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Analysis of Students' Ability to make HOTS Questions Related to the Basic Physics Material that has been Studied

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Abstrak
Tujuan-Penelitian ini menyelidiki kemampuan mahasiswa sarjana fisika untuk membuat pertanyaan *Higher Order Thinking Skills* (HOTS) berdasarkan topik yang dipelajari dalam fisika dasar. Fokusnya adalah pada seberapa baik siswa dapat merumuskan pertanyaan yang membutuhkan pemikiran yang lebih dalam. **Metodologi Penelitian/Desain/Pendekatan-**Penelitian ini melibatkan 40 siswa yang diminta untuk menyusun pertanyaan berbasis HOTS dan berpartisipasi dalam wawancara semi-terstruktur. Pertanyaan-pertanyaan tersebut dikategorikan ke dalam empat jenis HOTS: inferensial, interpretatif, transfer, dan hipotetis. Data dianalisis untuk memahami distribusi dan kualitas pertanyaan yang dibuat.**Temuan-**Sebagian besar siswa mampu menghasilkan pertanyaan inferensial (35%) dan interpretatif (30%), yang selaras erat dengan konten yang diajarkan di kelas. Namun, lebih sedikit siswa yang menghasilkan pertanyaan transfer (20%) dan hipotetis (15%), yang membutuhkan penerapan pengetahuan dalam konteks baru dan terlibat dalam penalaran spekulatif. Wawancara mengungkapkan bahwa siswa berjuang dengan jenis terakhir ini karena terbatasnya paparan tugas berpikir terapan dan kreatif. **Orisinalitas/Nilai-Penelitian** ini menawarkan perspektif baru dengan berfokus pada kemampuan siswa untuk berkreasi daripada hanya menjawab pertanyaan HOTS. Temuan ini menekankan perlunya strategi pengajaran yang mempromosikan pemikiran kontekstual, kritis, dan inovatif untuk mempersiapkan siswa dengan lebih baik untuk pemecahan masalah dunia nyata dan penyelidikan ilmiah.
Kata kunci: *Keterampilan Berpikir Orde Tinggi, Pendidikan Fisika, Perumusan Pertanyaan, Keterampilan Kognitif, Berpikir Kritis*

Abstract
Purpose-This study investigates the ability of undergraduate physics students to create Higher Order Thinking Skills (HOTS) questions based on topics learned in basic physics. The focus is on how well students can formulate questions that require deeper thinking. **Research Methodology/Design/Approach-**The research involved 40 students who were asked to construct HOTS-based questions and participate in semi-structured interviews. The questions were categorized into four types of HOTS: inferential, interpretive, transfer, and hypothetical. Data were analyzed to understand the distribution and quality of the questions created.**Findings-**Most students were able to generate inferential (35%) and interpretive (30%) questions, which align closely with the content taught in class. However, fewer students produced transfer (20%) and hypothetical (15%) questions, which require applying knowledge in new contexts and engaging in speculative reasoning. Interviews revealed that students struggled with these latter types due to limited exposure to applied and creative thinking tasks. **Originality/Value-**This study offers a fresh perspective by focusing on students' ability to create rather than just answer HOTS questions. The findings emphasize the need for teaching strategies that promote contextual, critical, and innovative thinking to better prepare students for real-world problem-solving and scientific inquiry.
Keywords: Higher Order Thinking Skills, Physics Education, Question Formulation, Cognitive Skills, Critical Thinking

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Introduction

Higher-order thinking Skills (HOTS) have become an important spotlight in education, especially in higher education, emphasizing complex cognitive skills development. HOTS includes a wide range of skills, such as critical thinking, creative thinking, problem-solving, decision-making, and the ability to make inferences, interpretations, knowledge transfer, and hypotheses (Alkiyumi, 2023; Li et al., 2024; Sitorus et al., 2021). In science education, especially physics, HOTS plays a central role in shaping a deep and applicable understanding of various scientific concepts (Boon et al., 2022; Hamzah et al., 2022). A physics learning process that only emphasizes memorization and repetition of concepts without developing HOTS skills risks producing graduates unprepared for real-world challenges (Magarelli, 2024), where analysis, synthesis, and evaluation skills are urgently needed.

