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Identification of Learning Obstacles on Surface Area of Cube and Cuboid for Junior High School Students

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ABSTRACT

In classroom learning, there are still difficulties in achieving goals in mathematics learning. One of the main factors that hinders this is misconceptions during mathematics learning. Based on the results of previous studies, it was found that many students still do not understand the basic concepts of geometry, make mistakes in symbolic representation of geometric objects, mistakes in reading data contained in images, mistakes in performing mathematical operations, and student mistakes in processing problem solving. These misconceptions will become learning obstacles for students. This study aims to identify learning obstacles that occur in the learning process of the surface area of cubes and cuboids. The design of this study uses a descriptive qualitative research method. The instruments used are learning obstacle identification tests and interview sheets. The subjects of this study were grade VIII students who took the test and interview, and mathematics teachers as interview respondents. The results of this study obtained the identification of learning obstacles, namely, first, ontogenic obstacles that occur due to students' mental unpreparedness when they are going to receive learning. Second, didactical obstacles where the teaching materials used by the teacher do not clearly explain the concept of cube and cuboid space and only display formulas. Third, epistemological obstacles that occur due to the teacher's execution process in conducting learning.

Keyword: Learning Obstacles, Surface Area of Cube and Cuboid

INTRODUCTION

Mathematics is one of the subjects that plays an important role in everyday life, so mathematics is studied from elementary school to college. One of the content elements studied in mathematics is Geometry. According to NCTM (2000), geometric ideas can represent and solve problems in other mathematical topics. Geometry is one of the centers of the school mathematics curriculum and is very important in children's mathematics education (Kemp & Vidakovic, 2021). Geometry is also one of the mathematical contents assessed in TIMSS as much as 20% which aims to monitor the results of the education system related to student learning achievements in mathematics and science (Mullis et al., 2020). Achievement in mathematics education can be seen in students' ability to complete assignments, the ability to apply the goals of mathematics education in everyday life, apply, and make mathematics important (Putra & Milenia, 2021). However, this is not seen in the TIMSS 2015 results. Indonesia is ranked 44th out of 49 countries, which means that Indonesia's position is low

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(Nizam, 2016).

There are several reasons why geometry is taught to students because geometry is a way to interpret and describe the physical environment and as an important tool in problem solving (Hardianti et al., 2017). However, from the results of research at the college level, especially on the concept of Geometry, there are still many students who do not understand the basic concepts of geometry. Many still make mistakes in the symbolic representation of geometric objects, namely not understanding the concept, mistakes in reading the data contained in the image, and mistakes in performing mathematical operations (Ikashaum et al., 2021). Student errors are also seen in processing problem solving caused by being less careful in calculating or drawing, not understanding the information in the questions, reading errors, understanding problems, and transformation errors (Purnomo & Machromah, 2017). In addition, students do not like and find it difficult to learn mathematics, especially geometry material (Hermawan et al., 2022; Moustafa et al., 2022; Nurani et al., 2016). In classroom learning, there are still difficulties in achieving goals in learning mathematics. One of the main factors that hinders this is misconceptions during mathematics learning. From the misconception, it will become a learning obstacle for students known as learning obstacle. In this study, the material studied is related to flat-sided space, namely the concept of the surface area of cubes and cuboids. The study was conducted to identify learning obstacles that occur in the learning process of the surface area of cubes and cuboids.

Based on the results of interviews with class VIII teachers of SMP N 24 Padang conducted on May 20, 2024, it was found that the problems of students in learning the concept of surface area of cubes and cuboids were that students were still hesitant and made mistakes in using formulas in solving problems, namely between the formula for flat shapes (squares or rectangles) and the formula for the surface area of cubes and cuboids. This happened because students were still memorizing the formulas, without understanding the concept. Based on the results of interviews with students, several students expressed doubts about using formulas in solving problems, in addition, some stated that they had forgotten because the material on the surface area of cubes and cuboids had been studied for a long time. Therefore, it is necessary to further analyze the learning obstacles experienced by students.

