Higher order thinking skills students in mathematical statistics course base on revised bloom taxonomy in factual and conceptual knowledge dimension

A Rahayu*, A Syah, and A Najib

Department of Mathematics Education, Faculty of Teaching and Learning, Universitas Al Asyariah Mandar, Indonesia

*Corresponding author: ayurahayu_makmur@mail.unasman.ac.id

Abstract. The purpose of this study was to identify Higher Order Thinking Skills (HOTS) in mathematics education study program students in the Mathematical statistics course. HOTS in this study is based on the Revised Bloom Taxonomy which includes analyzing, evaluating and creating, especially in the dimensions of factual knowledge and conceptual knowledge. This research is a qualitative descriptive study. The research subjects were 35 students of the fourth semester mathematics education study program of Al Asyariah Mandar University. The data collection techniques such as essay test and each of which consisted of 3 items of dimension of procedural knowledge and conceptual knowledge, which was C4 (analyzing), C5 (evaluating), C6 (creative) level. HOTS data were obtained from test answers given to students and then analyzed descriptively. HOTS criteria include low, medium, and high. The results of the research on the factual knowledge dimension with a C4 level (analyzing) of 6.7 (medium), a C5 level (evaluating) of 4.6 (low), and a C6 level (creating) of 4.3 (low). Whereas in the conceptual knowledge dimension with a C4 level (analyzing) of 6.9 (medium), a C5 level (evaluating) of 4.7 (low), and a C6 level (creating) of 4.1 (low). In general, students' HOTS are in low criteria.

1. Introduction

In the process of increasing human resources, education plays a very important role. The world of education must be able to produce human resources with competencies that are able to compete in the global era. Competencies that must be possessed are humans who have high character and intellectuality, namely having cognitive abilities and thinking patterns so that they are able to solve problems. Therefore, in the learning process both at the high school and college levels, the cognitive abilities of students must always be trained

According to [1,2] cognitive abilities based on the revised bloom taxonomy are divided into four dimensions of knowledge, namely the dimensions of factual, conceptual, procedural, and metacognitive knowledge. Each dimension of knowledge has a cognitive process dimension starting from C1 (remember), C2 (Understanding), C3 (Apply), C4 (Analyze), C5 (Evaluate) and C6 (Create). Cognitive processes at levels C1 to C3 are referred to as lower order thinking skills, while at levels C4, C5, and C6 are called higher order thinking skills (HOTS). One of the main focuses on cognitive abilities in the era of the industrial revolution 4.0 in achieving learning goals is Higher Order Thinking Skills (HOTS)[3–5] . HOTS is very important to be integrated for each subject either exact or non-exact [6–8].

HOTS emphasizes the skills to develop the thinking capacity of students to build existing knowledge, be able to solve problems, and be able to find new things in real life. HOTS is based on low level thinking skills (LOTS) such as remembering, understanding, and applying as well as cognitive strategies that relate to prior knowledge of the subject matter content. HOTS includes critical thinking and creative thinking [9,10]. The learning process by developing students' thinking skills can increase Low Order Thinking Skills to Higher Order Thinking Skills. In its application, HOTS requires repeated thinking activities.

HOTS is a student thinking activity that involves a high level cognitive level from Bloom's taxonomy of thinking which includes analyzing, evaluating, and creating [11–13]. HOTS activities help skilled students find knowledge in inductive and deductive reasoning to think about answers or identify and explore scientific examinations of existing facts. Table 1 describes HOTS in the learning to be achieved and the operational verbs used in learning.

Table 1. HOTS levels and operational verb.

HOTS Levels	Operational Verbs
Analyzing: Breaking matter down into its constituent parts and determining the relationships between the parts and the overall structure or purpose	Distinguishing, organizing, sorting, selecting, focusing, integrating, structuring, deconstructing,
Evaluating: Making decisions based on criteria or standards	Checking, criticizing, correcting, detecting, monitoring, testing, assessing
Create: Combining parts to form something new	Formulate, plan, hypothesize, design, construct, produce

The implementation of thinking activities in Table 1 can occur when teachers are creative in designing classroom learning activities that allow students to be able to explore their thinking skills so that they can hone their cognitive, affective, and psychomotor aspects. This process maximizes students actively in learning.

One of the taxonomies known in education is Bloom. The Bloom Taxonomy function is a framework for achieving teacher learning objectives in analyzing subjects and learning the dimensions of knowledge and dimensions of cognitive processes to be achieved by students. [14] stated that included in the HOTS category are (C4) analyzing, (C5) evaluating, and (C6) creating, as shown in Figure 1.
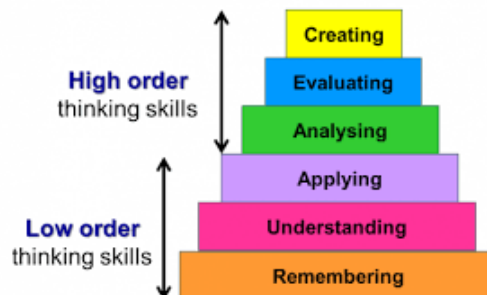

Figure 1. Levels of thinking revised Bloom's taxonomy.