As one of the branches of basic science, physics teaches concepts, laws, and principles of nature and instills scientific and systematic ways of thinking. Materials in fundamental physics, such as kinematics, dynamics, Newton's laws, the law of energy conservation, and others, require understanding, relating to, and applying these concepts in real-life situations and everyday problems (Coban & Buyukdede, 2024; Karwasz & Wyborska, 2023; Lyu, 2024). However, the reality in the field shows that physics learning at the university level still focuses a lot on routine and mechanistic problems, which emphasizes students' ability to solve mathematical calculations without demanding much in-depth conceptual thinking (Akinyemi, 2021). In this case, the skill to ask HOTS questions is an important indicator that shows the extent to which students not only understand the material passively (Gozali et al., 2021) but can also critically process, analyze, and evaluate information.

Asking questions is one of the metacognitive strategies that can reveal the depth of a person's understanding of a material (Apaydin & Hossary, 2017; Meijer et al., 2006). In this case, HOTS questions reflect students' thinking abilities beyond just knowing or understanding information (Lemons & Lemons, 2013; Schulz & FitzPatrick, 2016). The question shows the capacity to analyze phenomena, evaluate arguments, and design solutions or predictions to a problem based on physical concepts (Garbuio & Lin, 2021; Hestenes, 1987). Unfortunately, students' ability to formulate HOTS questions is rarely studied systematically, especially in Indonesian universities' physics education context. Most of the previous research focused more on the effectiveness of HOTS learning strategies, the development of HOTS assessment instruments, or lecturers' design of HOTS questions. However, not many have examined the ability of students themselves to construct questions that reflect HOTS.

This gap is important for further research because asking questions is a form of high-level thinking that can describe students' cognitive readiness to face academic and professional challenges. If students can formulate HOTS questions, it can indicate that they have high critical, analytical, and creative thinking skills. Conversely, the inability to design HOTS questions may reflect that the learning process has not thoroughly fostered deep, reflective thinking. Therefore, the study of students' ability to make HOTS questions is theoretically relevant and has practical implications in curriculum design, learning strategies, and physics learning assessments.

Furthermore, in the context of the development of the current higher education curriculum, there is increasing pressure to produce academically competent graduates and those with 21st-century skills, including critical thinking, problem-solving, and lifelong learning. The ability to formulate HOTS questions is closely related to these three competencies. The shift from teacher-centered to student-centered learning requires students to be active, reflective, and critical learners. In this case, the skill of making questions is important because it shows the ability of students to identify problems, dig up information, and develop independent thinking.

As part of a high-level cognitive process, creating HOTS questions demands the integration of multiple domains of knowledge and skills at once. According to Anderson and Krathwohl in Bloom's taxonomic revision, HOTS questions typically include analysis, evaluation, and creation levels. Thus, when students are invited to ask questions at this level, they are encouraged to understand the material more comprehensively, relate to relevant contexts, and evaluate possible

possible answers. This starkly contrasts with traditional learning that only demands a single correct answer without leaving room for exploration or alternative reasoning.

However, few empirical studies have explicitly evaluated the quality of student-designed HOTS questions, especially in fundamental physics. Some relevant studies evaluate students' critical thinking skills based on exam results or written assignments without looking at the expression of these abilities in the form of questions made by students. The ability to ask questions is a strong indicator in measuring the internalization and construction of meaning in the material studied. Therefore, this research is here to fill this gap by conducting an in-depth analysis of HOTS questions made by students in the context of basic physics learning.

