JPPIPA 8(2) (2022)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Higher-Order Thinking Skills in Prospective Physics Teacher

Kaharuddin Arafah[1*,2], Ruslan[2], Nurhayati[3], Aeman Hakim[3], Agriani Pongkessu[4]

[1]Department of Physics Education-Postgraduate Program, Universitas Negeri Makassar, Makassar, Indonesia
[2]Educational Research and Evaluation-Postgraduate Program, Universitas Negeri Makassar, Makassar, Indonesia
[3] Department of Physics, Universitas Negeri Makassar, Makassar, Indonesia
[4]Department ot Engineering, Akademi Maritim AIPI Makassar, Makassar, Indonesia

DOI: 10.29303/jppipa.v8i2.1480

Article Info
Received: February 28, 2022
Revised: April 20, 2022
Accepted: April 24, 2022
Published: April 30, 2022

Abstract: The rules regarding the assessment carried out by teachers have been refined to match the demands of 21st-century learning, the aspect that has been improved is the cognitive aspect, specifically in the assessment of Higher Order Thinking Skills. However, prospective teachers and even teachers still have difficulty implementing this assessment. The purpose of this study was to determine the profile of the ability of prospective physics teacher students in solving Higher Order Thinking Skills questions as an initial description in identifying problems that occur. This research was a descriptive study to determine the profile of postgraduate students at Makassar State University, South Sulawesi. The research data was obtained through test technique. These questions consist of 40 sets of items, with indicators of analyzing, evaluating, and creating. It has been developed by researchers and validated by experts. The percentage of the score obtained is 68, 79, and 55% for indicators of analyzing, evaluating, and creating respectively. Therefore, Prospective physics teachers can still be said to be unsatisfactory in solving Higher Order Thinking Skills questions.
.

Keywords: Higher order thinking skills; Prospective-physics-teachers; Learning

Citation: Arafah, K., Ruslan, R., Nurhayati, N., Hakim, A., & Pongkessu, A. (2022). Higher-Order Thinking Skills in Prospective Physics Teacher. *Jurnal Penelitian Pendidikan IPA*, *8*(2), 805–910. https://doi.org/10.29303/jppipa.v8i2.1480

Introduction

The role of teachers is becoming more complex and more vital in the 21st century. Teachers must realize that the characteristics of 21st-century learning are marked by 4Cs, namely critical thinking and problem solving, creativity and innovation, communication, and collaboration. Furthermore, 21st-century learning also requires Digital Literacy awareness which consists of information literacy, media literacy, and ICT literacy (Collins, 2014; Mısır, 2018; Anon, 2015). This means that teachers in carrying out their roles must be literate in digital technology and matters related to the application of information technology in learning. In addition, teachers must also understand that career and life are increasingly complex in this century (Mısır, 2018, Anon, 2015; Arends, 2012; Elby, 2015; Reiss, 2018).

The Indonesian government realizes the importance of fulfilling 21st-century learning so that the assessment standards are made improvements. One of the things that have changed is the cognitive aspect, namely the assessment of Higher-Order Thinking Skills (HOTS). The demands of attitude aspects are focused on Civics, Religion subjects, and counseling, so that teachers of other subjects, including physics teachers, focus on assessing cognitive and psychomotor aspects.

The general problems faced by teachers and prospective teachers in Indonesia, including in Makassar, especially Makassar State University as a producer of prospective teachers, have not ended. Prospective teacher students and even teachers generally still have difficulty applying higher-order thinking skills assessments (Collins, 2014; Abosalem, 2016; Arafah, et al., 2021).