According to (Brousseau & Warfield, 2020), there are three types of student learning obstacles, namely ontogenic obstacles, didactic obstacles, and epistemological obstacles. Ontogenic obstacles occur because students are not ready or because of their inability to think when learning with certain teaching materials. Didactic obstacles occur when the teaching materials, curriculum, and learning design used in learning cause errors that occur in students, and epistemological obstacles occur when students' knowledge is limited to a context. From the results of the study (Safitri, 2022), teacher-centered learning and only using teaching materials in the form of textbooks, causes students to be inactive, resulting in learning obstacles, namely the discovery of formulas carried out by the teacher (didactic obstacles), students' difficulties in solving problems (epistemological obstacles), and low student motivation in following the learning process (ontogenic obstacles). Learning obstacles in the material on the area of a rhombus found learning obstacles in the concept of perpendicular lines on a rhombus, the concept of area units, and the area of a rhombus (Yanti et al., 2020). In the material on the volume of cubes and cuboids, learning obstacles in learning are ontogenic obstacles which can be seen from the lack of understanding of concepts in solving problems and students' difficulties in solving problems, didactic obstacles related to the learning tools used by teachers, and epistemological obstacles, namely the limited context of understanding

that students have (Gunawan et al., 2023).

Based on the explanation above, it is necessary to conduct an analysis to determine the learning obstacle in the material of the surface area of cubes and cuboids to be considered in improving further learning. So that the learning that will be carried out can reduce learning obstacles to be able to understand the concept of the surface area of cubes and cuboids as a whole. The purpose of the study was to identify learning obstacles experienced by students in the material of the surface area of cubes and cuboids in order to compile a didactic design for the material of the surface area of cubes and cuboids. The existence of previous research related to other materials can be used as a consideration by researchers in compiling learning obstacle identification test questions.

METHOD

The research method used is a qualitative research method that refers to the Didactic Design Research (DDR) stage for the surface area of cubes and cuboids. Qualitative methods are used with the aim of describing the results of the analysis of learning obstacles experienced by students in the surface area of cubes and cuboids. However, in this study, only the didactic situation analysis stage was carried out through the analysis of the results of the student learning obstacle identification test. The subjects in this study were students who had studied the surface area of cubes and cuboids of class VIII SMP N 24 Padang. The research subjects were determined based on the considerations of the teachers at the location where this research was carried out. The data collection techniques used were tests and non-tests. The test carried out was a learning obstacle identification test in the form of 6 essay questions to identify learning obstacles that appeared in the surface area of cubes and cuboids. Non-test data in this study were obtained from the results of interviews conducted with teachers and some research subjects to obtain student responses after completing the test instrument.

RESULTS AND DISCUSSION

Based on the results of the data analysis conducted, it was found that there were learning obstacles experienced by students. Learning obstacles experienced by students during the learning process cause learning outcomes to be less than optimal. The learning obstacles identification test questions were given on May 20, 2024 to class VIII students of SMP N 24 Padang who had studied the material on flat-sided spatial figures containing 6 questions arranged according to the indicators of achieving learning objectives. The results of this test were analyzed to determine the learning obstacles experienced by students when working on questions on the surface area of cubes and cuboids. The following will explain each learning obstacle that occurs in each question indicator.

Question 1 and 2

The achievement indicator in Question 1 is to test students' understanding of the basic concepts of cubes and cuboids. In this question, students are asked to be able to determine which are cube and cuboid shapes from several images presented, and to provide reasons for choosing these shapes according to their respective opinions. Based on the results of the answers given by students, the researcher wants to test students' understanding in linking the elements of cubes and cuboids in describing cubes and cuboids can be seen in Fugure 1.