The novelty of this research lies in its specific focus on students' ability to design HOTS questions as a form of high-level thinking expression in introductory physics courses. In contrast to previous studies that emphasized the evaluation of HOTS-based learning outcomes or the development of HOTS questions by lecturers, this study pays attention to the active participation of students as subjects who design their questions. Thus, the results of this study are expected to provide new insights into the extent to which students can apply their understanding of physics concepts in the form of critical and reflective questions. In addition, this research also has the potential to produce pedagogical recommendations to encourage the integration of HOTS question-designing activities into the physics learning process in the classroom.

This study also aims to identify the types of questions asked by students, classify their cognitive level based on the revised Bloom's taxonomy, and evaluate the quality of these questions regarding clarity, conceptual relevance, and cognitive depth. With this approach, it is hoped that a general pattern can be found regarding students' tendency to ask questions and the factors that affect them, such as material understanding, critical thinking skills, or learning strategies used by lecturers. In addition, this study will also explore the possible relationship between the ability to make HOTS questions and other variables such as academic confidence level, previous learning experience, and perception of introductory physics courses.

The primary purpose of this study is to analyze the ability of students to make HOTS questions related to the basic physics material that has been studied. Specifically, this study aims to (1) identify and classify the questions asked by students based on the cognitive level in the revised Bloom taxonomy, (2) evaluate the quality of the questions based on indicators of clarity, relevance, and cognitive depth, and (3) examine the factors that affect the student's ability to design HOTS questions. The results of this study are expected to make a theoretical contribution to the development of question-based learning models, as well as practical contributions in designing learning strategies that can develop students' high-level thinking skills.

Overall, this study emphasizes the importance of paradigm change in physics learning, from providing material and practice questions to developing more complex and reflective thinking skills. One effective way to make this happen is to actively involve students in formulating questions, not just answering questions asked by lecturers. The learning process becomes more dialogical, dynamic, and meaningful by encouraging students to think critically and creatively in formulating questions. Therefore, this research is an important first step in encouraging pedagogical innovation based on the development of HOTS in physics education in higher education.

Method

This study uses a qualitative descriptive approach with a case study design to analyze students' ability to make higher-order thinking Skills (HOTS) questions in basic physics material (Sugiyono, 2013). This approach was chosen because it allows researchers to delve deeply into the phenomenon of high-level thinking expressed through questions designed by students. The main objective of this study was to evaluate and categorize the quality and cognitive level of the HOTS questions made by students, as well as to identify the factors that affect these abilities. The target of this study is students of the physics education study program at one of the public universities in Indonesia who have taken Basic Physics I and II courses. The population in this study is all students in the fourth semester who have studied basic physics material thoroughly.

At the same time, the sample was selected purposively, with as many as 40 students representing variations in academic abilities based on previous learning outcomes.

The research subjects were students who were asked to design five HOTS-based questions related to basic physics material, including kinematics, dynamics, Newton's laws, effort and energy, momentum, and the laws of eternity. The main instrument in data collection is the HOTS question-making task sheet, accompanied by an assessment rubric guide that refers to the revised Bloom taxonomy by Anderson and Krathwohl. In addition, semi-structured interviews were conducted with some of the selected subjects to explore their thought processes further when formulating questions. Data collection techniques include documentation of student assignment results, observation of learning activities, and interviews. The data from the collected questions were analyzed using content analysis techniques by categorizing each question based on cognitive level (analysis, evaluation, and creation), relevance to the physics material, and depth of questions based on the HOTS indicator.

The research model used is an evaluative-descriptive model with thematic analysis, allowing researchers to identify common patterns and individual variations in making HOTS questions. The validity of the data is maintained through data triangulation, both from assignments, interviews, and observations, as well as through peer checking (peer debriefing) to avoid assessment bias. The data analysis technique is carried out in stages, from data reduction to data presentation in categorization tables and drawing conclusions based on emerging themes. The analysis results are then interpreted to answer the formulation of the problem and support the research objectives. With this method, a comprehensive understanding of students' ability to design HOTS questions and their implications for developing physics learning strategies based on high-level thinking skills can be obtained.

