



Profile of High-Order Thinking Skills of Physics Teacher Prospective Students at the Cognitive Level of Evaluation and Creation

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ABSTRACT

High order thinking skills require not only the ability to remember, but also other higher abilities such as critical and creative thinking. These thinking skills are very important for teacher candidates to have as a provision for teaching in schools in the future. The research objective was to determine the profile of high order thinking skills of physics teacher prospective students at cognitive levels evaluation and creation. This research uses descriptive qualitative approach. The subjects of this study were 50 students of Physics Education Department UIN Ar-Raniry Banda Aceh who had programmed Basic Physics 1 course. Data was collected by giving written tests of description questions with evaluation and creation cognitive levels. The results of the data analysis showed that subjects had low high order thinking skills in solving evaluation questions and very low high order thinking skills in solving creation questions. At evaluation level, the subjects have not been able to apply a known concept to solve the problems. At creation level, the subjects have not been able to connect the problems in the questions with the physics concepts must be used. Therefore, students must be accustomed to giving high order thinking questions in the learning process in class. Lecturers must also use appropriate learning methods to improve students' high order thinking skills.

INTRODUCTION

The ability of students to master the field of study that is occupied needs to be measured periodically to obtain an overview of learning success and to provide feedback for lecturers. Actually, measuring student abilities during the learning process can be divided into three aspects, namely cognitive, affective, and psychomotor (Cahya, et al., 2022). The measurement of these three aspects is part of the lecture evaluation activities (Hadi, 2021). The cognitive aspect is the main aspect of many educational curricula related to thinking skills (Kunanti, 2020).

Evaluation in lectures can be carried out by utilizing various types of test instruments in the form of questions and non-test instruments in the form of observation sheets and questionnaires. The evaluation technique that is commonly used in measuring the achievement of mastery of lecture material, primarily in the cognitive domain, is the provision of test questions (Purwanti, 2020). According to the revised Bloom's Taxonomy, thinking skills in the cognitive domain are divided into six levels, namely C1 to C6. In learning, the levels of questions C4 (analysis), C5 (evaluation), and C6 (creation) are called HOTS (High Order Thinking Skills) levels which require high-order thinking

skills (Hartini, 2020). This thinking skill requires the ability to remember (Kok & Priemer, 2022) and other higher abilities, such as critical and creative thinking (Hadi, 2021).

As the name implies, higher-order thinking skills are the ability to think at a higher cognitive level than various cognitive methods and learning taxonomies. Individuals are required to understand and determine the solution to a problem with various methods from different perspectives (Kwangmuang, 2021). Higher-order thinking skills are created from developing previous concepts and methods (Hamzah, 2018), which include the ability to solve problems, think creatively, think critically, present arguments, and make decisions (Mello, 2021). In a broader definition, it can also be interpreted as the wider use of the mind in creating new challenges that require individuals to apply existing cognition (Nasir, 2020). There are three cognitive levels of high-order thinking skill (Shamboul, 2022), namely analysis (C4), which requires the ability to analyze or break down a problem, evaluation (C5), which relates to comparing, refuting, classifying, and making decisions, and creation (C6) that requires the emergence or construction of ideas or new ways (Saraswati, 2020).

Based on this explanation, it can be stated that in the context of an assessment, a HOTS instrument measures ability in terms of 1) transferring one concept to another, 2) processing and applying information, 3) looking for relationships from a variety of diverse information; 4) utilize information to solve problems; and 5) analyze information and ideas critically (Cahya, 2022). Nevertheless, HOTS questions are not always more complicated than questions of the remembering type (Pratiwi, 2020). HOTS questions have several characteristics, including using problems found in the surrounding environment (contextual), using different types of questions, using the principle of multi-representation, and some components that are analyzed, evaluated, and developed to create a stimulus (Listiani, 2020).

The character of this high-level type of question can encourage students to be skilled in the problem-solving process (Fong & Abu Bakar, 2023). HOTS-level questions can be found, for example, in computer-based written exam questions (UTBK) when someone wants to take part in the state university entrance selection or science olympiad, such as ON-MIPA PT, OSN Pertamina, and OASE. Higher-order thinking skills in students must continue to be developed, considering that students are already at a high level of formal operational intellectual development (Suhady, 2020). Students must also continue to be trained to solve problems that involve higher-order thinking skills (Balta & Asikainen, 2019), especially at the cognitive level of evaluation and creation (Ambarita, 2018).

