

High School Physics Assessments in Bontang City: Fostering Higher-Order Thinking

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Abstract. This research aims to determine the percentage of HOTS-level physics questions and the cognitive level and dimensions of knowledge of HOTS-level physics questions on the class X SMAN/MAN summative exam in Bontang. These questions were analysed based on Bloom's revised taxonomy: cognitive level and knowledge dimensions. The type of research used in this research is descriptive research with a quantitative approach. The subject of this research was four schools in Bontang city, including high schools A, B, C, and D. Data collection techniques use documentation techniques. The results of the research show that the percentage of HOTS-level physics questions is 12.2%, with the percentage of each question code being 5% for question code A, 15% for question code B, 20% for question code C, and 16% for question code D for cognitive level C4. In contrast, cognitive levels C5 and C6 are not found in the summative exam question document. The cognitive level in the summative exam questions includes C1 to C4 and factual, conceptual and procedural knowledge dimensions. The knowledge dimension in the HOTS level question is dominated by the procedural knowledge dimension, while there is only one question in the conceptual knowledge dimension. Future physics should consider the balance of cognitive level and dimension in school assessment.

Keywords: Bloom's taxonomy revised; HOTS problems; summative examination

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INTRODUCTION

21st-century education requires students to have higher-order thinking skills (HOTS) in order to be able to solve problems related to science in everyday life (Fahreza et al., 2018). The Directorate of High School Development, Ministry of Culture and Education (2019) stated that the government expects students to achieve various competencies by implementing HOTS. These competencies are critical thinking, creativity and innovation, communication, collaboration, and self-confidence. According to the Australian

Council for Educational Research (ACER), higher-level thinking skills are the ability to analyse, reflect, provide arguments, apply concepts, organise and create. HOTS is closely related to contextual problems, namely problems in everyday life, experiments, applications, communication and transfer (Widana, 2017).

Concerning this high level of thinking ability, the facts show that based on the results of the Trend International Mathematics and Science Study (TIMSS) in 2015, physics achievement in Indonesia was ranked 50th out of 53

countries, while the program for International Student Assessment (PISA) reported by the Organization for Economic Co-operation and Development (OECD) in 2018 was at level 73 out of 78 countries (Lestari, 2021). These results are caused by many factors, including students not being used to facing various TIMSS and PISA model questions that involve Higher Order Thinking Skills (HOTS) such as reasoning, logic and creativity (Anggraeni et al., 2023).

The teacher's role is very important in making students have high-level thinking abilities, including providing application questions in everyday life. However, the reality in the field is based on research conducted by Ikhsan et al. (2019). Of the 25 questions tested, only five questions were HOTS questions. Then, the results of the question item review carried out by the Directorate of High School Development during USBN assistance for the 2018/2019 academic year on 26 subjects in 136 reference high schools showed that most of the 1779 questions analysed were at levels C1 and C2. Only 27 schools compiled HOTS questions, as much as 20% of all USBN questions created, 84 schools compiled HOTS questions below 20%, and 25 students stated that they did not know whether the questions they prepared included HOTS questions. This is not in accordance with the demands of the 2013 curriculum assessment, which further increases the implementation of the HOTS assessment model.

Based on observations made at SMAN/MAN in Bontang, the questions tested in the summative exam contained questions the teacher had not analysed. Therefore, researchers analysed the questions by categorising them based on Bloom's revised taxonomy: cognitive level and knowledge dimensions. This research aims to determine the percentage of HOTS-level physics questions and the cognitive level and

dimensions of knowledge of physics questions in the class X SMAN/MAN summative exam in Bontang.

METHOD

The type of research used is descriptive research with a quantitative approach. Descriptive research aims to describe the cognitive level and dimensions of knowledge of HOTS-level questions with a quantitative approach to determine the percentage of HOTS-level questions on the summative exam in the city of Bontang. The research subjects consisted of four schools: SMA A, B, C, and D.

Data was collected using a question analysis sheet instrument containing a table with columns of numbers, questions, answer keywords, cognitive level and dimensions of knowledge (Qadar, 2023). The data collection technique uses documentation by collecting summative exam questions for the odd semester of class X 2021/2022 academic year from several SMAN/MAN in the city of Bontang. In this research, the question data were analysed by categorising questions based on the revised Bloom's taxonomy, taking into account cognitive levels (C1, C2, C3, C4, C5, and C6) and knowledge dimensions (factual, conceptual, procedural, and metacognitive). Then, the results from these categories are calculated to determine the percentage using a formula (Erniyanti et al., 2020):

$$Pi = \frac{Ni}{N} \times 100\% \quad \dots (1)$$

With:

Pi = percentage of the number of questions

Ni= number of questions

N= total questions

RESULT AND DISCUSSION

The researchers used summative exam question documents for Bloom's revised taxonomy, namely the level of cognitive processes and dimensions of knowledge.

