Students' Ability to Solve Higher-Order Thinking Skills (HOTS) Problems in Physics Instruction: A Literature Review

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ABSTRACT

This study aims to analyze students' ability to solve Higher Order Thinking Skills (HOTS) questions in physics learning based on a literature review. The method used is library research by examining 34 scientific articles obtained from various databases through the Google Scholar website in the period 2015–2025 using the keywords HOTS, constraints, physics. The analysis process was carried out through stages of selection, data reduction, grouping, and descriptive-analytical synthesis to identify relevant patterns of findings. The results of the study show that students' ability to solve HOTS questions is still relatively low. This is indicated by various difficulties experienced by students, namely suboptimal understanding of physics concepts, difficulty in determining problem-solving strategies, low analytical ability and comprehension of questions, limitations in the use of mathematical representations, as well as learning factors that have not fully supported the development of HOTS. In addition, the analysis of previous studies shows that most studies are still limited to certain aspects and have not comprehensively examined HOTS constraints. This research is expected to provide a comprehensive overview of students' abilities and serve as a basis for the development of HOTS-based learning and evaluation instruments in physics learning.

Keywords: Higher Order Thinking Skills (HOTS), students' ability, physics learning, literature review, learning obstacles

INTRODUCTION

The literature on students' ability to solve Higher Order Thinking Skills (HOTS) problems in physics education is highly relevant in the context of educational reform in Indonesia, which emphasizes the development of higher-order thinking skills as part of 21st-century competencies. Higher-order thinking skills are one of the essential competencies that students must possess to be able to face increasingly complex global challenges. HOTS encompasses analytical, evaluative, and

creative abilities that enable students to interpret knowledge and use it to solve various problems critically and systematically (Desiriah & Setyarsih, 2021). In physics education, these skills are particularly crucial because students are not only expected to understand concepts but also to connect those concepts to real-world phenomena and solve contextual problems that require higher-order reasoning.

However, in reality, students' ability to solve HOTS questions in physics class remains relatively low. Various studies show that students struggle when faced with questions that require higher-order thinking skills, even though in some cases their grasp of basic physics concepts is relatively good (Widjanarko, 2022). This situation reveals a gap between the ability to understand concepts and the ability to apply those concepts in more complex problem-solving situations. This suggests that students' ability to solve HOTS questions is determined not only by their mastery of concepts but also by various other factors that influence their thinking processes.

A review of theory and previous research indicates that higher-order thinking skills (HOTS) in physics learning are influenced by various factors, such as analytical skills, problem-solving strategies, and representational and mathematical skills. Several studies emphasize that low levels of HOTS are linked to teaching practices that remain focused on memorizing formulas and solving routine problems, leaving students ill-prepared to tackle problems that require higher-order reasoning (Herman et al., 2022). In addition, the lack of opportunities for students to practice solving contextual problems is also one of the reasons for their low HOTS skills. On the other hand, the literature also indicates that suboptimal HOTS assessment instrument design affects students' ability to solve HOTS-based problems, both in terms of validity and alignment with student characteristics (Unun et al., 2023).

In the school learning process, physics is often viewed as a difficult and uninteresting subject by some students. This situation has led to a learning process that tends to remain conventio nal, and thus has not been fully effective in encouraging students' active engagement in developing higher-order thinking skills. Previous research indicates that the implementation of learning models, such as problem-based learning and interactive learning, can help improve students' higher-order thinking skills (HOTS). However, the improvements observed in physics learning still yield varying results across different learning contexts (Khoiriyah et al., 2023). This indicates that improvements in HOTS do not depend solely on the instructional model used, but are also influenced by various other factors related to student characteristics and the learning process itself.

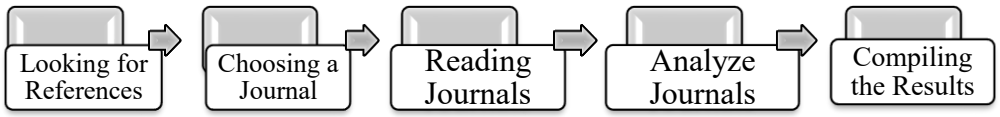
Based on a review of various previous studies, a research gap has been identified: there remains a limited number of studies that specifically synthesize the various obstacles affecting students' ability to solve HOTS problems in physics instruction in a comprehensive manner. Most studies

still focus on specific aspects, such as the development of learning models or assessment instruments, and thus do not provide a comprehensive picture of the difficulties students experience in the higher-order thinking process. Furthermore, studies are still needed that integrate various research findings to identify dominant patterns of challenges in solving HOTS questions. These findings are consistent with the results of previous research (Jasman et al., 2022).