The lecture process that is oriented towards mastering high-level skills is an important thing to do as one of the efforts to improve the quality of students as future teacher candidates, including physics teacher candidates (Jannah & Nasir, 2022). Student-teacher candidates must enhance their abilities and continue to practice with cases or problems that require high-level problem-solving abilities and skills (Ulfah, 2022). Such ability is essential in comprehensively describing and explaining scientific phenomena, including physics (Apata, 2022). The research objective was to determine the profile of prospective physics teacher students' high-level thinking skills at the cognitive evaluation (C5) and creation (C6) levels.

RESEARCH METHODS

Research Approach

The research is descriptive research with a qualitative approach.

Research Participants

The subjects of this research were 50 students of the Physics Education Department, Tarbiyah and teacher training faculty, Arraniry State Islamic University Banda Aceh, batch 2020 and 2021, who had taken the Basic Physics 1 course.

Research Instruments

The instrument used to collect research data was a written test in the form of description questions totaling 6 (six) items with C5 and C6 cognitive levels. In preparing the instrument, the test

items used refer to the teaching material for the Basic Physics 1 course, considering that good mastery in this course will determine the success of mastering the material in subsequent courses. The test items used refer to the RPS for the Basic Physics 1 course, which is as follows.

Table 1. Main material of basic physics course

Main material	Details
Measurement and scientific notation	Base and derived quantities, system of units, dimensions, scientific notation
Kinematics	Equation of motion, one and two-dimensional motion
Dynamics	Newton's laws of motion, motion, and force, rotational motion, inertia
Energy, work, impulse, and momentum	The work-energy relationship, the law of conservation of mechanical energy, the law of the conservation of momentum, collisions
Heat and fluids	Static fluids, dynamic fluids, Black's principle, heat transfer
Vibrations, waves, and sound	Harmonic vibrations, mechanical waves, sound, and sound intensity levels

Data Collection

Before being used, the test instrument will first be validated by three experts consisting of lecturers in the Basic Physics 1 course. The test were given to the subjects, and then the subjects were asked to fill out the answer sheets provided.

Data Analysis

In this study, the data analysis was carried out consisting of several stages as follows.

1. Check the answer sheets collected by the subjects and give a score for each item (maximum total score is 100 points).
2. Determine the category level of high-order thinking skills for each subject and the average thinking skills of all subjects with the following criteria (Purwanto, 2017).

Table 2. Level of high-order thinking skills categories

Score	Level	Code
<50	very low	VL
50-62	low	L
63-74	medium	M
75-86	High	H
87-100	very high	VH

3. Determine the average level category of high-order thinking skills for all subjects for each cognitive level achieved (evaluation and creation).
4. Calculate the percentage of subjects for the five assessment results of the level of thinking skills as in points 2 and 3.
5. Present the results obtained in point 4 in the form of tables and graphs and then analyze them and compare them with the results of related studies that have been conducted.

RESULTS AND DISCUSSION

Results

The results of the research that was conducted on prospective physics teacher students at the physics education department, FTK UIN Ar-Raniry Banda Aceh, were obtained by analyzing and adding up the scores obtained by each subject for the answers given to each test item. As explained above, the subject's ability to solve high-order thinking skills questions is grouped into five categories,

namely very low (VL), low (L), medium (M), high (H), and very high (VH) based on the total score obtained. Next, the average thinking skill level of all subjects and the average thinking skill category of all subjects will be determined for each cognitive evaluation and creation level. The recapitulation of students' thinking skills in solving test questions is presented in Table 3.

Table 3. The results of the subject's high order thinking skills

Statistic	Results
Ideal score	100
Highest score	89
Lowest score	15
Average	54,28
Standard deviation	16,78

The data in Table 3 above shows that the average value obtained by the subject is 54.28, with a standard deviation of 16.78. This indicates that overall, the high-level thinking skills of physics teachers in solving Basic Physics 1 questions are low. The highest score obtained by the subject was 89, while the lowest score was 15.