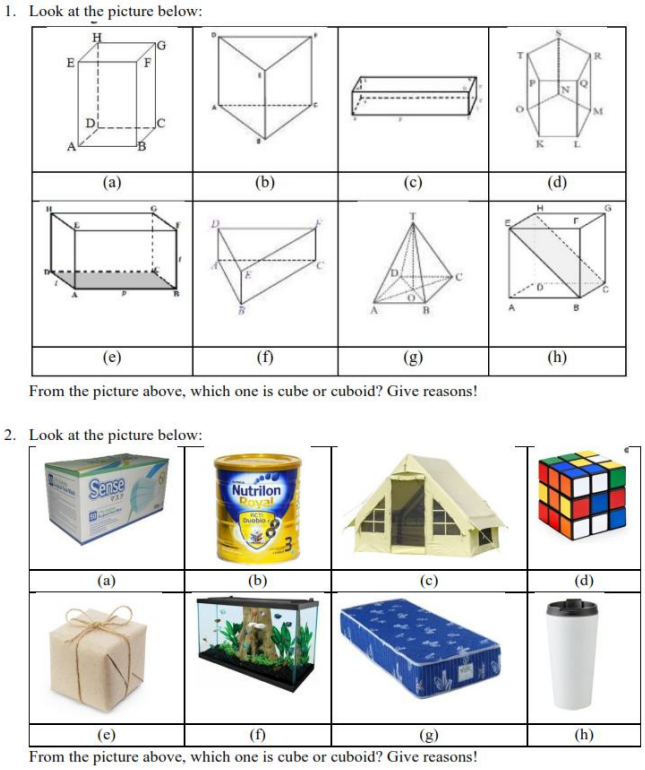


Figure 1. Learning Obstacle Identification Questions 1 and 2

The indicators and distribution of students' abilities in answering questions 1 and 2 are presented in the Table 1.

Table 1. Indicators and Distribution of Students' Abilities in Working on Questions 1 and 2

Ability Types	Indicator	Question 1		Question 2	
		n	%	n	%
0	Students do not answer	0	0	0	0
1	Students can choose the right geometric shapes but are not/less precise in providing reasons.	28	100	28	100
2	Students can choose the right geometric shapes and provide correct reasons.	0	0	0	0
	Total	28		28	

Based on the results of the students' answers, it can be seen that the students have been able to answer correctly in determining the shape of a cube and a cuboid, but from the reasons given, it can be seen that there are still many students who experience learning obstacles in that students do not understand the concept of cubes and cuboids, and there are even some students who cannot provide reasons. Figure 2 is one of the answers from students who experienced learning obstacles.

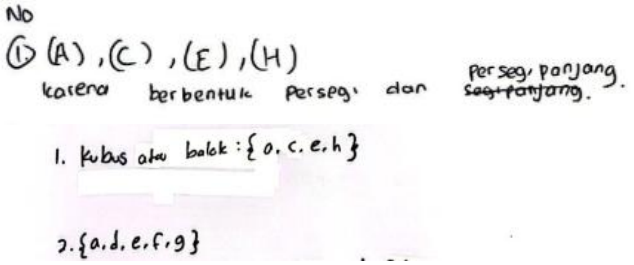


Figure 2. One of the learning obstacles for Questions 1 and 2**.**

Question 3

This question is arranged based on competency achievement indicators to find out whether students can determine the surface area of a cube and a cuboid from known elements. In questions 2a and 2c, students are asked to determine the surface area of a cube and a cuboid whose edge lengths are known, but in questions 2b and 2d, students need to first find the unknown values to determine the surface area of a cube and a cuboid. Figure 3 are the questions given.

3. Look at the cube and cuboid below:



a. If the length of AB = 5 cm, then what is the surface area of the cube?
b. If the length of AC = $6\sqrt{2}$ cm, then what is the surface area of the cube??
c. If the length of PQ = 5 cm, UV = 7 cm, and SX = 10 cm, then what is the surface area of the cuboid?
d. If the length of SR = 4 cm, PR = 5 cm, and PV = 13 cm, then what is the surface area of the cuboid?

Figure 3. Learning Obstacle Identification Question 3

The indicators and distribution of students' abilities in answering question number 3 are presented in Table 2.

Table 2. Indicators and Distribution of Students' Abilities in Working on Questions 3

Ability Types	Indicator	Question 3	
		n	%
0	Students do not answer	0	0
1	Students cannot answer points 2b and 2d	0	0
2	Students are less precise in determining the solution to 2b and 2d	9	32,14
3	Students can answer questions 2a – 2d, but do not include complete solutions.	19	67,86
4	Students can answer questions 2a – 2d) correctly	0	0
Total		28	

Based on the distribution of Table 2, it can be seen that more than 60% of students have the ability at a score of 3 where students can actually answer the question. However, their answers do not provide a clear explanation in finding the value of the length of the edge. To find out the learning obstacle that occurred, the researcher asked one of the students who was included in the ability type with a score of 3 and asked the student to explain his answer. From the results of the question and answer, the student knew the formula for the surface area of a cube if the value of the diagonal of its side was known even though the formula was obtained from linking other mathematical materials, namely Pythagoras. So, the researcher asked the student to explain the formula, but the student could not find the derivative of the formula. In this case, the researcher concluded that the identified learning obstacle was the student's dependence on memorizing the formula without studying the derivative of the formula.

