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Analysis Junior High School Students' Conceptual Understanding of Flat-Sided Space Structures Based on Bloom's Taxonomy

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Abstract:
This study aims to analyze junior high school students' conceptual understanding in solving problems on three-dimensional with flat surfaces based on the revised Bloom's Taxonomy. This research employed a descriptive qualitative method with 6 seventh-grade students of SMP Negeri 1 Glagah , selected through purposive sampling. The research instruments consisted of essay tests and semi-structured interview guidelines referring to the six cognitive levels of Bloom's Taxonomy (C1–C6) and validated by experts. The data were analyzed through data reduction, data display, and conclusion drawing, with methodological triangulation to ensure the validity of the findings. The results showed that 13% of students were in the high category, 73% in the medium category, and 13% in the low category. High-category students mastered all conceptual understanding indicators, while medium- and low-category students experienced difficulties at the analyzing (C4), evaluating (C5), and creating (C6) levels. These findings indicate the need for learning strategies that enhance higher-order thinking skills through contextual problem-solving, the use of visual media, and problem-based learning.

Keywords: understanding concept, build room side flat, Bloom's Taxonomy, junior high school mathematics

Introduction

Mathematics learning in Indonesia generally still tends to use conventional methods that focus on memorizing formulas and mechanical procedures. This kind of approach often makes students passive and they simply follow the steps taught by the teacher without understanding the underlying meaning of the concepts. As a result, students experience difficulties when faced with problems that require critical, analytical, creative thinking, and problem-solving skills. This is a fundamental problem in mathematics learning because the essential goal of learning is to develop a deep understanding of concepts, not merely to master procedures.

One of the topics in mathematics learning that requires a good grasp of concepts is solid geometry. This topic includes cubes, rectangular prisms, prisms, and pyramids, each with different characteristics, elements, and properties. Students are expected to be able to identify the elements of solid figures, understand the relationships between these elements, and apply the formulas for surface area and volume in various situations. In reality, many students still struggle, for example, miscalculating surface area because they choose the wrong net, or misdetermining volume due to misunderstanding the relationship between the height of the shape and its base.

These difficulties indicate that students' conceptual understanding is not yet optimal. Understanding a concept itself includes the ability to restate the concept, classify objects based on specific properties, provide examples and non-examples, present the concept in various representations, relate concepts, and develop the necessary and sufficient conditions for a concept. Without this mastery, students will struggle to solve problems that require logical reasoning and higher-order thinking skills.

To identify and map students' cognitive abilities more structurally, the revised Bloom's Taxonomy (Anderson & Krathwohl, 2001) can be used as a reference framework. This taxonomy divides the cognitive domain into six levels: remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creating (C6) (Wilson, 2016). These levels help teachers assess the extent to which students have mastered concepts from the most basic to those requiring creativity and critical evaluation. Using this framework, teachers can identify students' learning difficulties at a specific level and then design appropriate learning strategies to address them.

Previous research findings indicate that students' ability to solve problems at levels C4, C5, and C6 is still low. Tianingrum and Sopiany (2017) found that most students only mastered levels C1–C3, while the levels of analysis, evaluation, and creation were rarely achieved. Yulianti and Novtiar (2021) also reported that the limited use of problem-based learning and contextual exercises made it difficult for students to achieve higher-order thinking skills. Rahmawati's (2020) research revealed that students frequently exposed to contextual problems tend to have a better understanding of concepts compared to students who only work on routine problems.

Additionally, observations at SMP Negeri 1 Glagah showed that many students could only memorize formulas but were unable to use them in different contexts. For example, students can calculate the volume of a cube if the side length is known directly, but they struggle when they have to determine the side length if the volume is known. This indicates that students have not yet mastered the reciprocal relationships between concepts, which should be part of a good conceptual understanding.

Based on the description, research is needed to specifically analyze students' conceptual understanding based on the cognitive levels of the revised Bloom's Taxonomy for the material on flat-sided geometric shapes. This will provide a clear picture of students' mastery levels at each level, areas of weakness, and influencing factors. This research aims to analyze the conceptual understanding of junior high school students in solving problems related to flat-sided geometric shapes based on the revised Bloom's Taxonomy. The research findings are expected to contribute to mathematics teachers in designing more effective learning, facilitating the development of higher-order thinking skills, and helping students build a strong and applicable conceptual understanding.

Research Methods

This qualitative research aims to describe the ability to understand concepts in flat-sided solid geometry based on the revised Bloom's Taxonomy at SMP Negeri 1 Glagah, specifically for eighth-grade students. The object of this research is the analysis of students' concept understanding ability in solving flat-sided solid geometry problems based on the revised Bloom's Taxonomy. The subjects of this research are eighth-grade students at SMP Negeri 1 Glagah, totaling 6 students. The research was conducted by administering a concept understanding ability test based on the six cognitive levels of the revised Bloom's Taxonomy. Students were asked to answer the questions, and then the results were analyzed qualitatively to determine their level of understanding of concepts related to flat-sided geometric shapes. Data sources were obtained from concept understanding ability tests, interviews, and documentation. Meanwhile, the cognitive processes in Bloom's taxonomy are presented in Table 1.