Prospective physics teacher students' ability to solve HOTS questions was analyzed at each evaluation and creation cognitive level. Students' thinking skills expressed in this percentage are obtained by dividing the subjects in each group category for each cognitive level by the total number of subjects taking the test and then multiplying by 100%. The step taken is to add up the scores of all subjects at each cognitive level and then divide by the maximum score obtained at each cognitive level and multiply by 100. The results obtained for the category of high-order thinking skills of the subjects at the evaluation level are presented in Figure 1 below.

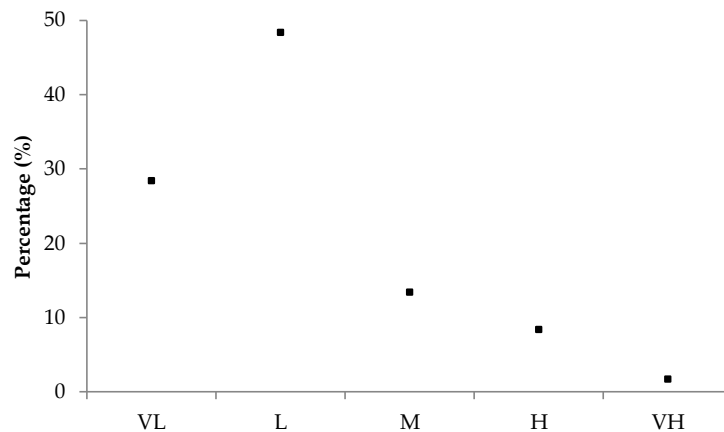


Figure 1. Category of subjects' high-order thinking skills at the evaluation level

Based on the graph above, it can be stated that at the evaluation level, most of the subjects' high-level thinking skills were in a low category, namely 48.33% of students, followed by a very low level of 28.33% of students, furthermore, 13.33% of students at the moderate level and 8.33% of students at the high level. From the picture above, it can also be seen that 1.67% of students have very high skills in solving evaluation-level questions. The following is an example of a subject answer sheet for this type of question. The student has low high-order thinking skills in solving evaluation questions. The student's ability to evaluate physics problems is relatively low,, which can be seen from his inability to answer the problems about the moment of inertia and converting mph to km/h.

4	Tiga buah benda yang terdiri dari silinder pejal, bola pejal dan bola berongga berada pada puncak suatu bidang miring dengan sudut θ dan ketinggian h . Ketiga benda ini dilepaskan dalam waktu yang bersamaan sehingga menggelinding tanpa slip. Urutkanlah benda dari yang paling cepat hingga paling lama tiba di dasar bidang miring. Jelaskan jawaban anda!	Tiga buah benda yang terdiri dari Silinder Pejal, bola pejal dan bola berongga yang akan paling cepat menggelinding adalah bola pejal. Karena bola tersebut memiliki momentum yang begitu besar dan kemudian disusul bola pejal karena memiliki momentum lebih kecil dibandingkan bola berongga. Pejal kemudian yang terakhir adalah silinder pejal karena benda itu tidak memiliki permukaan yang sama dengan bola pejal dan bola berongga.
No	Soal	Jawaban
1	Batas kecepatan maksimum kendaraan yang diizinkan di jalan raya antar kota di Britania Raya adalah 70 Mph (mil per jam) dan di area pemukiman umumnya 30 Mph. Sementara itu, batas kecepatan maksimum kendaraan di jalan raya antar kota di Indonesia umumnya 80 km/jam dan di kawasan pemukiman sebesar 30 km/jam. Suatu ketika seorang turis asal Britania Raya memacu sebuah mobil di Kota Bandung dengan kecepatan 34 m/s saat melewati rambu bertuliskan batas kecepatan maksimum 80 km/jam. Sementara itu, seorang warga Bandung memacu mobilnya di Kota Bandung dengan kecepatan 22 m/s saat melewati rambu yang sama. Apakah turis ini melanggar batas kecepatan maksimum yang diizinkan di negaranya? Apakah warga Bandung ini melanggar batas kecepatan maksimum yang diizinkan?	Warga Bandung tidak melanggar krn : → Batas kecepatan di rambu = 80 km/jam = 22,2 m/s → Kecepatan warga = 22 m/s $\frac{80 \text{ km}}{\text{jam}} = \frac{80.000 \text{ m}}{3600 \text{ s}} = 22,2 \text{ m/s}$ Turis juga melanggar krn : → Batas kecepatan di Britania = $\frac{70 \text{ mil}}{\text{jam}} = \frac{70.1609 \text{ m}}{3600 \text{ s}} = 31,293 \text{ m/s}$ → Kecepatan turis = 34 m/s

Figure 2. Examples of subject answer sheets on evaluation questions

Then, the results obtained for the subject's high-order thinking skills category at the creation level are presented in Figure 3 below.