Table 1 Analysis results on all summative exam questions

Level	Factual	Conceptual	Procedural	Metacognitive	Percentage
C1	-	8.7%	-	-	8.7%
C2	0.9%	16.5%	2.6%	-	20%
C3	2.6%	5.2%	51.3%	-	59.1%
C4	-	0.9%	11.3%	-	12.2%
C5	-	-	-	-	-
C6	-	-	-	-	-
Percentage	3.5%	31.3%	65.2%	-	100%

Table 1 shows that the summative exam questions in Bontang are dominated by cognitive level C3 and procedural dimensions, with percentages of 59.1% and 65.2%, respectively. Meanwhile, the C1 cognitive level questions and the factual dimension have the smallest percentage categories, namely 8.7% and 3.5%, respectively.

HOTS questions consist of a cognitive analysis process, evaluation,

and creation. The analysis process is a process that describes students' ability to decompose data into other data based on scientific principles (Setiyoaji et al., 2020). The analysis level categories consist of differentiating, organising, and attributing. The following are questions that fall into the analysis category with procedural dimensions from question codes A and C:

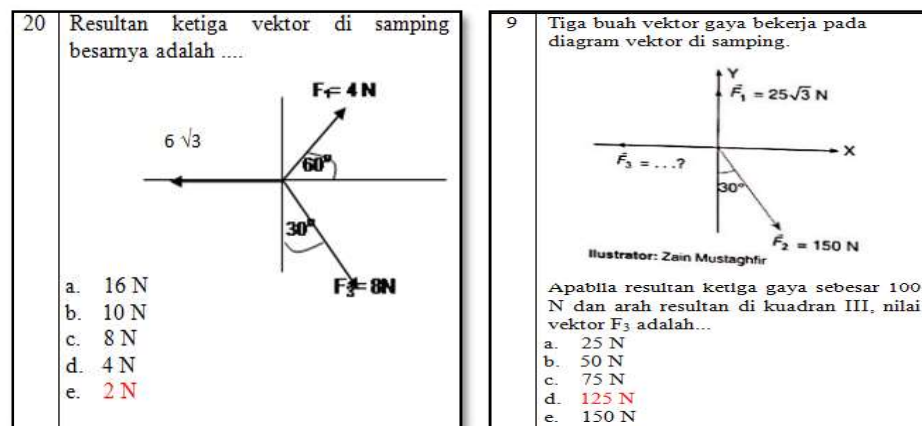


Figure 1. C4-Procedural category questions from question code A and C

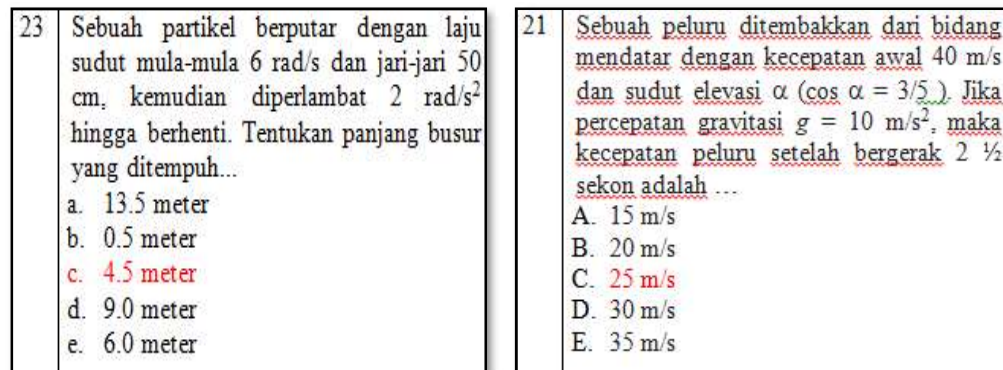


Figure 2. C4-Procedural category questions in question codes B and D

Figure 1, number 20, is a question in question code A. Students are expected to

be able to analyse the vectors that act on these three forces. Then, the vector

formula is applied so that a procedural dimension is needed in steps using an algorithm to obtain the result of the three vectors. Question number 9 is a question in question code C. In this question, students are expected to analyse each vector acting on the three forces until the resultant vector is obtained using vector rules. Then, use procedural dimensions as steps with vector formulas to find vector values.

The question in Figure 2 number 23 is in question code B about circular motion. Students are expected to be able to analyse circular motion by connecting the components, namely angular speed, circle radius, and deceleration. Then, organise these components using a procedural dimension in the form of steps using a circular motion formula to obtain the answer to the problem.

Figure 2, number 21, is a question in question code D about parabolic motion. Students are expected to be able to analyse parabolic motion at the speed of a bullet after moving for a time interval by connecting the components of parabolic motion, such as the initial speed at the bullet is fired, the elevation angle at which the bullet is fired, and the acceleration due to gravity. Steps are needed by applying the parabolic motion formula to obtain the speed of the bullet after a certain time interval.

10	Lima buah roda (A,B,C,D, dan E) diputar dengan kecepatan sudut yang sama. Jika kelima roda tersebut digelindingkan secara bersamaan, roda-roda berikut yang paling cepat melaju adalah...		
		Roda	Jari-jari (cm)
a	A		50
b	B		40
c	C		30
d	D		20
e	E		10

Figure 3 C4-Conceptual category questions in question code C

Based on Figure 3, students are expected to be able to analyse circular motion. The concept of circular motion relates linear speed, angular velocity, and circle radius. From this concept, linear speed is directly proportional to the angular speed and radius of the circle, so the circle with the largest radius has the fastest speed.