Therefore, this study was conducted as a literature review aimed at synthesizing various findings from previous research regarding students' ability to solve HOTS questions in physics instruction. Specifically, this study focuses on identifying and categorizing the challenges students face in solving HOTS questions based on the results of previous research. Thus, this study is expected to provide a more comprehensive picture of students' abilities and serve as a foundation for the development of more effective physics instruction aligned with the demands of higher-order thinking skills. Additionally, the results of this study are also expected to contribute to the development of assessment instruments capable of measuring students' HOTS abilities more accurately and comprehensively, in line with research emphasizing the importance of developing valid and reliable HOTS instruments. (Dinata et al., 2024).

METHOD

Figure 1:
Study Data Collection Methods



The research method used in this study is a literature review, which aims to examine and analyze various scientific sources to gain a comprehensive understanding of students' ability to solve Higher Order Thinking Skills (HOTS) problems in physics education. This approach was chosen because it provides a broad conceptual overview based on the findings of previous research without the need for direct field data collection. The search for data sources was conducted by utilizing various scientific databases via Google Scholar. The search process focused on publications released between 2015 and 2025 using keywords such as "HOTS, challenges, physics." Following the literature identification process, sources were selected based on several criteria: relevance to the research topic, being peer-reviewed articles, containing clear empirical data or conceptual analyses, and being available in full text. Based on this selection process, a total of 34 articles were analyzed in this study. To clarify the stages of the literature selection process conducted in this study, the article selection flow is presented in a diagram in Figure 2. The next stage is close reading and systematic note-taking regarding the research objectives,

methods, main findings, and implications of each study on students' HOTS abilities.

Figure 2:
Research literature selection flowchart

FINDINGS AND DISCUSSION

Table 1:
Classification of the limitations and strengths of previous studies

No	Name	Year	challenge
1.	Azizah et al.	2017	Understanding Physics Concepts
2.	Arie Purwa Kusuma & Adna	2020	
3.	Tri Nuraini & Julianto	2022	
4.	Srinia Khairani & Sani	2018	
5.	Dinda Yulia Darsa et al.	2020	
6.	Suarez et al.	2017	
7.	Lin & Singh	2016	
8.	Singh & Rosengran	2016	
9.	Maloney	1994	
10.	McDermott & Redish	1999	
11.	Isra	2023	Problem-Solving Strategies
12.	Elmayanti et al	2025	
13.	Maylita Hasyim & Andreina	2018	
14.	Y.H.M. Yusuf et al	2023	
15.	Docktor & Mestre	2014	
16.	Heller	1999	
17.	Chi et al	1981	
18.	Doni Adi et al	2025	
19.	Homi Apriani et al	2024	

20.	Felomina Loru et al	2023	Analysis and Understanding of Questions
21.	Murtafiah	2022	
22.	Puput Puji Lestari et al	2024	
23.	Rezza Akbar Thoyip et al	2024	
24.	Widjanarko	2022	HOTS Instructional Design and Assessment Tools
25.	Fauziana et al	2020	
26.	Khoiriyah et al	2023	
27.	Jasman et al	2022	
28.	Verawati et al	2020	
29.	Unun et al	2023	
30.	Dinata et al	2024	Representation and Mathematics
31.	Irfani Salsabilla & Hidayati	2020	
32.	Leo Charli et al	2018	
33.	Hsu et al	2004	
34.	Van Heuvelen	1991	

Based on the analysis of various previous studies, several challenges faced by students in solving Higher Order Thinking Skills (HOTS)-based problems in physics instruction have been identified. These challenges can be classified into five main categories, ranked by their frequency of occurrence in the literature. The most dominant challenge is the understanding of physics concepts. Most studies indicate that students struggle to grasp fundamental physics concepts, which impacts their ability to solve problems requiring higher-order thinking skills. When these foundational concepts are not well-mastered, students tend to merely memorize formulas without understanding the underlying physics principles. This situation causes students to struggle in relating concepts to the problem situations presented in HOTS questions. Several studies also indicate that misconceptions regarding physics concepts such as energy, momentum, or heat further exacerbate students' difficulties in solving physics problems conceptually. Therefore, mastery of fundamental concepts is a critical factor in supporting students' higher-order thinking skills in physics learning.

The next challenge is problem-solving strategy. When solving HOTS problems, students are not only required to understand the concepts but also to be able to systematically design problem-solving steps. However, various studies show that students often struggle to determine the appropriate problem-solving strategy. Students tend to immediately apply formulas without first analyzing the given problem. Additionally, students also struggle to evaluate or review the solutions they have obtained. This indicates that students' metacognitive skills in the problem-solving process still need to be improved so that they can solve problems requiring deeper analysis and reasoning.

