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DEVELOPMENT OF INSTRUMENTS FOR ASSESSING HIGHER-ORDER THINKING SKILLS (HOTS) PHYSICS IN HIGH SCHOOL (LITERATURE REVIEW)

Nurmaliati[1*], Ilwandri[2], Tomi Apra Santosa[3]
[1, 2,3.]Akademi Teknik Adi Karya Kerinci, Indonesia
*Corresponding email: liacmg02@gmail.com

Abstract

Higher-order thinking skills (HOTS) are a student's abilities that include logical and reasoning abilities, analysis, evaluation, and creation. This study aims to identify the development of instruments for assessing higher-order thinking skills (HOTS) in Physics in high school. This review uses a qualitative approach by examining journals from 2016 to 2020. Based on the results of the analysis, show that one form of assessment developed is test questions with multiple choice, reasoned multiple choice, and description-type instruments. The test questions were developed to pay attention to HOTS, KKO indicators, physics, and stimulus problems, as well as Bloom's taxonomy. The materials that are widely developed are temperature and heat, harmonic vibrations, and static and dynamic fluids. The methods often used in this development research are the R&D method from Brog and Gall, the 4D method, the qualitative descriptive method, and the ADDIE method. The HOTS instrument is carried out through a feasibility test and analysis process, including through a validity test by a validator, reliability test, difficulty level test, differential power test, Rasch model analysis, analysis using Cronbach's Alpha formula, and question distractor test. The results of this study are an illustration of important points related to how to develop instruments for assessing higher-order thinking skills(HOTS) in Physics in high school

Keywords: Development, Instrument, HOTS.

Introduction

We are now in the era of the 5.0 generation of the industrial revolution, characterized by a surge in connectivity, interaction, and the rise of digital systems, artificial intelligence, and virtual frameworks. This period demands individuals to possess a diverse array of HR competencies such as advanced problem-solving, interpersonal skills, process knowledge, systemic understanding, and cognitive capabilities. Attaining these competencies is achievable through the implementation of high-quality education that aligns with evolving requirements. In the educational sphere, three primary competencies are essential: the ability to address complex challenges, engage in critical analysis, and foster creativity, ensuring students are not just armed with knowledge but also with a robust thought process. The mode of thinking that should be encouraged is not merely conventional, but one that is intricate, layered, and systematic. This cognitive approach is known as higher-order thinking skills (HOTS: Higher Order Thinking Skills). These higher-order thinking skills (HOTS) empower students to think critically and innovatively, enabling them to thrive in the face of contemporary global challenges, allowing them to evolve and become exceptional individuals. (Badjeber et al., 2018).

Widyastuti (2017) highlighted that higher-order thinking skills (HOTS) represent a learner's ability to grasp knowledge that transcends mere memorization, guiding them on how to integrate and apply information at an advanced cognitive level, enabling them to analyze and generate ideas. This suggests that with elevated thinking abilities, one is anticipated to derive solutions to challenges (Ayumniyya & Setyarsih, 2021). Heong et al. (2011) contend that higher-level thinking involves expansive reasoning to tackle fresh challenges. Higher-order thinking requires the application and manipulation of newly acquired information to uncover possible solutions in unfamiliar contexts. Furthermore, Brookhart (2010) asserts that higher-order thinking skills (HOTS) encompass reasoning and logical abilities, analysis, evaluation, and creative thinking. Artworl and Anderson (2001) mentioned that the revised Bloom's Taxonomy identifies three cognitive levels that reflect HOTS: C4 (analyzing capability), C5 (evaluating capability), and C6 (creating capability). Through advanced thinking, students will have the capacity to differentiate between ideas, articulate arguments effectively, solve problems, construct thorough explanations, form hypotheses, and understand complex concepts with greater clarity, clearly illustrating their reasoning skills.