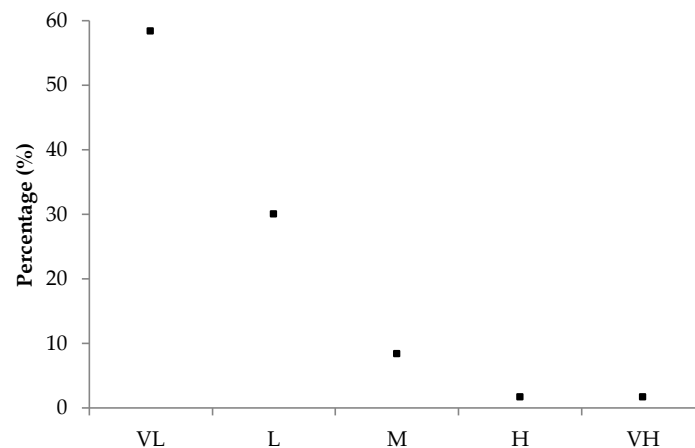


Figure 3. Category of subjects' high-order thinking skills at the creation level

Based on the graph above, it can be stated that at the creation level, most of the subjects' high-level thinking skills were in the very low category, namely 58.33% or more than half of the total subjects, followed by a low level of 30% of students. Furthermore, there were 8.33% of students at the moderate level and 1.67% of students at the high level. From the picture above, it can also be seen that 1.67% of students have very high skills in solving creation-level questions. The following is an example of a subject answer sheet for this type of question. The student has a very low level of high-order thinking skills in solving creation questions. The student's ability to create a new formula in solving physics problems is relatively very low, which can be seen from his inability to present the correct answer to the problems about Newton's laws of motion and transverse waves.

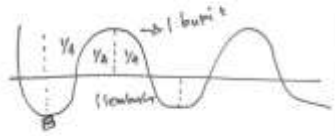
3	Dua balok masing-masing bermassa m dihubungkan dengan seutas tali dan ditempatkan pada bidang miring licin menggunakan sebuah katrol. Jika massa tali dan katrol diabaikan dan sistem bergerak ke kanan, rumuskanlah persamaan untuk menentukan besar tegangan tali pada sistem! 	Tegangan benda ke kanan $\Sigma F = ma$ $T - W \sin \theta_2 = ma$ $T = m a + W \sin \theta_2 \dots (1)$ Tegangan benda ke kiri $\Sigma F = ma$ $W \sin \theta_1 - T = m a$ $T = W \sin \theta_1 - m a \dots (2)$
9	Dua benda A dan B berjarak 15 cm bergerak naik turun bersama permukaan air laut. Benda A berada di puncak dan benda B di dasar gelombang, di antara keduanya terdapat satu bukit dan satu lembah. Bila cepat rambat gelombang 60 cm/s dan amplitudonya 5 cm, buatlah persamaan umum gelombang pada peristiwa ini! 	Dik: 15 cm $v = 60 \text{ cm/s}$ 15 cm $f = ?$ $x = 15 \text{ cm}$ $x = \frac{5}{4} \lambda$ $15 = 2 \lambda$ $\lambda = 7.5$ $v = \lambda \cdot f$ $60 = 7.5 \cdot f$ $f = 8$

Figure 4. Examples of subject answer sheets on creation question

Discussion

The study results show that the subjects have low-level high-order thinking skills on evaluation-level questions and very low high-order thinking skills on creation-level questions. In the evaluation cognitive level, most subjects have difficulty understanding the questions and determining what quantities to look for. In addition, the subjects have not been able to apply a known concept to solve the problems. The subjects' ability to carry out evaluation cognitive level is low, so they have not completed. In the creation cognitive level, most subjects experience difficulties in determining and combining what equations should be used to solve problems. In addition, the subjects have been unable to connect the problems in the questions with the physics concepts that must be used. The subjects' ability in creation cognitive level is very low, so they did not successfully solve the type of creation problem properly.