Furthermore, another common challenge is analyzing and understanding the questions. HOTS questions are generally presented in the form of contextual problems that require the ability to read, comprehend information, and identify relationships between concepts within the question. However, many students struggle to grasp the intent of the question, particularly when it is presented as a lengthy narrative or contains multiple pieces of information simultaneously. This difficulty prevents students from identifying the key information needed to solve the problem. Consequently, students often make errors in determining the solution steps or are unable to even begin the problem-solving process.

The next challenge relates to the design of instruction and HOTS assessment instruments. Several studies indicate that students' difficulties in solving HOTS questions are not solely due to their individual abilities but are also influenced by the instructional processes implemented in the classroom. In some cases, instruction still focuses on solving routine, procedural problems, so students are less accustomed to tackling questions that require higher-order analysis and reasoning. Additionally, developing valid and reliable HOTS instruments or questions remains a challenge for educators.

This situation is also observed in the context of physics education in Palangkaraya. Based on research conducted by Ulfah (2022) at SMA Negeri 1 Palangkaraya, it was found that the use of Higher-Order Thinking Skills (HOTS)-based questions in physics instruction remains suboptimal, and teachers face difficulties in developing HOTS-based assessment instruments. The questions used tend to be dominated by the analyzing cognitive level (C4), while questions at the evaluating (C5) and creating (C6) levels remain very limited. This indicates that students' higher-order thinking skills are not yet fully facilitated in the learning process. Additionally, research conducted by Ulfah et al. (2023) also indicates that most students perceive physics as a difficult subject with a learning motivation level that tends to be moderate. This situation results in low student engagement in HOTS-based learning, thereby preventing students' higher-order thinking skills from developing optimally. These findings further reinforce that HOTS issues are not merely a general phenomenon but are also tangibly present among students in Palangkaraya. Therefore, there is a need for more contextual learning designs as well as the development of assessment instruments capable of effectively training and measuring students' higher-order thinking skills.

The final category of challenges involves representational and mathematical skills. In physics education, problem-solving often involves the use of various representations, such as mathematical equations, graphs, diagrams, and physics symbols. However, some students struggle to translate physical phenomena into mathematical representations or vice versa. Additionally, limited mathematical ability can also hinder the process of solving physics problems, particularly for problems requiring more

complex computational analysis. This indicates that representational skills and mathematical ability are crucial aspects that must be addressed in physics education to support students' higher-order thinking skills.

Based on the discussion above, it can be concluded that the main challenges in solving HOTS problems in physics learning are not only related to conceptual understanding but also involve analytical skills, problem-solving strategies, and the teaching methods employed in the classroom. Therefore, improvements are needed in the physics learning process, whether through strengthening conceptual understanding, implementing learning models that train higher-order thinking skills, or developing assessment instruments capable of measuring students' HOTS abilities more comprehensively.

Review of Previous Research and the Novelty of the Study.

Several previous studies have examined the application of higher-order thinking skills (HOTS) in physics education; however, there are still limitations in comprehensively examining the challenges faced by students. Therefore, an analysis of previous research was conducted to identify research gaps as the basis for the novelty of this study.

Table 2:
Analysis of Previous Research

Researcher	Category of Findings	Amount	Type
Darsa et al. (2020); Dinata et al. (2024); Salsabilla & Hidayati (2020); Kusuma & Adna (2020); Nuraini & Julianto (2022); Loru et al. (2023); Lestari et al. (2024); Elmayanti et al. (2025)	Limited to a single aspect (conceptual/analytical/mathematical)	8	Limitations
Widjanarko (2022); Fauziana et			

al. (2020); Unun et al. (2023); Jasman et al. (2022); Singh & Rosengrant (2016); Maloney (1994)	Failing to analyze students' challenges in depth	6	
Azizah et al. (2017); Charli et al. (2018); Isra (2023); Adi et al. (2025); Yusuf et al. (2023)	Focus on outcomes/HOTS skills	5	
Van Heuvelen (1991); Hsu et al. (2004); Lin & Singh (2016); Chi et al. (1981); Murtafiah (2022)	Focus on a specific representation or concept	5	
Khairani & Sani (2018); Apriani et al. (2024); Thoyip et al. (2024); Hasyim & Andreina (2018)	The analysis is not yet comprehensive	4	
Khoiriyah et al. (2023); Heller & Heller	Focus on learning models/methods	3	

(1999); Verawati et al. (2020)			
Docktor & Mestre (2014); Suarez et al. (2017); McDermott & Redish (1999)	Focus on general problem-solving	3	
Seluruh penelitian dalam kajian ini	A systematic analysis of HOTS challenges	34	Advantages
Charli et al. (2018); Isra (2023); Thoyip et al. (2024); Apriani et al. (2024); Adi et al. (2025); Fauziana et al. (2020)	Analysis of the problem-solving process	6	
Dinata et al. (2024); Lestari et al. (2024); Darsa et al. (2020); Elmayanti et al. (2025)	Integration of various aspects (concepts, strategies, analysis)	4	
Singh & Rosengrant (2016); Maloney (1994); Murtafiah (2022)	The Relationship Between Misconceptions and HOTS	3	
Van Heuvelen (1991); Hsu et al.	Representation analysis	3	