Bloom's level of taxonomic thinking moves from things that are concrete to abstract and things that are simple to things that are more complex. Therefore, to achieve the goals in the taxonomy, it is necessary to link concrete and simple things around the students' environment. To achieve that, it is

necessary to have a dimension of knowledge and cognitive processes. The dimension of knowledge includes conceptual, factual, procedural, and metacognitive knowledge. Meanwhile, the cognitive process dimension includes remembering, understanding, applying, analyzing, evaluating, and creating.

Understanding the realm of cognitive analysis includes the skills to distinguish or break a unit into parts and determine how these parts are connected to one another. Evaluation relates to the skills to form an opinion about something or several things along with the accountability of that opinion based on certain criteria by giving judgments. Creating is defined as generalizing a new idea, product or new way of thinking of an event [14]. The creation process is generally related to students' previous learning experiences.

In Table 2, the Revised Bloom's educational taxonomy relates the dimensions of knowledge and dimensions of cognitive processes in learning.

Table 2. The knowledge and cognitive process dimensions.

Knowledge Dimension	Cognitive Process Dimensions					
	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual						
Procedural						
Metacognitive						

The relationship between the two dimensions in the table above is that the achievement of students' cognitive process thinking skills can be formed when the teacher conducts learning by linking material accompanied by facts, concepts, and through direct observation to the field, student activity sheets or other learning media such as pictures and videos. HOTS can be increased regularly when the teacher carries out learning activities that train students to analyze, evaluate, and create in the learning process. In the end HOTS makes it easier for students to remember, understand, and apply in learning. [12] In this study, HOTS refers to students' skills in producing various alternative answers by distinguishing between different concepts, giving statements by providing logical reasons, and answering with a new perspective of the learning process that students. Based on this description, the research conducted a study covering the HOTS of students at levels C4, C5, dan C6 Revision of Bloom's Taxonomy on the dimensions of factual and conceptual knowledge. The purpose of this research is to describe students' higher order thinking skills.

2. Methods

This study used a survey method with qualitative research type and data analysis was carried out descriptively. This research was conducted in the fourth semester of mathematics education study program at Al Asyariah Mandar University in mathematics statistics subject I. The number of respondents was 35 students. The instrument used to measure students' HOTS level by giving a test in the form of an essay consisting of several questions C4, C5, and C6 which belonged to the dimensions of factual and conceptual knowledge, as shown in Table 3. The HOTS problem is based on the revised Bloom's Taxonomy covering the cognitive domains of analyzing, evaluating, and creating.

The HOTS score of each student is the number of scores obtained in accordance with the number of overall scores that appear when solving the test questions. The maximum score is the highest score (score 3) multiplied by the number of questions (6 items). The maximum score is 18, while the minimum score is 0. The researcher divided the intervals into 3 intervals with ranges of 6 with the criteria in Table 4.

Table 3. HOTS criteria.

Cognitive Process	Operational Indicators	Score
Analyze	Students correctly distinguish among different concepts	3
	Students are less precise in distinguishing among different concepts	2
	Students do not correctly differentiate among different concepts	1
	Students did not answer	0
Evaluate	Students correctly provide statements by providing logical reasons	3
	Students are less precise in giving statements by giving logical reasons	2
	Students do not correctly give statements by giving logical reasons	1
	Students did not answer	0
Create	Students answer correctly by creating/developing new perspectives	3
	Students are less precise answer correctly by creating/developing new perspectives	2
	Students do not answer correctly by creating/developing new points of view	1
	Students did not answer	0

The learning outcomes instrument before being used in collecting research data, first conducted trials to determine the validity of the instrument items. This test method is used to determine students' cognitive abilities. Testing the validity of each item using Pearson correlation coefficient test. In addition, construct validation was carried out and test using expert judgment. The result of the validation process states that the instrument is declared valid.

Table 4. HOTS criteria for HOTS level category.

$Score_{HOTS}$	Criteria
$0.00 \leq N_{HOTS} \leq 6.00$	Low
$6.00 < N_{HOTS} \leq 12.00$	Medium
$12.00 < N_{HOTS} \leq 18.00$	High

3. Results and Discussion

Higher order thinking skills (HOTS) in this study were assessed based on a learning outcome test which included process and product skills. The test scores of student learning outcomes are used to determine students' higher order thinking skills because the tests given are included in the cognitive domains of C4 (analyzing), C5 (evaluation), C6 (creating) which aims to train higher order thinking skills.