Table 1. Bloom's Taxonomy Cognitive Processes

Cognitive processes	Component	Level
Create (C6)	Design, build, plan, create	Tall
Evaluate (C5)	Check, Review, Conclude, Explain	Tall
Analyze (C4)	Compare, Arrange	Currently
Implementing (C3)	Implementing, Carrying Out, Using	Currently
Understanding (C2)	Describe	Low
Remembering (C1)	Predict, Recognize, Identify	Low

Data collection was carried out using three techniques, including:

1. Tests – in essay form, designed based on indicators of understanding mathematical concepts, including:
   (1) restating concepts in one's own words,
   (2) providing examples and non-examples,
   (3) classifying objects according to specific properties in accordance with the concept,
   (4) representing concepts in various mathematical forms,
   (5) connecting concepts in mathematics, and
   (6) applying concepts to solve everyday problems.

2. Interviews – conducted in a semi-structured manner to delve deeper into students' responses for each indicator of conceptual understanding.

3. Documentation – consisting of photos, interview recordings, and student answer archives from written tests.

The test instruments used in this study were first consulted with the supervising lecturer, then validated by three mathematics teachers from SMP Negeri 1 Glagah. This validity test is conducted to ensure that the questions align with the indicators being measured. The validation results from the three validators indicate that the instrument is suitable for use with some revisions as suggested by the validators. The material tested in the exam is flat-sided solid figures because this material is an important part of geometry learning that requires a strong understanding of concepts, especially for solving problems with high-level thinking processes according to the revised Bloom's Taxonomy.

Results and Discussions

Based on the results of students' conceptual understanding tests on flat-sided solid figures, analyzed using Bloom's Taxonomy indicators, the distribution of students' conceptual understanding levels was obtained in three categories: high, medium, and low. This category is determined based on pre-defined value intervals.

It was found that students' level of conceptual understanding was in the moderate category with a percentage of 73%. The percentage of students with low conceptual understanding ability was 13%, while students with high conceptual understanding was 13%. To assess students' conceptual understanding ability, six indicators were used, namely: (1) restating concepts using one's own language, (2) providing examples and non-examples, (3) classifying objects according to specific properties in accordance with the concept, (4) representing concepts in various forms of mathematical representation, (5) connecting concepts in mathematics, and (6) applying concepts to solve daily problems.

Based on the students' scores, it can be concluded that the majority of students are in the moderate category, with 11 students (73.33%), while there are 2 students (13.33%) in the high category and 2 students (13.33%) in the low category. This indicates that, overall, students' level of conceptual understanding falls into the moderate category with a total average score of 70.07%. Looking at each indicator, indicators C1 (96%) and C2 (87%) show excellent results, indicating that most students have a good grasp of basic knowledge and understanding. Indicators C3 (70%), C4 (66%), and C5 (68%) are in the sufficient category, which indicates a decline in conceptual mastery at the application level. Indicator C6 (58%) received the lowest percentage, making it an indicator that requires special attention because it reflects students' still low higher-order thinking skills (HOTS). Overall, although students are able to grasp basic knowledge well, they still need learning that emphasizes higher-order thinking skills, analysis, and in-depth application of concepts. Here is the data from the research subjects.

In the high category, there are two students: SWR with code T1 and ETI with code T2. These two students were selected because they have relatively better conceptual understanding abilities compared to other students. The medium category is also represented by two students: OYW with code S1 and SZD with code S2. These two subjects have abilities at an intermediate level, providing insight into students with average abilities. Meanwhile, in the low category, there are ANN with code R1 and RJN with code R2. These two students were selected because their conceptual understanding abilities were lower than the other categories, providing information about the difficulties faced by students with low abilities. Thus, the selection of subjects in this study encompasses the entire range of student ability categories, ensuring more comprehensive data for analyzing mathematical concept understanding based on different ability levels. Here is the data on ability results based on Bloom's Taxonomy. In the high category, subject T1 successfully met all indicators, while T2 only met 5 out of 6 indicators. This is because subject T2, although the calculations were correct, tended to only memorize formulas without in-depth understanding. In the medium category, subject S1 also met 5 indicators, but the explanation for the 5th indicator was less in-depth compared to T2. Subject S2 only met 4 indicators. In the low category, subject R1 met 3 indicators and, for the 3rd indicator, provided examples and non-examples, giving relevant examples although limited. Subject R2 met 2 indicators and, for the 2nd indicator, was able to meet the indicator of classifying objects based on concepts by grouping them according to common characteristics.

Subjects with high categories can meet 5-6 indicators of conceptual understanding according to Maharani. The medium category meets 5-4 indicators, and the low category meets 2-3 indicators of conceptual understanding according to Maharani. It can be concluded that each subject has similarities, so it can be declared valid.