An evaluation was conducted to gather insights regarding the advanced cognitive skills of students. This aligns with the findings of Edi et al. (2019), which indicates that skills of higher order thinking can be nurtured through education and evaluation.. In carrying out an assessment, an assessment instrument is needed that is truly appropriate to the learning material that has been implemented and the quality of the instrument's suitability has been tested. A good/decent instrument at least meets the basic requirements for a good/decent instrument, namely valid (legitimate) and reliable (can be trusted). It is very important to test the feasibility of the instrument because the quality of the accuracy/feasibility of the assessment instrument can influence the status of students' learning outcomes, especially hot skills. A proper instrument will produce accurate or precise data so that it will have an impact on making appropriate policies in the learning process. In reality, in the field there are still many teachers who have not implemented learning and assessment to develop high-level thinking abilities, this is in line with the statement of Chia & Malisa 2019, Rayendra, 2008, which is that teachers have not fully developed students' high-level thinking abilities.

This article attempts to provide an overview to teachers regarding the development of assessment instruments containing HOTS. This study aims to find out the type of assessment, the form of instrument used, the indicators for creating questions, the physics material studied, the research methods applied, and how to determine the feasibility of the higher-order thinking skills (HOTS) Physics assessment instrument in high school that was developed. The results of this study can provide knowledge regarding important points related to the development of higher-order thinking skills (HOTS) physics assessment instruments in high school.

Research Methods

The approach adopted in this investigation is a comprehensive review of existing literature. This literature review entails a meticulous analysis and synthesis of data, concentrating on key findings, encapsulating the essence of the writings, and deriving conclusions from it (Randolph, 2009). The study examined a total of 23 articles sourced from a variety of national and international journals published within the past six years (2016-2021). The discourse surrounding this subject is analyzed thoroughly.

The stages in carrying out this literature review research are outlined in Figure 1.

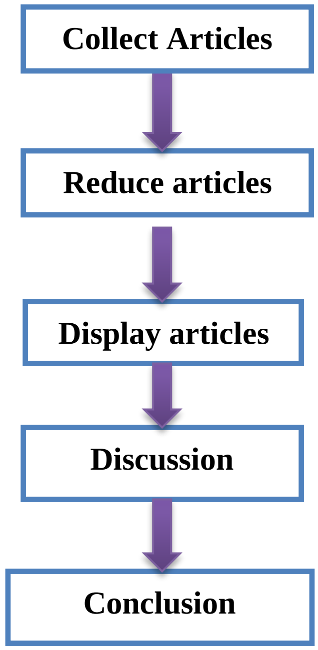

Figure1. *Stages of literature review (Kurniawan in Prasela et al., 2020*).

Results And Discussion

Tabel. 1 provides a review of 23 articles regarding the type of assessment, the form of instrument used, indicators for making questions, physics material studied, and research methods applied in developing instruments for assessing higher-order thinking skills (HOTS) in Physics in high school.

Table 1. Research on the Development of the HOTS Assessment Instrument

NO	Writer's name	Type of Assessment	Instrument Form	Question Criteria HOTS	Material	Development Methods
1	(Ariansyah et al., 2019);	Written Test	*Essays*	Physics Problems	Harmonious Vibration	*Descriptive qualitative approach*
2	(Agustihana & Suparno, 2019)	Written Test *Test package*	*Reasoning multiple choices*	HOTS indicator	Thermodynamics	Early Development
3	(Akhsan et al., 2019)	Written Test	*Reasoning multiple choices*	Bloom's Taxonomy	Harmonious Vibration Static Fluid Dynamic Fluid	4D Stage
4	(Agusta et al., 2019);			Bloom's Taxonomy	Temperature and Heat	R & D from Brog and Gall 6 stages
5	Afriani et al., 2019)	Written Test	Multiple choices	Bloom's Taxonomy	Straight Motion Changes Uniformly	R & D from Brog and Gall 7 stages
6	(Desilva et al., 2020);	Written Test	Multiple choices	HOTS indicator KKO	Elasticity and Hooke's Law	R & D from Brog and Gall 8 stages