In addition, in answering this question, it can be seen that the learning obstacle experienced by students is the difficulty in answering questions (b) and (d), where students are asked to first determine the length of the rib of the known shape through the information on the known diagonal length. From the students' answers, it can also be seen that the learning obstacle experienced by students is still wrong in determining the formula so that it is not right in determining the solution. In fact, many students did not answer this part. Figure 4 is an example of an answer or learning obstacle to question 3.

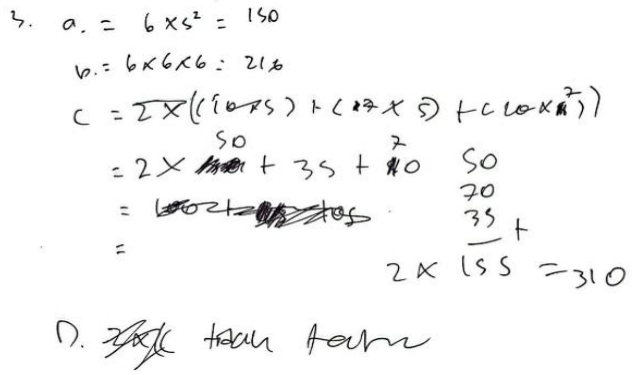


Figure 4. One of the learning obstacles for Question 3

Question 4

Figure 5 is the question number 4 that was given.

4. The surface area of a cuboid is 342 cm2. If the ratio of the length, width, and height of a cuboid is 4:3:1, respectively, then what is the length, width, and height of the cuboid?

Figure 5. Learning obstacle identification Question 4

The indicator in question number 4 is to determine students' understanding in linking other mathematical materials, namely comparison in determining the surface area of a cuboid. Students are asked to find the length, width and height of the cuboid by linking it to the comparison material. Students can solve this problem after the length, width and height are known, then determine the surface area of the cuboid. The indicators and distribution of students' abilities in answering question number 4 are presented in Table 3.

Table 3. Indicators and Distribution of Students' Abilities in Working on Question 4

Ability Types	Indicator	Question 4	
		n	%
0	Students do not answer	27	96,3
1	Students make mistakes in performing algebraic operations	0	0
2	Students can answer questions correctly	1	3,7
	Total	28	

Based on the students' answers, it can be seen that almost all students experienced learning obstacles, namely not being able to relate the material on the surface area of a cuboid to the material on comparison. It can be seen that students are still unable to understand the questions so they do not know or have difficulty solving the questions. In addition, students also experienced learning obstacles for students who were less careful in performing algebraic operations. However, there was still one student who was able to answer, it's just that there was a slight obstacle for students in answering, namely not adding units to the results obtained. Figure 6 is an example of an answer or learning obstacle for question 4.

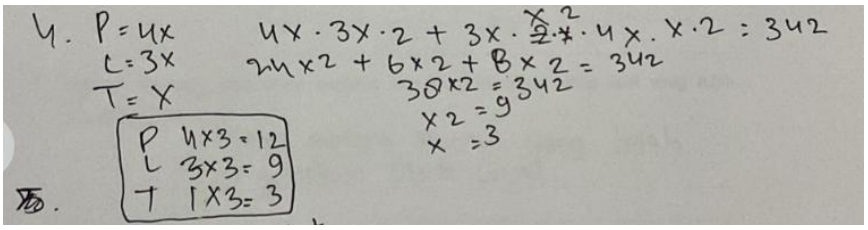


Figure 6. One of the learning obstacles for question 4.

Question 5

Figure 7 is the question number 5 that was given.

5. A 1 m^2 piece of cardboard is made into a cube-shaped object with edges of 10 cm. What is the size of the remaining unused cardboard?