The results of this study were based on the students' test results by giving 6 essay questions with each dimension of the HOTS cognitive process consisting of 2 questions with 1 question each on the dimensions of factual and conceptual knowledge. The student skill level based on HOTS criteria can be seen in Table 5 and Table 6.

Table 5. Results of the learning outcomes test of factual knowledge dimensions.

$Score_{HOTS}$	Criteria	Percentage of Students					
		Analyze	%	Evaluate	%	Create	%
$0.00 \leq N_{HOTS} \leq 6.00$	Low	20	57.14	27	77.14	30	85.71

$6.00 < N_{HOTS} \leq 12.00$	Medium	15	42.86	8	22.86	5	14.29
$12.00 < N_{HOTS} \leq 18.00$	High	0	0.00	0	0.00	0	0.00

Table 6. Results of the learning outcomes test of conceptual knowledge dimensions.

Scorei_HOTS	Criteria	Percentage of Students					
		Analyze	%	Evaluate	%	Create	%
$0.00 \leq N_{HOTS} \leq 6.00$	Low	19	54.28	25	71.42	29	82.85
$6.00 < N_{HOTS} \leq 12.00$	Medium	16	45.71	10	28.57	6	17.14
$12.00 < N_{HOTS} \leq 18.00$	High	0	0.00	0	0.00	0	0.00

The following is a description of Table 7, the average value of each dimension of cognitive processing is converted to the HOTS level criteria.

Table 7. Mean of HOTS cognitive domains factual knowledge dimensions.

Cognitive Process	Mean	HOTS Criteria
Analyze	6.70	Medium
Evaluate	4.60	Low
Create	4.30	low
Mean	5.20	low

The overall average HOTS score of the students is described by referring to the scoring assessment in Table 4. The students' answers to the cognitive processing questions (C4) analyzed obtained an average conversion result of 6.70 with moderate criteria. Whereas the value on the cognitive process of C5 (evaluating) obtained an average conversion result of 4.60 with low criteria and C6 (Creating) an average conversion result of 4.30 with low criteria.

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Table 8. Mean of HOTS cognitive domains conceptual knowledge dimensions.

Cognitive Process	Mean	HOTS Criteria
Analyze	6.90	Medium
Evaluate	4.70	Low
Create	4.10	Low
Mean	5.23	Low

The overall average HOTS score of students is described by referring to the scoring assessment in Table 4. Students' answers to the cognitive process questions (C4) analyzed obtained an average conversion result of 6.90 with moderate criteria. Whereas the value on the cognitive process of C5 (evaluating) obtained an average conversion result of 4.70 with low criteria and C6 (Creating) an average conversion result of 4.10 with low criteria.

The results of the research analysis in Table 5 and Table 6 show that all students are not yet skilled in solving questions with more complex thinking characteristics. This indicates that students are not yet skilled in analyzing, evaluating, and creating answers needed by questions. Therefore, it is necessary to have a strategy in the learning process that stimulates students' repeated thinking activities such as problem solving learning, assignments, inquiry learning, cooperative learning and so on [15]. Students

should be encouraged to develop individual skills to think about answers or to indicate and explore scientific examinations of facts.

Students' understanding in answering the questions is still low, this proves that the lack of students producing new ideas in the form of answers to the questions given. [16] states that students have not had skilled in solving mathematical problems with more complex characteristics (high criteria). The difficulty of generating ideas is a key factor in influencing student achievement. Thus, students need to learn higher thinking skills (HOTS) to overcome difficulties in generating ideas. HOTS can be increased regularly when learning activities involve complex cognitive domains such as analyzing, evaluating, and creating [16].

The results of the above research indicate the importance of linking the knowledge to be achieved with the conditions and facts that exist in the environment around students. [8,17] stated that the strategy of educators and the learning environment plays a strong role in shaping students' thinking skills. An effective strategy will stimulate students to be able to analyze, interpret, respond, evaluate, and create [4].

4. Conclusion

The results of research and discussion can be concluded that in general HOTS fourth semester students of the 2019/2020 academic year of Al Asyariah Mandar University in the mathematics statistics course I based on the bloom taxonomy revision on the factual dimension is in the low category with an average conversion of 5.20 and on the conceptual knowledge, is in the medium category with an average conversion rate of 5.23. The number of students who are skilled in answering questions in the HOTS category both on the dimensions of factual and conceptual knowledge is still below 50% of the total number of research respondents. This shows that students are still not skilled at accurately providing answers on the criteria of distinguishing between different concepts, providing statements by providing logical reasons, and giving answers with new perspectives.

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