Percentage of HOTS-level Physics Questions

The percentage results of HOTS level summative exam questions in the city of Bontang based on Table 1 are 12.2% for cognitive level C4. Considering the importance of having HOTS-level questions available in summative exams, students have good thinking skills in education. They can provide solutions or solve problems they encounter in everyday life (Oktarina & Armariena, 2020).

The HOTS level percentage for cognitive levels C5 and C6 is 0%, due to the use of summative exam questions in multiple-choice form. Multiple-choice questions do not have C5 and C6 cognitive levels because C5 and C6 cognitive levels are not suitable for multiple-choice questions because they are more suitable for essay questions (Anita et al., 2018). According to Anderson (2001), the C6 level has three phases which students are required to formulate, plan and produce; this phase is at the student commanding stage, whereas the summative exam questions it is only at the asking stage, where the questioning stage is presented in the form of multiple choice questions so that no C6 level questions are found in the summative exam questions.

The knowledge dimensions in HOTS-level questions are conceptual and procedural knowledge, as in the example of questions with the C4-conceptual category, which can be seen in Figure 3 and C4-procedural in Figures 1 and 2. Meanwhile, factual knowledge

and metacognitive knowledge are not found in HOTS-level questions. Factual knowledge is the lowest level in Bloom's revised taxonomy, which includes the basic elements (definitions, labels, symbols, notations, or symbols) that students must know when studying scientific disciplines. Factual knowledge cannot be part of HOTS because this knowledge does not allow for more complex thought processes (analysing, evaluating, creating) and is only rote (Jailani et al., 2018).

The percentage results for each question code show that C3 category questions are more dominant than the other categories. This can be seen in the percentage value for category C3, which is more than 50%. In line with research conducted by Aflah & Sunarti (2022), the physics subject exam questions have accommodated HOTS level questions with a smaller percentage than the percentage of LOTS level questions, and no questions in the C6 category were found.

Cognitive Levels and Knowledge Dimensions

The distribution of cognitive levels and dimensions of knowledge in summative exam questions in the city of Bontang is uneven because there are no C5 and C6 cognitive level questions or metacognitive knowledge in all question codes. This is in accordance with the statement by the Organization for Economic Co-Operation and Development (2015); data from PISA shows that questions made in Indonesia at levels C5 and C6 are 0%. Remembering the importance of having HOTS questions available for students because HOTS questions are able to hone students' ability to think more complexly. Questions that do not emphasise high-level thinking skills will produce questions that only present facts, knowledge and laws without any skill in relating the concepts learned to everyday

life. This can cause students to have difficulty applying the knowledge they have in real life (Pantiwati & Permana, 2017).

Based on observations that have been made, there are questions tested in the summative exam that have not been analysed by the teacher. Thus, the questions are more dominant in C3-procedural questions, which emphasise applying formulas. Then, C2-conceptual questions which emphasise understanding concepts. This is in accordance with research by Umacina et al. (2020) that implementing final semester exams in physics subjects in schools only prepares questions without analysing and studying in more depth about a test that meets the requirements to be used as a standard. Then, research conducted by Andriani et al. (2020) showed that the results of an interview with one of the teachers in Palu stated that they did not make HOTS criteria essay questions because they had limited time to complete them.

In Bloom's revised taxonomy, metacognitive knowledge is the knowledge that is higher than the other three knowledge because metacognitive knowledge allows students to know different strategies for learning, thinking, and solving problems using their knowledge and knowing strengths and weaknesses can adjust their cognition (Fatmawati, 2013). Procedural knowledge is the most dominant knowledge found in summative exam questions because it includes the application of a procedure or formula to obtain the right answer. The factual knowledge dimension is the least available in Bontang's summative exam questions. The metacognitive dimension of knowledge is the most complex (Pertiwi, 2021). So, this dimension is not found in Bontang's summative exam questions.

The explanation above shows that the cognitive level in the summative

exam questions in Bontang is at levels C1 to C4, and there are dimensions of factual, conceptual and procedural knowledge. However, no C5 and C6 cognitive levels and metacognitive knowledge dimensions exist. C3 dominates the cognitive level and knowledge dimensions with procedural knowledge. This can be seen in the categorisation of each question code, where the percentage of the C3-procedural category is greater than that of the factual and conceptual knowledge dimensions.

CONCLUSION

This research used summative exam question documents for class. 1. The percentage of HOTS-level physics questions at cognitive level C4 is 12.2%, while cognitive levels C5 and C6 are 0%. 2. There are cognitive levels C1 to C4. The knowledge dimension categories are factual, conceptual and procedural knowledge dimensions. However, there were no questions with cognitive levels C5 and C6 in the summative exam questions in the city of Bontang. The knowledge dimension in HOTS-level questions is dominated by the procedural dimension, while there is only one question in the conceptual dimension.

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