Findings and discussion

Analyzing students' ability to prepare higher-order thinking Skills (HOTS) questions showed significant variations in the category of question types. Based on the grouping using the cognitive dimension in the HOTS framework, the distribution was obtained as follows: inferential questions dominated by 35%, followed by interpretive questions at 30%, then transfer at 20%, and the least were hypothetical questions with a percentage of 15%. These findings reflect that students tend to be more able or more comfortable formulating questions directly related to the material studied explicitly, compared to the types of questions that demand both applicative and predictive thinking. The distribution of questions made by students can be seen in Table 1 below:

Table 1. Distribution of HOTS Questions Created by Students

Question Types	Number of Questions	Percentage (%)
Inferential	56	35%
Interpretation	48	30%
Transfer	32	20%
Hypothetical	24	15%
Total	**160**	**100%**

Each student was asked to create five questions based on the Basic Physics material they had studied, covering topics such as kinematics, dynamics, Newton's laws, effort and energy, and conservation laws of momentum and energy. With 40 sampled students, as many as 200 questions were collected. However, after a selection based on question validity and consistency criteria with the HOTS indicator, only 160 questions were worth analyzing in depth.

Inferential Questions

The type of inferential question was the most asked by students, with 56 questions or 35% of the total data analyzed. Questions in this category require students to conclude a data or phenomenon. One example of a question that is categorized as inferential is: "How can you deduce the relationship between force and acceleration from the results of an experiment on an oblique plane?". Questions like this require students to relate the results of observations to Newton's second law and show the existence of a critical thinking process to find cause-and-effect relationships. The dominance of inferential questions can be interpreted as an indicator that students are used to drawing conclusions based on practicum results or procedural problem-solving (Susanti & Azhar, 2019; Sutarto et al., 2022). This activity is also practiced in the form of questions in class so that students have relatively higher confidence to develop questions at this level.

Interpretation Questions

Interpretation questions also have a high frequency of as many as 48 questions (30%). This type of question generally relates to the student's ability to understand and explain the meaning of visual information, graphs, or experimental results (Guo et al., 2020; Klein et al., 2019). An example would be: "Explain the meaning of the velocity graph against time in a straight-moving experiment changing in order.". This question demonstrates the student's ability to read and interpret representations of physics data in graphs. Interpretive abilities are critical in physics because most concepts are explained through mathematical visualization (Stefanel, 2019). The dominance of this question also shows that students feel relatively familiar with the forms of data, such as graphs, tables, and diagrams, that often appear in learning and exams (Chang et al., 2024; Shreiner, 2019). From interviews conducted with five students with different ability ranges, it was found that they felt more confident in compiling interpretation questions because they "had often seen graphs or tables in practicum and exam questions," as conveyed by the M3 subject. This indicates that the intensity of exposure to certain forms of representation in learning materials significantly affects students' cognitive tendency to develop questions.

Transfer Questions

Transfer questions only constitute 32 or 20% of the total questions analyzed. This question requires students to apply the concepts they have learned in new or different situations. Examples are: "How can the principle of energy conservation be applied in hydropower technology?". Transfer questions indicate a deep conceptual understanding and the ability to relate physical material to real-life phenomena or technological applications (Falloon, 2020; Hajian, 2019). However, its lower frequency than inferential and interpretive shows that students struggle to bridge theoretical concepts with applicable contexts. From the results of the interviews, the students revealed that they "had difficulty finding a suitable real situation" or were "not used to associating physics concepts with the outside world." The statement from the subject of M7 states that: "If I am asked to make a question directly from a book or module, I can. But if I have to think about the application of that concept in the real world, I am confused about where to start." These findings indicate a lack of experience or stimulus in learning that is contextual or based on real-life problems, which should be an important part of modern science learning (Mc Pherson-Geyser et al., 2020). This shows the need to integrate more problem-based learning or project-based learning approaches into the physics curriculum.