Students use their knowledge in various ways. Teaching for transfer, as well as teaching for meaning, enables students not only to remember and understand but also to use knowledge in increasingly complex ways (Bloom, et.al, 2015; Mohamed & Lebar, 2017; Hyder & Bhamani, 2016; Ocy, 2021; Urgo, et al., 2019). Taxonomy can help in remembering important learning targets and thinking skills students want to achieve. For any content

* Corresponding Author: kahar.arafah@unm.ac.id

domain (not just in physics), we usually want students to know some facts and concepts and also to be able to think and reason with these facts and concepts in some way. Every time students try to solve new problems or do original thinking with their knowledge, they transfer and change what they learn, so their understanding grows (Bloom, 2015; Heong, et al., 2012; Peppen, et al., 2021)

The book "*Taxonomy of Educational Objectives, Handbook I: Cognitive Domain*" by Bloom, Engelhart, Furst, Hill, & Krathwohl in 1956 is the most widely used taxonomy. Regardless of age, Bloom's taxonomy is still used in many curricula and teaching materials. Then Anderson and Krathwohl and a group of colleagues published the revised Bloom book in 2001. The main difference between the revised taxonomy and the original is that the 2001 version has two dimensions, namely Knowledge and Cognitive Process. The Knowledge Dimension classifies the types of knowledge that students face: facts, concepts, procedures, or metacognition (Bloom, 2015; Hyder & Bhamani, 2016). The Cognitive Process dimension is very similar to the original Bloom's taxonomy except that the order of the last two categories is reversed. Since the Knowledge dimension uses the word "knowledge", the first level of the Cognitive dimension is called "Remember". Anderson divides the cognitive level into six which is an adaptation of Bloom's cognitive taxonomy, namely; knowing (C1) is categorized as Lower-Order Thinking Skills (LOTS), understanding (C2), applying (C3) is categorized as Middle-Order Thinking Skills (MOTS). Meanwhile, the cognitive level of analyzing (C4), evaluating (C5), and creating (C6) is categorized into HOTS. The description of each level can be seen in Table 1 (Bloom et.al, 2015; Hyder & Bhamani, 2016).

Table 1. Cognitive Level and descriptors

Cognitive Level		Description
HOTS	Creating	Creating ideas - Verbs: construct, design, create, develop, write, formulate.
	Evaluating	Make decisions - Verbs: evaluate, judge, argue, decide, choose, support.
	Analyzing	ɔecifying aspects / elements. - Verbs: compare, examine, criticize, test.
MOTS	Applying	Use information on a different domain - Verbs: use, demonstrate, illustrate, operate.
	Understanding	Explain the idea / concept. Verbs: describe, classify, accept, report.
LOTS	Knowing	Recalling. - Verbs: remember, list, repeat, imitate

Actually, there are many taxonomies proposed by experts, but there are similarities of all these taxonomies, the similarity of each taxonomy of cognitive processes is that when the level of thinking becomes more complex, students need to deal with more information and increasingly complicated relationships between them (Mohamed & Lebar, 2017; Merta, at al., 2017). Next, we focus on assessing higher-order thinking with such a view, as the top end of cognitive taxonomy, which requires the transfer of ideas from the context in which they are taught to a new context. By using the revised Bloom's taxonomy, it is possible to determine higher-order thinking skills by assessing students' ability to analyze, evaluate, and create.

Based on the description above, this study is aimed at measuring the ability of prospective physics teacher students to solve problems oriented to higher-order thinking skills (HOTS) as an effort to identify problems faced by prospective physics teachers.

Method

The purpose of this study was to determine the profile of the ability of prospective physics teacher students in solving HOTS questions as an initial description in identifying problems that occur. This research was a descriptive study to determine the profile of 55 postgraduate students at Makassar State University, South Sulawesi. The research data was obtained through test technique. The following outlines the stages of the research as follows.