				Stimulus Contextual Problems		
7	(Dulay & Sabani, 2019);	Written Test	*Essays*	Bloom's Taxonomy	Work and Energy	4D Stage
8	(Erfianti et al., 2019)	Written Test	*Reasoning multiple choices* *Essays*	HOTS indicator		4D Stage
9	(Elyana et al., 2016);	National exam		Bloom's Taxonomy		*Descriptive document analysis*
10	(Hidayah et al., 2018);	Written Test	*Essays*	Bloom's Taxonomy	Harmonious Vibration	R & D from Brog and Gall 6 stages
11	(Kistiono, 2019);	Written Test	*Reasoning multiple choices*		Particle Dynamics	4D Stage
12	(Kusuma et al., 2017);	Written Test	*Reasoning multiple choices*	HOTS indicator	Static Fluid	R & D from Brog and Gall 7 stages
13	(Liana et al., 2018)	Written Test	*Reasoning multiple choices*	KKO Stimulus Bloom's Taxonomy	Static Fluid	Development of the Adams and Weiman test
14	(Marwan et al., 2020)	Written Test	Multiple choices *Essays*	Stimulus		R & D from Brog and Gall 6 stages
15	(Najihah et al., 2018)	Written Test	*Essays*	HOTS indicator	Temperature and Heat	ADDIE
16	(Nisa & Wasis, 2018)	UAS USBN		HOTS indicator		
17	(Ramadhan et al., 2019)	*Diagnostic tests*			Straight Motion Turns Irregular	Development of instruments with modifications to the Oreondo Model
18	(Rohmah & Sunarti, 2020);	Written Test	*Essays*	Bloom's Taxonomy	Temperature and Heat	*Descriptive qualitative approach*
19	(Sari et al., 2018)	*Package test*	*Multiple Choice*		Straight Motion Changes Uniformly Uniform Straight Motion	4D Stage
20	(Supahar & Saputro, 2018)	Written Test	Multiple choices	Bloom's Taxonomy	Optics	Development of the Mardapi test
21	(Siswoyo & Sunaryo, 2017)	*Physics problem test*			Dynamic Fluid	
22	(Widyastuti, 2017)	Authentic Assessment				

23	(Yuliantaningrum & Sunarti, 2020)	Written Test	Multiple choices *Essays*		Straight Motion	ADDIE

a. **Types of Assessment and Instruments for Assessment of Higher Order Thinking Skills**

From the 23 articles analyzed, several types of assessments and forms of instruments can be seen that can be used to carry out assessments of higher-order thinking skills (HOTS). This can be seen in Table 2.

Table. 2. Types of Assessment and HOTS Assessment Instruments

No	Type of Assessment	Assessment Instrument
1	Written test	*Multiple Choice, Reasoning multiple choices Essays*.
2	*Package test*	*Multiple Choice.*
3	*Physics problem test,* Authentic Assessment, Diagnostic test, National Examination, UAS, USBN.	

In the creation of the HOTS tool, the accomplishments attained focused on evaluating knowledge skills. The data analysis outcomes indicate that the types of evaluations suitable for gauging HOTS abilities include assessment exams, package evaluations, physics problem assessments, authentic evaluations, diagnostic assessments, national tests, UAS, and USBN. The UN and USBN evaluations are conducted by the government to gauge the educational standards attained across Indonesia, while the UAS is an assessment executed by educational institutions at the conclusion of each semester. As such, the UAS, UN, and USBN are anticipated to effectively measure the extent of higher-order thinking skills (Nisa & Wasis, 2018). Furthermore, the evaluation of higher-order thinking skills is approached through authentic assessment. Authentic assessment involves evaluating students' capability levels in conjunction with their activities in addressing these challenges, thus allowing for a true understanding of students' capabilities (Widyastuti, 2017). HOTS assessments can also be carried out through diagnostic assessments of students' learning difficulties, and can also be carried out for school package assessments. From the literature review, assessments are also carried out to test students' physics problems (Physics problem test).