It is not much different from the results obtained by Retta (2021) that the ability of PGRI Palembang University students to solve HOTS questions shows a high category for the level of analysis and evaluation. However, students still have a very low ability to solve creative-level questions. Pratiwi (2020) also obtained results that the ability of Yogyakarta Sanata Dharma University students to solve HOTS questions at the creative level was still lacking. Out of all the students, only two have achieved the problem indicator: modeling a contextual problem as a mathematical sentence and planning a solution. Kwangmuang (2021) also researched students' competency in Thailand and found that students were quite good at working on HOTS questions at level evaluation but still not good at the creation level.

Based on the results in Figures 1 and 3 above, it can be stated that at the cognitive evaluation level, students have better higher-order thinking skills than those at the creation cognitive level. The study results also show that, on average, these Physics teacher candidates have not been able to solve problems with more complex characteristics. These results align with research conducted by Murtafiah (2022) that students are not used to thinking critically to generate new ideas, causing them to experience problems in solving complex and complex problems. Listiani (2020) also found that the students who are aspiring teachers were able to arrange the framework of the HOTS test items while taking analyzing) and evaluating into consideration, but they struggled to create HOTS test items and

could only reach a score of 33%. Fong & Abu Bakar (2023) stated that students' cognitive ability. There is another view that students with high thinking ability can perceive creative aspects, while students with moderate thinking ability can perceive creative aspects and express their opinions. On the other hand, students with low thinking ability are not aware of the creative and concluding aspects.

Overall, students still face many difficulties in solving evaluation and creation-level questions related to physics material. They tend not to be able to properly resolve problems to the final stage. The findings show similar results from Balta (2019) that most students have difficulty solving questions with a high level of difficulty and require critical and analytical thinking skills. Suwonjandee (2018) also found that almost 20% of students believe that difficulty in learning physics is due to illiteracy of physics concepts and 40% of students thought that they are not good in mathematics and critical thinking.

Critical thinking is used in mental activities such as analyzing assumptions, solving problems, persuading, and making good decisions (Zuniari, 2023). Therefore, students must be encouraged to study questions that stimulate higher-order thinking skills to get used to critical thinking. Critical and creative thinking skills will provide opportunities for students to increase understanding through observation, and experiments in the laboratory and encourage the development of scientific concepts by connecting the knowledge gained with reality in everyday life (Murtafiah, 2022). The student's problem-solving ability is the major target of an educational institution (Halim, 2021). Therefore, students must be accustomed to giving higher-order thinking questions in the learning process in class. Lecturers must be creative in adapting learning to the demands of the 21st century, one of them is to master scientific process skills. Lecturers must also use appropriate learning methods to improve students' higher-order thinking skills (Sari, 2023). In addition, these higher-order thinking skills must be well owned by prospective teacher students so that they can fully understand mathematical concepts and can later guide their students in developing thinking skills and solving problems they face (Retta, 2021). These prospective teacher students are also expected to be able to tutor students in dealing with the minimum competency assessment (Suwonjandee, 2018). This is because questions that require higher-order thinking skills are a form of questions that will be tested in the minimum competency assessment.

CONCLUSION

Based on the research data analysis, it can be concluded that prospective physics teacher students have low high-order thinking skills in solving evaluation-level questions and very low high-order thinking skills in solving creative-level questions. Most subjects have difficulty understanding the questions and determining what quantities to look for in the evaluation level. The subjects have not been able to apply a known concept to solve the problems. At the creation level, most subjects experience difficulties in determining and combining what equations should be used to solve problems. The subjects have been unable to connect the problems in the questions with the physics concepts that must be used. Therefore, students must be accustomed to giving high-order thinking questions in the learning process in class. Lecturers must also use appropriate learning methods to improve students' high-order thinking skills. Further readers and researchers are advised to develop research results by involving more research subjects between classes at the same university and between universities with Physics Education Department students.

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