(2004); Salsabilla & Hidayati (2020)			

Based on the results of the categorization in the table, it can be seen that previous studies still have various limitations in examining students' ability to solve Higher Order Thinking Skills (HOTS) problems in physics learning. The most prominent limitation found was that studies focused only on a specific aspect, such as concepts, analysis, or mathematical skills, with a total of eight studies. This indicates that most studies remain partial and have not yet integrated the various important aspects required for comprehensively solving HOTS problems.

Another significant limitation is the lack of in-depth analysis of the challenges faced by students, a shortcoming identified in six studies. This suggests that many previous studies have focused primarily on final outcomes or students' achievement levels, without examining in detail the thinking processes and difficulties students encountered while solving problems. Additionally, there are studies that focus solely on students' HOTS outcomes or abilities in general without analyzing the process, as well as studies that emphasize specific aspects of representation or concepts. This further reinforces that research on HOTS in physics education has not yet been conducted comprehensively. On the other hand, some studies also reveal limitations in the context of the approaches used, such as research focused on specific learning models or methods, as well as studies examining problem-solving in general without specifically linking it to HOTS. These limitations indicate that more targeted and specific studies are still needed to connect problem-solving abilities with students' higher-order thinking skills.

Given these limitations, this study offers several strengths that constitute its main contributions. The most notable strength is the systematic analysis of HOTS challenges, which encompasses all the studies analyzed (34 studies). This indicates that the study does not focus solely on a specific aspect but aims to provide a more comprehensive picture of the challenges students face in solving HOTS problems. Additionally, this study emphasizes the analysis of the problem-solving process, as evidenced by the studies referenced in examining students' thinking stages. This approach is crucial because HOTS proficiency is not merely assessed by final outcomes but also by how students understand problems, devise strategies, and evaluate the solutions they arrive at. This study also integrates various important aspects, such as conceptual understanding, problem-solving strategies, and analytical skills, resulting in a more comprehensive analysis compared to previous studies. Furthermore, this study also links misconceptions to HOTS skills and analyzes students' representational abilities in solving physics problems. This indicates that

the study does not focus solely on a single dimension of ability but encompasses various interrelated aspects of the higher-order thinking process. Thus, this study is expected to provide.

CONCLUSION

Based on a literature review of various previous studies, it can be concluded that students' ability to solve Higher Order Thinking Skills (HOTS) problems in physics instruction is still suboptimal. This is evidenced by the various challenges students face when solving problems that require higher-order thinking skills. The analysis results indicate that the most dominant challenge is a low level of understanding of physics concepts, which impacts students' difficulty in connecting concepts to contextual problems. In addition, students also have difficulty determining problem-solving strategies, particularly in designing systematic solution steps and evaluating the results obtained. Other challenges include the ability to analyze and understand problems, limitations in interpreting information contained in contextual problems, and difficulties in using mathematical and symbolic representations in solving physics problems.

On the other hand, instructional factors also influence students' abilities, particularly regarding instructional design and the development of HOTS-based assessment instruments, which are not yet optimal. Instruction that remains focused on routine problems results in students being underprepared to tackle problems that require analysis, evaluation, and creativity. This finding is reinforced by a review of previous research, which indicates that most studies still have limitations, primarily because they tend to focus on a single specific aspect—such as concepts, analysis, or mathematical skills—resulting in studies that remain partial in nature. Additionally, many studies have not conducted an in-depth analysis of the challenges students face and place greater emphasis on final outcomes rather than the students' thought processes in solving HOTS questions. On the other hand, some studies have contributed to the development of HOTS-based learning and instruments. However, these contributions are generally still limited to specific aspects and have not fully integrated the various dimensions of students' abilities comprehensively. Therefore, this study contributes by presenting a more systematic analysis of HOTS challenges through the categorization of various findings from previous research, thereby providing a more comprehensive picture of the difficulties students face in solving HOTS problems in physics learning.

Thus, students' ability to solve HOTS problems in physics learning is influenced not only by their mastery of concepts but also by their analytical skills, problem-solving strategies, representational skills, and the quality of the teaching methods employed. Furthermore, the results of this study indicate that previous research still requires more comprehensive and integrated development in examining HOTS. Therefore, improvement efforts are needed through strengthening conceptual understanding,

implementing instruction that fosters higher-order thinking, and developing assessment instruments capable of measuring students' HOTS abilities more comprehensively and systematically.

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