Hypothetical Questions

Hypothetical questions are the type of questions with the lowest frequency, only 24 questions or 15% of the total data. An example of a hypothetical question students ask is: "If the earth's gravitational force is suddenly reduced by half, how will it affect the motion of objects on the earth's surface?". This question requires predictive and speculative thinking skills based on scientific knowledge that has been learned. This type of question requires students to think beyond the actual, anticipate possibilities based on the laws of physics, and consider various consequences logically (Coenen et al., 2019; Healey & Hodgkinson, 2024). However, most students have difficulty asking questions like this. Based on interviews, the majority stated that they were not used to thinking speculatively and tended to worry that their questions "would sound wrong or strange." Subject M1 said: "I am afraid my question is too weird or absurd, so it is better just to make a casual question." This statement reflects the low confidence of students to explore ideas freely and creatively, which should be one of the main characteristics of high-level thinking. The lack of hypothetical questions also reflects the weakness of divergent thinking exercises and the lack of use of exploratory approaches in physics learning (Stolte et al., 2022). This question is fundamental to building scientific thinking skills that open to various possibilities and facilitate the birth of innovative ideas.

Overall, the results of this study show that students are more likely to make questions that are direct and based on material that has been explicitly taught in class. This is consistent with the traditional learning approach still dominant in higher education, where mastery of concepts is emphasized more than developing higher-level thinking skills. When challenged to create questions that demand transferability and hypothetical, most students show doubt, confusion, or even avoid the attempt.

This phenomenon needs to be taken seriously because the purpose of learning physics is to understand concepts and train scientific, creative, and reflective ways of thinking. Based on the framework, cognitive levels such as applying, analyzing, evaluating, and creating are the main focuses in HOTS. However, data shows that most of the students' questions are still at the analyze and understand levels, while the apply and create levels are still very lacking. In addition, the results of the interviews reinforce the hypothesis that the limitations of real-context-based learning experiences and the lack of exploratory encouragement from lecturers also contribute to students' low ability to make transfer and hypothetical questions. A learning environment that emphasizes too much on "correct answers" and "certainty" makes students reluctant to take intellectual risks to think outside the box.

This research provides important practical implications for developing the physics curriculum and learning strategies. Lecturers need to explicitly train students to develop questions covering all HOTS categories, not just inferential and interpretive. Approaches such as inquiry-based learning, case-based learning, or the use of simulations and speculative scenarios in class discussions can improve student thinking quality. Furthermore, the skill of making HOTS questions also needs to be assessed and given feedback in the learning process. In this way, students will realize that the ability to ask questions is an important part of scientific competence and not just an additional skill. Over time, students can understand and apply physics concepts and challenge, reflect, and develop new ideas through critical and creative questions.

Conclusion

This study shows that students' ability to make HOTS questions in basic physics materials is still dominated by the types of inferential (35%) and interpretive (30%) questions. Transfer (20%) and hypothetical (15%) questions are relatively low. This indicates that students are more comfortable with direct and material-based questions and have difficulty formulating questions requiring application and speculative thinking. A lack of contextual learning experience and training in critical and creative thinking influences this difficulty. Therefore, a more exploratory and applicative learning strategy is needed to improve students' HOTS abilities.

Declaration

All manuscripts must contain the following sections under the heading 'Declarations':

Competing interests

If you do not have any competing interests, please state "The authors declare that they have no competing interests" in this section.

Author contributions

M.A. Martawijaya contributed to the conceptualization of the study, research design, data collection, and drafting and editing of the manuscript. Mahir was responsible for data analysis, interpretation of findings, conducting interviews, and writing the results and discussion sections. Both authors collaboratively revised and approved the final version of the manuscript for submission.