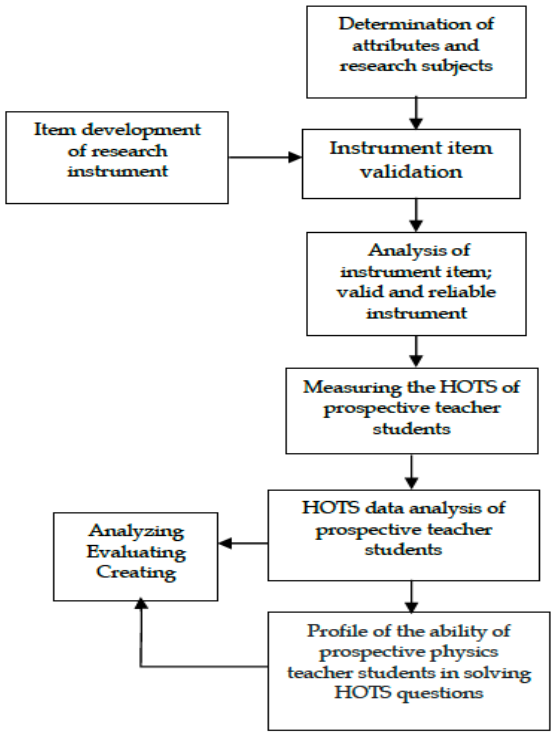

Figure 1. Research process

The assessment of higher-order thinking skills that are carried out involves the following principles: (1) clearly and precisely determining what will be measured, in this case, higher-order thinking with physics content; (2) Designing test items that require respondents to demonstrate higher-order thinking, in this case, making questions derived from indicators of higher-order thinking skills. These questions consist of 40 sets of items, with indicators of analyzing, evaluating, and creating; (3) Deciding the standards used to show the level of higher-order thinking skills, in this case, categorization is used as in Table 2.

Table 2. Higher-order thinking skills category based on the percentage of the test score

Percentage (%)	Category
$x \leq 20$	Very Low
$20 < x \leq 40$	Low
$40 < x \leq 60$	Medium
$60 < x \leq 80$	High
$x > 80$	Very High

The principles that are applied are actually general for attribute measurement. Specifically for measuring higher-order thinking skills carried out in this study, there are the following additional principles: (1) Each item contains an introduction as material for thinking, whether in the form of text, pictures, scenarios, or some kind of problem; (2) each item contains material which tends to bring novelty to the respondent so as not to lead the respondent to "recall"; (3) the instruments used can distinguish the level of difficulty and the level of thinking and control them separately. Therefore, the instrument used has been empirically validated to see the correct proportion of each item. To ensure all these aspects, theoretical validation is also carried out by involving experts.

Result and Discussion

The results of measurements using tests of higher-order thinking thinking skills can be seen in the Table 3, where the measurement results are separated for cognitive levels.

Table 3. The percentage of higher-order thinking skills scores for each cognitive level

Cognitive Level	Score (%)	Category
Analyzing	67.97	High
Evaluating	78.74	High
Creating	55.10	Medium
Total	65.59	High

Based on Figure 2, it can be seen that the analyzing indicator has a score percentage of 67.97% which is in the high category; the evaluating indicator has a score percentage of 78.74% which are in the high category; the creating indicator has a score percentage of 55.10% which is in the medium category.

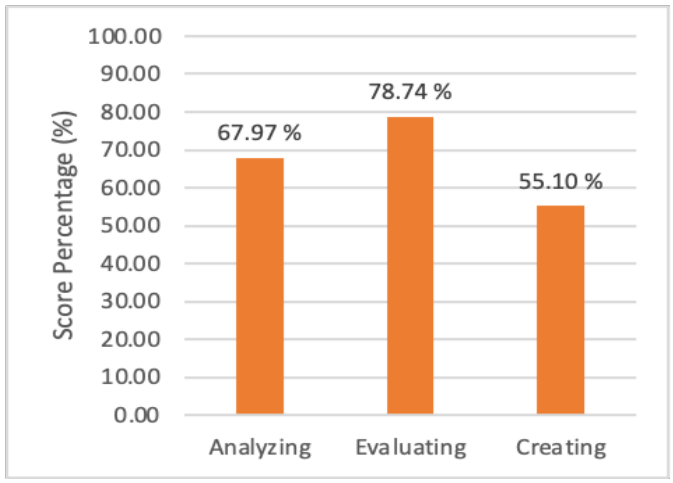

Figure 2. The diagram of higher-order thinking skills scores for each cognitive level

Although the higher-order thinking skills of prospective physics teachers is in the high category when viewed through the percentage of their score, this result is actually not very satisfying, considering the difficulty level of the questions made aimed at the high school level. Even the tests that are made are really only designed for the higher-order thinking skills without the need for difficult physics content. When viewed from the difficulty level of the questions given, prospective physics teachers who have gone through many physics' courses should be in the very high category.