Figure 7. Learning obstacle identification question 5

The indicator in question number 5 is to determine students' understanding of the material on the surface area of a cube with implementation in everyday life, namely determining the remaining unused cardboard. The indicators and distribution of students' abilities in answering question 5 are presented in Table 4.

Table 4. Indicators and Distribution of Students' Abilities in Working on Question 5

Ability Types	Indicator	Question 5	
		n	%
0	Students do not answer	26	92,86
1	Students make mistakes in performing algebraic operations	2	7,14

2	Students can answer questions correctly	0	0
	Total	28	

Based on the students' answers, it can be seen that many students did not answer question number 5, meaning that students were identified as experiencing learning obstacles, namely not being able to solve everyday life problems related to the concept of the surface area of a cube.



Figure 8. One of the learning obstacles for question 5.

Question 6

The achievement indicator in question number 6 is to know the students' ability in determining the surface area of a cuboid from problems in everyday life. In this question, students are asked to determine the total cost of painting a hall obtained after students determine the number of sides to be painted. The questions are given can be seen in Figure 9.

6. A cuboid-shaped hall with dimensions of 9 m, 7 m wide, and 4 m high. The interior walls are painted at a cost of Rp 50,000/m2. How much does it cost to paint the hall in total?

Figure 9. Learning obstacle identification question 6

The indicators and distribution of students' abilities in answering question number 6 are presented in Table 5.

Table 5. Indicators and Distribution of Students' Abilities in Working on Question 6

Ability Types	Indicator	Question 6	
		n	%
0	Students do not answer	11	39,28
1	Students can answer question number 6 correctly, but do not include how to solve it.	15	53,57
2	Students are less precise in determining which areas to paint.	2	7,1
3	Students can answer question number 6 correctly.	0	0
	Total	28	

Based on the percentage in the distribution Table 5, it can be seen that 39.28% of students are classified as having a score of 0 in answering question number 6. Based on the results of students' answers, it can be seen that many students have not answered, meaning that students are identified as experiencing learning obstacles, namely not being able to solve everyday life problems related to the concept of the surface area of a cuboid. Then 53.57% of students are classified as having a score of 1. It can be seen from the results of students' answers that there are some students who answer the question, but there is no explanation regarding the steps taken and go directly to the calculation stage. This identifies the learning

obstacle experienced by students, namely that students cannot associate the elements of a cuboid in solving the problem of the surface area of a cuboid, and the lack of students' ability to describe the steps for working on the problem properly. Figure 10 is one of the student's answers.

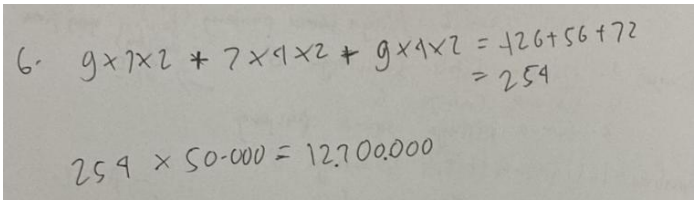


Figure 10. One of the learning obstacles for question 6

Based on the explanation of the results of the learning obstacle test conducted above, there are learning obstacles that appear in each question indicator. The learning obstacles found in each question indicator can be seen in Table 6.

Table 6. Learning obstacles for each question indicator

Question	Indicator	*Learning Obstacle*
1 and 2	Determining the geometric shapes of cubes and cuboids based on the elements of cubes and cuboids	Students cannot relate the elements of cubes and cuboids in describing the characteristics of cube and cuboid geometric shapes.
3	Determining the surface area of a cube if the known elements are different	Students cannot determine the surface area of a cube if the elements they know are different, and students lack the ability to interpret questions, students are used to relying on memorizing formulas.
4	Relating other mathematical concepts in determining the surface area of a cuboid from everyday life problems.	Students cannot relate the material on the surface area of cuboids to the material on comparisons, as well as students making mistakes in carrying out algebraic operations.
5	Determining the surface area of a cube from everyday life problems.	Students cannot solve everyday life problems related to the concept of the surface area of a cube.
6	Relating other mathematical concepts to determine the elements of a block in everyday life problems.	Students are unable to solve everyday life problems related to the concept of the surface area of a cuboid, are unable to relate the elements of a cuboid in solving cuboid surface area problems, and lack the ability of students to describe the steps for working on problems properly.