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References

Akinyemi, A. R. (2021). *Investigation of Students ' Use and Understanding of Evaluation Strategies*. Electronic Theses and Dissertations. 3447. https://digitalcommons.library.umaine.edu/etd/3447

Alkiyumi, M. (2023). New Classification of Higher-Order Thinking Skills (HOTS). *Onomazein*, *March*, 1054–1068. https://www.researchgate.net/publication/379153600

Apaydin, M., & Hossary, M. (2017). Achieving metacognition through cognitive strategy instruction. *International Journal of Educational Management*, *31*(6), 696–717. https://doi.org/10.1108/IJEM-05-2016-0130

Boon, M., Orozco, M., & Sivakumar, K. (2022). Epistemological and educational issues in teaching practice-oriented scientific research: roles for philosophers of science. *European Journal for Philosophy of Science*, *12*(1), 1–23. https://doi.org/10.1007/s13194-022-00447-z

Chang, H. Y., Chang, Y. J., & Tsai, M. J. (2024). Strategies and difficulties during students' construction of data visualizations. *International Journal of STEM Education*, *11*(1). https://doi.org/10.1186/s40594-024-00463-w

Coban, A., & Buyukdede, M. (2024). *Exploring Motion: Integrating Arduino in Physics Education for 21st Century Skills*. https://arxiv.org/abs/2405.06647v2

Coenen, A., Nelson, J. D., & Gureckis, T. M. (2019). Asking the right questions about the psychology of human inquiry: Nine open challenges. *Psychonomic Bulletin and Review*, *26*(5), 1548–1587. https://doi.org/10.3758/s13423-018-1470-5

Falloon, G. (2020). From simulations to real: Investigating young students' learning and transfer from simulations to real tasks. *British Journal of Educational Technology*, *51*(3), 778–797. https://doi.org/10.1111/bjet.12885

Garbuio, M., & Lin, N. (2021). Innovative idea generation in problem finding: Abductive reasoning, cognitive impediments, and the promise of artificial intelligence. *Journal of Product Innovation Management*, *38*(6), 701–725. https://doi.org/10.1111/jpim.12602

Gozali, I., Lie, A., Tamah, S. M., & Jemadi, F. (2021). HOTS questioning ability and HOTS perception of language teachers in Indonesia. *Indonesian Journal of Applied Linguistics*, *11*(1), 60–71. https://doi.org/10.17509/ijal.v11i1.34583

Guo, D., Zhang, S., Wright, K. L., & McTigue, E. M. (2020). Do You Get the Picture? A Meta-Analysis of the Effect of Graphics on Reading Comprehension. *AERA Open*, *6*(1), 1–20. https://doi.org/10.1177/2332858420901696

Hajian, S. (2019). Transfer of Learning and Teaching: A Review of Transfer Theories and Effective Instructional Practices. *IAFOR Journal of Education*, *7*(1), 93–111. https://doi.org/10.22492/ije.7.1.06

Hamzah, H., Hamzah, M. I., & Zulkifli, H. (2022). Systematic Literature Review on the Elements of Metacognition-Based Higher Order Thinking Skills (HOTS) Teaching and Learning Modules. *Sustainability (Switzerland)*, *14*(2), 1–15. https://www.mdpi.com/2071-1050/14/2/813

Healey, M. P., & Hodgkinson, G. P. (2024). Overcoming strategic persistence: Effects of multiple scenario analysis on strategic reorientation. *Strategic Management Journal*, *45*(8), 1423–1445. https://doi.org/10.1002/smj.3589

Hestenes, D. (1987). Toward a modeling theory of physics instruction. *American Journal of Physics*, *55*(5), 440–454. https://doi.org/10.1119/1.15129

Karwasz, G. P., & Wyborska, K. (2023). How Constructivist Environment Changes Perception of Learning: Physics Is Fun. *Education Sciences*, *13*(2). https://doi.org/10.3390/educsci13020195