To carry out an assessment an assessment instrument is needed. The instrument is a measuring tool for assessing knowledge attainment after learning (Purwanto, 2006). Based on the literature review conducted, not all research reveals the focus on the type of assessment and the form of instrument used to develop HOTS questions. In Table 2 you can see the form of assessment instrument used to measure higher-order thinking skills in the form of Multiple Choice, Reasoning multiple choice, and Essay. Multiple Choice was chosen because this test has several advantages such as being able to measure various levels of knowledge, can be corrected easily, and is the right form for conducting tests with many participants. Even though it has various advantages, multiple-choice tests also have disadvantages (Education, 2019). So far, multiple-choice tests are tests that are often used, but they cannot provide a clear picture regarding students' understanding and train of thought. Apart from that, from literature searches. The HOTS instrument is also carried out through reasoned multiple choice.

By using Reasoning Multiple Choice, teachers can measure higher-order thinking skills at various levels of knowledge and also make it easier for teachers to carry out tests with many participants, and with this reasoned multiple choice instrument teachers can also measure higher order thinking skills and find out the train of thought of students. learners. Furthermore, from the literature search to measure higher-level thinking abilities, an instrument in the form of essay questions was also used. Essay questions have demands on students who work on them to describe and organize the knowledge they have so that students can freely solve problems in the questions (Education, 2019). This allows teachers to know how high the level of ability possessed by students.

b. Criteria for Hot Questions and Physics Learning Materials

The HOTS evaluation consists of test queries designed to challenge students at an advanced cognitive level, thereby enhancing their critical and creative thinking skills (Hidayah et al., 2018). Barnett and Francis highlighted that presenting HOTS questions enables students to grasp the subject matter in greater depth (Kusuma et al., 2017). In terms of assessment, HOTS inquiries can be utilized to evaluate (1) comprehension skills among concepts, (2) the assimilation and analysis of information, (3) the exploration of relationships among the acquired information, (4) the application of information for problem-solving, and (5) the capacity to generate new ideas from this data (Ministry of Education and Culture, 2019b). From the analysis of 23 articles, the content and standards for crafting HOTS questions were identified.

Table 3. Material and Criteria for Preparing HOTS Questions

No	Material	Criteria
1	Thermodynamics,	HOTS indicator
2	Elasticity and Hooke's Law,	HOTS indicator KKO (C4, 5,6) Stimulus Contextual Problems
3	Static Fluid	HOTS indicator KKO Stimulus Bloom's Taxonomy
4	Temperature and Heat	HOTS indicator Bloom's Taxonomy
5	Harmonious Vibration	Bloom's Taxonomy Physics Problems
6	Dynamic Fluid,	Bloom's Taxonomy
7	Straight Motion Changes Uniformly	Bloom's Taxonomy
8	Work and Energy	Bloom's Taxonomy
9	Optics.	Bloom's Taxonomy

In Table 2, it can be seen that from the 23 articles analyzed, there were 9 physics materials for the development of the Hots instrument. Determining the material in carrying out development is very important because selecting this material can be used to measure HOT capabilities in a more structured manner. Apart from that, you can also find out the level of students' understanding of the subject matter being tested. This is what Trilling and Fadel (Liana et al., 2018) stated that integration of content knowledge is needed in every subject and level of education.