In this section we will dicuss for every indicators based on ressults. The discussion presented as follows:

1. *Restating a Concept*

In the first indicator, subjects T1 and T2 were able to restate the definition of flat-sided geometric shapes in their own words completely and correctly, including relevant elements, properties, and examples. Undergraduate students were also able to explain the concept correctly, but their presentation was simpler and did not cover all the intended properties. Graduate students only explained some of the properties, and some even incorrectly associated them with the intended shape. Meanwhile, R1 provided an inaccurate explanation mixed with properties of other shapes, while R2 was unable to fully explain the concept, only mentioning the shape's name without defining it. (Hanggara et al., 2022) The ability to restate concepts indicates initial mastery in understanding a material. This finding aligns with Oktaviani's (2021) research, which states that low-achieving students tend to memorize without truly understanding the meaning of the concept.

2. *Classifying Objects According to Specific Properties*

In this indicator, T1 and T2 can accurately classify three-dimensional shapes based on their characteristics such as base shape, number of sides, and shape of the vertical faces. S1 can correctly group most shapes but still makes mistakes on one shape that is similar to others. S2 makes mistakes on several shapes due to a lack of understanding of their specific properties. In the low category, R1 was only able to correctly classify a small portion of the shapes and the rest incorrectly, while R2 was able to classify the shapes accurately even tho the explanations of their properties were still lacking in detail. (Putri et al., 2025) emphasize that classifying objects is an important skill for understanding concepts. This result aligns with research (Murtiyasa & Sari, 2022) which found that misconceptions are common among low-ability students.

3. *Providing Examples and Non-Examples*

Research findings on the third indicator show that T1 and T2 were able to provide accurate examples and non-examples of flat-sided solid figures, both in the form of images and verbal explanations. S1 can provide the correct example, but it's not the example that's presented is less accurate. S2 is able to provide the correct example, but the example given is not relevant. In the low category, R1 only provides examples without being able to provide non-examples, while R2 is incorrect in providing both examples and non-examples. (Sari et al., 2021) emphasize that the ability to provide non-examples helps students distinguish between concepts and non-concepts, and research (Kristanto & Manoy, 2021) shows that low-achieving students are often confused in distinguishing between the two.

4. *Presenting Concepts in Various Forms of Mathematical Representation*

In this indicator, T1 and T2 can accurately present concepts thru various forms of representation, such as images, net models, and verbal descriptions. S1 can draw three-dimensional shapes correctly but lacks detail in their dimensions and elements. S2 can draw the shapes but makes mistakes in creating the nets and proportions. R1's drawings are nearly correct but incomplete and not to scale, while R2 struggles with both drawing and creating nets, resulting in a drawing that does not represent the intended shape. (Mukarom et al., 2023) explain that mathematical representation connects abstract concepts with concrete forms, and research (Hartini & Setyaningsih,

2023) reveals that low-ability students tend to struggle with switching between representations.

5. *Developing Necessary and Sufficient Conditions*

T1 is able to state and develop the necessary and sufficient conditions of a concept completely and correctly. T2 can also do this, but their explanation is not in-depth enough. S1 can state some of the conditions but not accurately, while S2 is incorrect in determining the relevant conditions. In the low category, R1 was unable to state the necessary and sufficient conditions, and R2 did not provide an appropriate answer. (Febriana et al., 2020) This ability requires strong deductive reasoning, and (Priliawati et al., 2019) shows that this indicator is one of the most difficult for students to master.

6. *Using, Utilizing, and Selecting Specific Procedures or Operations*

In the final indicator, T1 and T2 were able to select the appropriate solution procedure and correctly complete the calculations. S1 may choose the correct procedure but be less thorough in the calculations, leading to incorrect results. S2 may choose the wrong procedure, resulting in an inaccurate final answer. R1 may choose the wrong procedure and not complete the calculations, while R2 may not understand the procedure to be used and not attempt to solve the problem. (Khairul et al., 2024) emphasize that selecting the correct procedure is a characteristic of effective problem-solving, and (Febriana et al., 2020) found that low-ability students often incorrectly choose formulas or solution steps.

Conclusions and Suggestions

Based on the results of written tests and interviews with eighth-grade students regarding their understanding of the concept of flat-sided solid figures, it can be concluded that Students with high abilities demonstrate a deep understanding of the elements of solid figures, are able to explain their properties and characteristics, and can apply these concepts to problem-solving. They can provide examples and non-examples of three-dimensional shapes, represent information in the form of diagrams, and apply formulas accurately and logically. This is evident in their ability to explain both orally and in writing in a coherent and correct manner.

Students with moderate abilities still have an unstable understanding of concepts. They can name some elements and formulas, but often have difficulty representing concepts or solving problems logically and systematically. Errors usually arise from a lack of thoroughness or a misunderstanding of the relationships between elements in three-dimensional shapes.

Students with low abilities tend to only memorize formulas without understanding the basic concepts. They struggled to name the elements of solid figures, made mistakes in drawing, and often made calculation errors because they didn't understand the meaning of the steps they were taking.

Thus, the majority of students have not yet reached higher-order thinking skills (C4–C6) in Bloom's Taxonomy. Only high-achieving students are able to demonstrate analytical, evaluative, and creative thinking processes in solving mathematical problems.

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