Cognitive level is actually hierarchical, which means that a person cannot have good evaluation skills if they do not have good analytical skills. This then gives us the signal that the analytical ability score should be higher than the ability to evaluate. However, what is obtained does not indicate this. To discuss this further, it will be discussed one by one regarding the critical thinking skills of prospective physics teachers for each indicator.

Analyzing

Assessing the quality of students' thinking in breaking information down into sections and reasoning with that information requires questions that require the respondent to find or describe these parts and find out how they are related. The analysis level question being tested consists of giving mechanics material (or asking them to find mechanics material) to the respondent, then presenting a question or presenting a problem whose answer requires differentiating or organizing parts of the information in a sensible way (Heong et al, 2012; Malik et. al, 2017; Supeno, et. al 2019).

The ability to analyze can be defined as the individual's ability to determine the parts of a problem

and show the relationship between these parts, see the causes of an event or provide arguments that support a statement. Analysis emphasizes the ability to break down an essential element into parts and see the relationship between these parts. The category to analyze consists of the ability to differentiating, organizing and attributing (Bloom et.al, 2015).

The factor that makes this ability low for prospective physics teachers is: its inability to differentiating what information is needed and what is not needed from what is known in the questions; Even though prospective physics teachers have been able to differentiating pieces of information in the questions, they are then still hampered in connecting the existing information, due to the characteristic of HOTS questions which are full of information; The amount of information in HOTS questions (especially in physics material) can make it difficult for prospective physics teachers to sort out various points of view that don't really need to be focused on solving the questions.

Evaluating

Assessing evaluations requires items that can assess how students assess material as well as methods for their intended purpose. Students can assess material based on criteria. These criteria can be standards or criteria that students find themselves (in this case the element of creativity is also involved). The evaluation item tested does not prioritize personal preferences, but a reasoned evaluation that can be stated as an argument or conclusion supported by evidence and logic. To assess how well students do the evaluation, items are made by providing material and asking students to rate their "value" against a goal (Collins, 2014; Bloom et. al, 2015; Hyder, Bhamani, 2016; Heong et al, 2012).

Evaluating is defined as the ability to make judgments based on certain criteria and standards. The criteria most often used are quality, effectiveness, efficiency and consistency. The evaluation category consists of checking and critiquing (Bloom et.al, 2015).

The factor that makes this ability low for prospective physics teachers is: Lack of basic mathematical abilities of prospective physics teachers greatly affects their ability to check errors in mathematical operations that have been carried out, this then has a vital effect in confirming assumptions in questions that must be supported through data processing (Peppen, 2021; Trisnawaty, 2017; Wulan, et al., 2017). The lack of direct experience that prospective physics teachers have gone through in the process of solving daily problems (one of the characteristics of HOTS questions) actually makes them confused in determining and criticizing which methods are more effective.

The question of "evaluating" high school level tested on prospective physics teachers actually has a good level of difficulty when tested on high school students, but the difficulty level drops dramatically when tested on prospective teachers who are actually a little able to answer questions even without going through the evaluation process (just by remembering). This is the reason why the test results on the evaluation indicator are higher than the analysis indicators.

Creating

Judging whether students can "create" in a taxonomic sense means assessing whether they can combine different things in new ways or rearrange existing things to make something new. This is done by giving students problem items or problems to solve that include many solutions, planning procedures to achieve certain goals, or producing something new (Bloom et.al, 2015; Hyder, & Bhamani, 2016; Ocy, 2021).

Creating is generalizing new ideas, products or perspectives from an event. Prospective physics teacher is said to be able to create if they can make new products by remodelling some elements or parts into shapes or structures that have never been explained by the lecturer. Some of the criteria for creating, namely: formulating or making hypotheses (generating), planning and producing.