Klein, P., Viiri, J., & Kuhn, J. (2019). Visual cues improve students' understanding of divergence and curl: Evidence from eye movements during reading and problem solving. *Physical Review Physics Education Research*, *15*(1), 10126. https://doi.org/10.1103/PhysRevPhysEducRes.15.010126

Lemons, P. P., & Lemons, J. D. (2013). Questions for assessing higher-order cognitive skills: It's not just Bloom's. *CBE Life Sciences Education*, *12*(1), 47–58. https://doi.org/10.1187/cbe.12-03-0024

Li, D., Fan, X., & Meng, L. (2024). Development and validation of a higher-order thinking skills (HOTS) scale for major students in the interior design discipline for blended learning. *Scientific Reports*, *14*(1), 1–20. https://doi.org/10.1038/s41598-024-70908-3

Lyu, X. (2024). Exploring the Cognitive Obstacles in High School Students' Learning of Physics and Mechanics. *Contemporary Education Frontiers*, *2*(2), 36–42.

Magarelli, R. (2024). *Critical Analyses in Science: Course Impact on Critical Thinking Skills and Hypothetical-deductive Reasoning*.

Mc Pherson-Geyser, G., de Villiers, R., & Kavai, P. (2020). The use of experiential learning as a teaching strategy in life sciences. *International Journal of Instruction*, *13*(3), 877–894. https://doi.org/10.29333/iji.2020.13358a

Meijer, J., Veenman, M. V. J., & Van Hout-Wolters, B. H. A. M. (2006). Metacognitive activities in text-studying and problem-solving: Development of a taxonomy. *Educational Research and Evaluation*, *12*(3), 209–237. https://doi.org/10.1080/13803610500479991

Schulz, H., & FitzPatrick, B. (2016). Teachers' understandings of critical and higher order thinking and what this means for their teaching and assessments. *Alberta Journal of Educational Research*, *62*(1), 61–86. https://doi.org/10.55016/ojs/ajer.v62i1.56168

Shreiner, T. L. (2019). Students′ use of data visualizations in historical reasoning: A think-aloud investigation with elementary, middle, and high school students. *Journal of Social Studies Research*, *43*(4), 389–404. https://doi.org/10.1016/j.jssr.2018.11.001

Sitorus, M. M., Silalahi, L. H., Rajagukguk, H., Panggabean, N., & Nasution, J. (2021). The effect of Higher-Order thinking skill (HOTS) in reading comprehension. *IDEAS Journal of Language Teaching and Learning, Linguistics and Literature*, *9*(1), 455–463.

Stefanel, A. (2019). Graph in Physics Education: From Representation to Conceptual Understanding. *Mathematics in Physics Education*, 195–231. https://doi.org/10.1007/978-3-030-04627-9_9

Stolte, M., Trindade-Pons, V., Vlaming, P., Jakobi, B., Franke, B., Kroesbergen, E. H., Baas, M., & Hoogman, M. (2022). Characterizing Creative Thinking and Creative Achievements in Relation to Symptoms of Attention-Deficit/Hyperactivity Disorder and Autism Spectrum Disorder. *Frontiers in Psychiatry*, *13*(July), 1–15. https://doi.org/10.3389/fpsyt.2022.909202

Sugiyono. (2013). *Metode Penelitian Kuantitatif, Kualitatif dan R&D*. Alfabeta.

Susanti, N., & Azhar, Y. (2019). Student Tutoring, Facilitator and Explaining Models: A Problem Solving Metacognition towards Learning Achievements of Informatics Students. *Journal of Educational Sciences*, *3*(2), 145–154.

Sutarto, Dwi Hastuti, I., Fuster-Guillén, D., Palacios Garay, J. P., Hernández, R. M., & Namaziandost, E. (2022). The Effect of Problem-Based Learning on Metacognitive Ability in the Conjecturing Process of Junior High School Students. *Education Research International*, *2022*. https://doi.org/10.1155/2022/2313448