing the HOTS question grid, the researcher also designed the HOTS question card following the HOTS question preparation guidelines. The HOTS question card is a translator of the question grid. The HOTS question cards also contain basic competencies, indicators, questions, materials, question numbers, and cognitive levels as identities on the question cards. Then 10 HOTS question cards were made to adjust the ten questions and the scoring guidelines and descriptions. To make it clearer, the question card looks like Figure 2.

QUESTION CARD DESCRIPTION
(QUESTION HOTS)

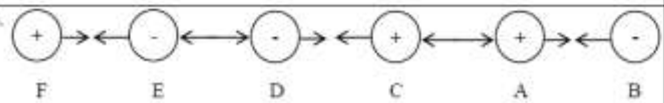
Subjects : Physics
Class/Semester : XII/Odd
Curriculum : Curriculum 2013

Basic competencies	: 3.2 Analyze electric charge, electric force, electric field strength, flux, electric potential, electric potential energy and its application in various cases
Theory	: Coulomb's Law
Question Indicator	: Information from experiments on several charged points is presented. Students can evaluate what happened during the experiment and conclude the position of the charged point.
Cognitive Level	: Penalaran (L3)

Question :

1. In a laboratory, students are experimenting with 6 charged point objects in order to better understand the concept of Coulomb's law. Electric charge consists of two groups, namely positive charge and negative charge. On 6 objects named A, B, C, D, E, and F. An experiment was carried out and resulted in object A attracting B, A repelling C, C attracting D, D repelling E, and E attracting F, while F is charged positive. Define::
   a. Why does object A attract B while object A repel C. Give your conclusion based on the concept of coulomb's law!
   b. Draw the six points and their charge!

SCORING GUIDELINES :

No	Description of Answers/Keywords	Score
1.	a. Because in the concept of coloumb's law two objects with similar charge will repel and 2 objects with unlike charge will attract each other	4
	b. 	6
	Total score	**10**

Description :

The questions above include level 3 (reasoning) in the cognitive process evaluation dimension, because to answer the question, students must be able to understand the characteristics of the charged point from the description, determine the many possible positions of the charged object, analyze the exact position according to the charge given, give conclusions based on understanding the concept of Coulomb's law of charge.

Figure 3 Question card

The development stage of the HOTS Assessment Instrument

After the design is carried out, it continues with the development stage. The development stage carried out includes validation of the HOTS assessment instrument, the practicality of the HOTS assessment instrument and instrument testing to see the reliability of the questions. The validity of the HOTS assessment instrument can be known after being validated by experts, namely three physics lecturers. After the HOTS assessment instrument was declared valid, the teacher saw its practicality and deserved to be tested on students. This follows Thiagarajan's opinion that the development stage includes device validation by experts and limited trials with real students. Based on this explanation, to make it clearer, pay attention to the data analysis at the development stage below (Fitri et al., 2021).

Assessment Instrument Validation

In this study, the Higher Order Thinking Skill (HOTS) assessment instrument that has been designed is validated by three expert validators. After giving the assessment, the expert validator gave suggestions for further instrument development. In line with an opinion (Amalia & Widayati, 2012:18) that validity reflects the extent to which the accuracy and precision of an instrument developed to function as a measuring tool. Suggestions given by the validator can be seen in Table 4.

Table 4 Validator suggestions

Validator	Validator Suggestions
Validator 1	Improve grammar and use of symbols in formulas
Validator 2	Question number 8 was changed because it was too easy
Validator 3	Assessment Instruments can already be used

Based on the results of the analysis that has been carried out, it can be seen that the results of the validation of the HOTS test instrument, in general, obtained an average score of 88.32%, with a very valid category. The description of the assessed aspects includes the following. Aspects of the feasibility of the content obtained an average percentage of 87.5%, with a very valid category. Aspects of language feasibility obtained an average percentage of 89.5%, with a very valid category. For more details, see Table 5.

Table 5 Expert validation results

Presentation Aspect	**Data**	
	Validation Value (%)	**Category**
Content Feasibility Aspect	87.50	Very Valid
Language Eligibility Aspect	89.50	Very Valid
Amount	88.32	Very Valid

Based on the results of the validation of the HOTS assessment instrument in Table 5, it can be concluded that, in general, the HOTS assessment instrument developed is in a very valid category. Judging from the feasibility aspect, the contents of the HOTS questions have supported the achievement of basic competencies and indicators. The problems presented in the questions do not have multiple meanings, and the questions given can develop students' thinking skills. The HOTS questions follow the EYD, communicative and written regarding language feasibility. This means that the HOTS assessment instrument developed can be tested on students.

The practicality of Assessment Instruments

Based on the results of data analysis, the practicality of the HOTS assessment instrument for teachers obtained an average score of 95.55% with a very practical category. The description of the practicality of the HOTS assessment instrument for teachers is as follows. The ease of use of the HOTS assessment instrument obtained an average score of 96.66% in the very practical category. The aspect of language use obtained an average score of 93.33% in the very practical category. To make it clearer, see Table 6.

Table 6 Practicality of HOTS assessment instruments for teachers

Presentation Aspect	Data	
	Validation Value (%)	**Category**
Aspects of ease of use	96.66	Very Practical
Aspects of language eligibility	93.33	Very Practical
Amount	95.55%	Very Practical

Based on Table 6 above, it can be seen that the assessment of the practical aspects of the HOTS assessment instrument for teachers is categorized as very practical. Judging from the aspect of ease of use, it is stated that the HOTS questions are following the levels in the HOTS questions; the questions can be used as teaching materials for educators and make it easier for teachers to know the students' higher-order thinking skills. In the aspect of language use, it is stated that the HOTS questions have presented communicative and clear language. Therefore, the HOTS assessment instrument can be used to support students in critical thinking.

Question reliability

The reliability of the questions can be seen from the results of the test questions to students. The test results showed that the reliability of the questions in the low category was caused by learning factors that were less than optimal during the covid 19 pandemic. In this study, item validity analysis was not carried out because experts had carried out the validity in line with the research (Fitri et al., 2021). Analysis of the test results obtained calculations in Table 7.

Table 7 Question reliability calculation

Result	**Question item**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Question Item Variance (σ^2_i)	0.10	2.93	3.93	2.56	4.20	0.49	6.19	5.34	0.72	1.13
Number of Item Variances ($\sum\sigma^2_i$)						27.60				
Total Variance (σ^2_t)						35.28				
Reliability (r_{11})						0.24				
Category						Low				

Based on Table 7, there are three questions with high item variance, causing the results of the 0.24 reliability to be categorized as low. Another thing that can impact is that the trials that are carried out can only be done online through the google meet platform, so researchers cannot fully control students to focus on working on the questions being tested. Meanwhile, working on the HOTS questions takes concentration and focus of students to analyze the questions correctly. In line with the results of the research (Budiman & Jailani, 2014)

CONCLUSION

Based on the results of the research carried out, it can be concluded that the HOTS assessment instrument developed is viewed from two aspects, namely, the aspect of the feasibility of the content and the aspect of the feasibility of the language. Based on these two aspects, the results of the validity of the HOTS assessment instrument are generally 88.32, with a very valid category. The practicality of the developed HOTS assessment instrument is seen based on two aspects, namely the ease of use and aspects of language use. Based on these two aspects, teachers' practicality results are generally 88% with a very practical category. Analysis of the test results to see the reliability of the questions resulted in 0.24 with a low reliable category.

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