The factor that makes this ability low for prospective physics teachers is: Prospective physics teacher are too dependent on reading material in the text of questions and in books so that they have great difficulty in providing various possible solutions, this can be improved by practicing divergent thinking skills; The rigid way of thinking (in short, not creative) makes prospective physics teachers unable to plan good solutions, they tend to immediately use their memory in solving problems.

Several similar studies also show the higher-order thinking skills of prospective physics teacher students are still not satisfactory. Although we can consider higher-order thinking skills not related to the material being tested, the closely related dimensions of knowledge in the HOTS assessment cannot be ignored. Prospective physics teachers still have to improve their understanding of physics concepts as a step in improving those skills (Arafah, et al., 2020).

Conclusion

Prospective physics teachers can still be said to be unsatisfactory in solving HOTS questions. We can still say that the ability to analyze and evaluate prospective physics teachers is sufficient, but there are still many improvements needed, especially in practicing divergent thinking skills and their creativity in solving problems. Prospective physics teachers must always be reminded of the importance of procedural knowledge and metacognition, as their support in understanding

HOTS standard questions. As teachers in the future, they must also be reminded of the importance of learning to teach.

Acknowledgments

The author would like to say thank to the undergraduate students and lecturer team in our research classroom at one of State University in Makassar, who have given us permission and convenience during the research, also to prospective physics teachers who are still enthusiastic for improving their quality.

References

Abdullah, A.H., Mokhtar, M., & Halim, N.D.A. (2017). Mathematics Teachers' Level of Knowledge and Practice on The Implementation of Higher Order Thinking Skills (HOTS). *EURASIA Journal of Mathematics Science and Technology Education,13, 3-17.* https://doi.org/10.12973/eurasia.2017.00601a

Abosalem, Y. M. (2016). Assessment Techniques and Students' Higher-Order Thinking Skills *International, Journal of Secondary Education*. 4(1). 1-11. http://dx.doi.org/10.11648/j.ijsedu.20160401.11

Anon. (2015). New Vision for Education Unlocking the Potential of Technology, *World Economic Forum*, 91-93. Retrieved from https://www3.weforum.org/docs/WEFUSA_NewVisionforEducation_Report2015.pdf

Arafah, K., Rusyadi, R., Arafah, B., Arafah, A.N., (2020). The Effect of Guided Inquiry Model and Learning Motivation on the Understanding of Physics Concepts, *Talent Development and Excellence.* 12(1). 71–83. Retrieved from https://www.researchgate.net/publication/342211986_The_Effect...Concepts

Arafah, K., Amin, B.D., Sari, S. S., & Hakim, A. (2021). The Development of Higher Order-Thinking Skills (HOTS) Instrument Assessment in Physics Study. *Journal of Physics: Conference Series, 1899 (2021) 012140. 1-8.* https://doi.org/10.1088/1742-6596/1899/1/012140

Arends, R. (2012). *Learning to teach* (Dubuque, Iowa: McGraw-Hill. Retrieved from https://hasanahummi.files.wordpress.com/2017/04/connect...2012.pdf

Bloom, B. S., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P.R., Raths, J. & Wittrock, M. C. (2015). *Kerangka Landasan Untuk Pembelajaran, Pengajaran, dan Asesmen Revisi Taksonomi Pendidikan Bloom (Edisi Bahasa Indonesia,* Cetakan I), Yogyakarta: Pustaka Pelajar, ISBN: 978-602-8764-97-1. Retrieved from http://smaratungga.web.id/library/repository/Pembelajaran_Anderson.pdf

Collins. (2014). *Skills for the 21st Century: teaching higher-order thinking.* Retrieved from https://www.semanticscholar.org/paper/Skills-for-the-21st-...3026c72796603a3bf8f3197

Elby, A., Kuo, E., Gupta, A., & Hull, M.M. (2015). Tensions and Trade-offs in Instructional Goals for Physics Courses Aimed at Engineers, Paper presented at 2015 *ASEE Annual Conference & Exposition, Seattle, Washington. 10.18260/: 24836.* Retrieved from https://strategy.asee.org/tensions-and-trade-offs...engineers#