Preparation of questions to measure high-level thinking skills, based on HOTS ability measurement indicators, operational verbs, stimuli, Bloom's taxonomy, contextual problems, and physics problems. When preparing hot questions, it can be based on various criteria. Preparation of questions to measure Hots abilities, based on hots indicators, namely the questions that are prepared require ability answers up to the analysis, evaluation, and creation stages (Desilva et al., 2020). Furthermore, it is also known that the preparation of hot questions can be done based on KKO (operational verb). According to Anderson and Krathwohl (2001), the ability to classify the dimensions of the thinking process is shown in the Figure 2 :

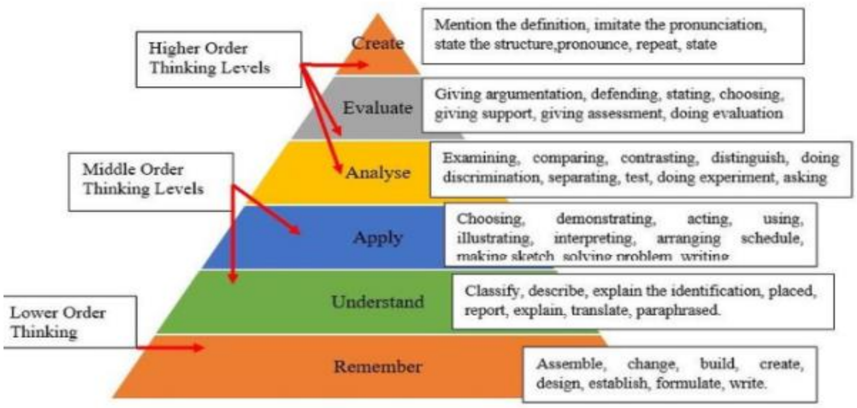

Figure 2. Taksonomi Bloom HOTS -LOTS (Anderson, L.W., and Krathwohl, D.R. (2001), modified

When choosing operational verbs (KKO) to formulate HOTS questions, you should not get caught up in KKO groupings. The domain of operational verbs (KKO) is greatly influenced by what thought process is needed to answer the question given because not all uses of KKO at levels C1 to C3 are not included in HOTS, if the KKO used includes C2 but the questions presented require a cognitive level analyze it first then the question is still included in the HOTS question (Ministry of Education and Culture, 2019b). Within Bloom's taxonomy, advanced cognitive skills are identified at tiers C4, C5, and C6. Specifically, these tiers involve dissecting, appraising, and synthesizing information, enabling students to not only grasp concepts but also evaluate their problem-solving capabilities, critical analysis, innovative thinking, reasoning skills, and decision-making abilities. Then it was also found that the development of HOTS questions was based on stimulus, that is, the questions that were prepared contained stimulus in the form of discourse, graphics, or images, which were interesting to students, then operational verbs were determined which described a high level of cognitive level, from the material. that will be achieved.

d. Methods in HOTS Instrument Development and Feasibility Testing

The steps in the HOTS assessment instrument development process are carried out in a structured manner and are referred to as research methods.

Table 4. HOTS Instrument Development Method

No	Method/model	Author
1	R&D from Brog and Gall	Desilva et al., 2020, Afriani et al., 2019, Kusuma et al., 2017, Agusta et al., 2019, Marwan et al., 2020, Hidayah et al., 2018.
2	4D Stage	Erfianti et al., 2019, Kistiono, 2019, Sari et al., 2018, Daulay & Sabani, 2019, Akhsan et al., 2019. Supahar&Saputro, 2018
3	ADDIE	Yuliantaningrum & Sunarti, 2020, Najihah et al., 2018.
4	Development of instruments with modifications to the Oreondo Model.	Ramadhan et al., 2019
5	Development of the Adams and Weiman test.	Liana et al., 2018,
6	Early Development	Agustihana & Suparno, 2019)

Based on Table 4, it is evident that there are 6 distinct methods for developing HOTS instruments. The analysis of the articles reveals that Brog and Gall's R & D method stands out as the most frequently utilized development approach. This method encompasses 10 stages of research, which include: "Research and Information Gathering, Planning, Creating the preliminary product, Initial field testing, Product modification, Main field testing, Operational product refinement, Practical field testing, Final product revision, and Dissemination and implementation" (Brog & Gall, 1983). Nonetheless, in any given development, stages may be streamlined according to the specific needs of the research being conducted.