Heong, Y. M., Yunos, J. M., Othman, W., Hassan, R., Kiong, T. T., & Mohamad, M. M. (2012). The needs analysis of learning higher order thinking skills for generating ideas. UKM Teaching and Learning Congress 2011, *Procedia - Social and Behavioral Sciences 59 (2012) 197 – 203.* http://dx.doi.org/10.1016/j.sbspro.2012.09.265

Hyder, I., Bhamani, B. (2016). Bloom's Taxonomy (Cognitive Domain) in Higher Education Settings: Reflection Brief, *Journal of Education and Educational Development.* 3(2): 288-300. http://dx.doi.org/10.13140/RG.2.2.14634.62406

Malik, A., Setiawan, A., Suhandi, A. & Permanasari, A. (2017). Enhancing pre-service physics teachers' creative thinking skills through HOT lab design, *AIP Conference Proceedings* 1868 070001. Retrieved from https://aip.scitation.org/doi/abs/10.1063/1.4995177

Merta, D. K., Rosidin, U., Abdurrahman, A., & Suyatna, A. (2017). The Development of Higher Order Thinking Skill (Hots) Instrument Assessment In Physics Study. *IOSR, Journal of Research & Method in Education (IOSR-JRME)* 7: 26–32. http://dx.doi.org/10.9790/7388-0701052632

Michael J. R. (2018). Beyond 2020: ten questions for science education, *SSR: School Science Review.* September 2018,100(370): 47-52. Retrieved from https://www.researchgate.net/publication/328879343_Beyond_2020...education

Mısır, H. (2018). Digital literacies and interactive multimedia-enhanced tools for language teaching and learning. *International Online Journal of Education and Teaching (IOJET),* 5(3). 514-523. Retrieved from http://iojet.org/index.php/IOJET/article/view/178/250.

Mohamed, R., & Lebar, O. (2017). Authentic Assessment in Assessing Higher Order Thinking Skills. *International Journal of Academic Research in Business and Social Sciences,* 7(2): 466-476. Retrieved from https://www.semanticscholar.org/paper/Authentic-...ddcdd4067a7524aa5a

Ocy, D. R. (2021). Learning Design to Improve Higher Order Thinking Skills (HOTS), *Jurnal Riset Pendidikan Matematika Jakarta.* 3(2), 34-41. Retrieved from http://journal.unj.ac.id/unj/index.php/jrpmj/article/view/19983

Peppen, L. M. V., Verkoeijen, P. P. J. L., Heijltjes, A. E. G., Janssen, E.M., Gog, T. V. (2021). Enhancing students' critical thinking skills: is comparing correct and erroneous examples benefcial, *Instructional Science (2021)* 49:747–777. https://doi.org/10.1007/s11251-021-09559-0

Supeno, Astutik. S., Bektiarso, S., Lesmono, A. D. & Nuraini, L. (2019). What can students show about higher order thinking skills in physics learning? *IOP Conf. Ser.: Earth Environ. Sci.* 243 012127. https://doi.org/10.1088/1755-1315/243/1/012127

Trisnawaty, W. (2017). Analyze of Student's Higher Order Thinking Skills to Solve Physics Problem on Hooke's Law 6. *4th ICRIEMS Proceedings, Published by The Faculty of Mathematics and Natural Sciences, Yogyakarta State University: 91-95.* ISBN 978 602 74529 2J3.

Urgo, K., Arguello, J., & Capra, R. (2019). Anderson and Krathwohl's Two-Dimensional Taxonomy Applied to Task Creation and Learning Assessment. *ICTIR '19: Proceedings of the 2019 ACM SIGIR International Conference on Theory of Information*. 117-124. http://dx.doi.org/10.1145/3341981.3344226

Wulan, T., Alfina. C. M., Anas, T. (2017). Self Assessment For Student Performance Based on Higher Order Thinking Skills in Physics Learning. *Journal of Education and Learning*. 11(4): 446-452. https://doi.org/10.11591/edulearn.v11i4.6456