Moreover, the second most favored development method is the 4D Stage method. This approach condenses the R & D process into just 4 steps as proposed by Tiaragajan (Sari et al., 2018). The 4D method includes the following steps: Define Instructional Requirements, Design a prototype instructional model, Develop a tested and dependable instructional model, and Disseminate the instructional model. Additionally, there exists the ADDIE development method. ADDIE is an acronym representing the five phases of the development process: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model emphasizes a sequential execution of each stage. This approach fosters continuous improvement by focusing on feedback. The choice of model or development method is contingent on the requirements of the research.

e. HOTS Instrument Feasibility Test and Analysis Process

To be able to measure and obtain accurate information about learning, teachers must use appropriate instruments that have been tested for their suitability. The viability of an evaluation tool can be examined from various perspectives, including the degree of validity of the tool, the stability/reliability of the tool, the complexity level, the discernibility, and the capacity to mislead respondents' answers. The quality of accuracy of assessment instruments can influence the status of students' learning outcomes. Testing the suitability of the instrument can be done through instrument trials or analyzed through statistical tests. From the results of the article analysis, several methods were obtained to test the feasibility of the instrument, as shown in Figure 3.

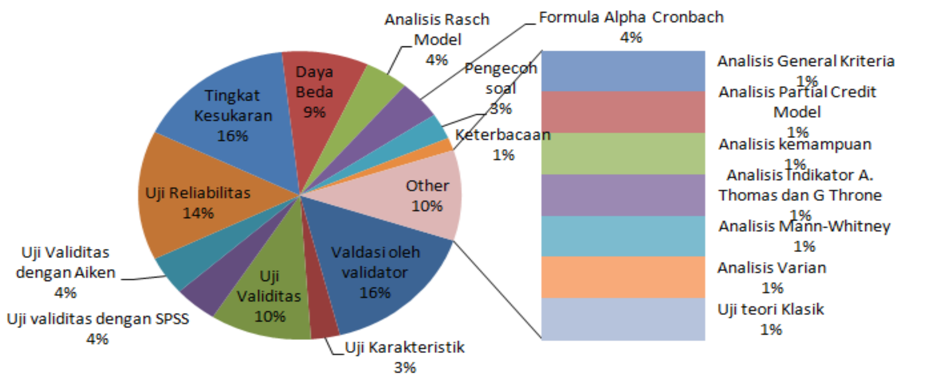

Figure 3. Testing Process and Feasibility Analysis

From the graph above, it is known that the methods most often used include validation tests with experts, reliability, level of difficulty, differential power, and Rasch model analysis. In order to acquire an appropriate tool, the instrument should satisfy a minimum of three criteria. Validity, dependability, and equity are the three primary benchmarks for assessing the quality of the evaluation process (Brian)(Brian, C 2020).

CONCLUSION

From the findings of the conducted review, it can be inferred that the types of tools for evaluating advanced cognitive skills that may be utilized are multiple-choice questions, reasoning-based multiple-choice, and essays, tailored to the nature of the assessment performed. When crafting or refining an advanced cognitive skills tool, several criteria should be taken into account, including focusing on HOTS question indicators, incorporating stimuli, framing problems in the questions, considering Bloom's taxonomy, and applying KKO. This aligns with the physics educational content and the learning objectives.

The techniques applied in the creation of this Hots instrument encompass the research and development approach from Brog and Gall, the 4D framework method, the qualitative descriptive technique, descriptive document analysis, the ADDIE framework, the Adams and Weiman test formulation process, the Mardapi test formulation technique, the instrument creation method using modifications of the Oreondo Model, and initial development strategies. Measure the suitability of an instrument, it can be done in various ways, namely through validity tests from validators, characteristic tests, reliability tests, difficulty level tests, differential power tests, Rasch model analysis, analysis using the Cronbach Alpha formula, question distraction tests, readability tests, general analysis. criteria, partial credit model analysis, ability analysis, A. Thomas and G. Throne indicator analysis, Mann-Whitney analysis, variance analysis, and classical theory test analysis.

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