Based on the description of the identification of learning obstacles above, it can be concluded that most students have not fully understood the material on the surface area of cubes and cuboids, this can be seen from students who only memorize the formula, so they are unable to solve the problem. In addition, it was also identified that students lacked the ability to understand the problem, students' dependence on always memorizing formulas without studying the derivatives of the formula, to students who were not yet able to compile steps to solve the problem.

In addition to the learning obstacle identification test, interviews were also conducted with teachers and some of the research subjects. From the results of interviews with teachers, it was found that there were no obstacles experienced by teachers in teaching the initial concept of the surface area of cubes and cuboids, because the initial concept was the area of squares and rectangles, and it was well understood by students, but students had difficulty in other areas, but if applied to questions, there were indeed obstacles because the concept was taught in grade VII, so it is possible that some students forgot the material and were no longer motivated to solve the questions. According to the teacher, another difficulty experienced by students was the lack of student accuracy in multiplication, or if the questions given used large numbers or decimals, so that learning obstacles could be identified in the fraction material. The teacher also added that appropriate learning had been carried out in the learning process, namely with the guided discovery method, starting from making nets to being able to find the formula for the surface area of cubes and cuboids. Because in mathematics learning, student-centered learning is needed, so that students can develop their own knowledge in finding concepts so that the material can be understood well by students, not just memorized (Udayani et al., 2019). Based on this interview, it can be concluded that in learning the material on the surface area of cubes and cuboids, the learning obstacles experienced by students are in applying concepts in solving problems and modified questions.

Based on the results of the test and interview analysis, the researcher grouped the learning obstacles experienced by students on the surface area of cubes and cuboids. The grouping is based on three main factors causing learning obstacles, namely ontogenical obstacles, didactical obstacles, and epistemological obstacles. Ontogenic obstacles experienced by students in grade VIII of SMP N 24 Padang are related to students' unpreparedness when they are about to receive learning. This can be caused by the lack of student interest in learning the material being studied. Based on the results of interviews with teachers, information was obtained that students lacked interest in learning. Second, the didactic obstacles experienced by students were caused by the methods used that were not yet very supportive so that students could construct their own knowledge. Students had difficulty applying concepts in solving problems because they were only used to memorizing formulas so that students still found it difficult to work on non-routine questions. This means that students are not used to developing their thinking skills. Third, epistemological obstacles experienced by students were identified from students' errors in answering questions which could be caused by students' lack of ability to understand formulas and lack of thorough understanding of the questions. The teaching materials used are related to literacy, but this may be the cause, because students have not been able to understand the concept of the surface area of cubes and cuboids given. This causes students to experience limited concepts and only focus on the sources provided by the teacher. Students' difficulties in learning can occur due to the way teachers present material or teaching materials (Putra & Milenia, 2021). So that students only know the formula in the calculation but cannot develop their own

knowledge which results in students' ignorance of how the formula is formed.

CONCLUSION

Based on the results and discussions carried out on the results of the learning obstacle test on class VIII students of SMP N 24 Padang in the 2023/2024 academic year regarding the material on the surface area of cubes and cuboids, several obstacles were found, including: (1) Students cannot associate the elements of cubes and cuboids in describing the characteristics of cube and cuboid space shapes, (2) Students cannot determine the surface area of a cube if the elements they know are different, and the lack of students' ability to interpret questions, the dependence of students who are used to memorizing formulas, (3) Students cannot associate the material on the surface area of cuboids with the material on comparisons, as well as student errors in performing algebraic operations, (4) Students cannot solve everyday life problems related to the concept of the surface area of a cube, and (5) Students cannot solve everyday life problems related to the concept of the surface area of a cuboid, cannot associate the elements of a cuboid in solving cuboid surface area problems, and the lack of students' ability to describe the steps for working on questions properly.

Based on the results of tests and interviews to identify students' learning obstacles on the surface area of cubes and cuboids, there are three factors that cause learning obstacles in students, namely: (1) Ontogenic Obstacle experienced by students due to students' unpreparedness when they are about to receive learning which can be caused by students' lack of interest and passion in learning the material being studied, (2) Didactic Obstacle occurs in students because the method used does not support students in constructing their own knowledge, where students have difficulty applying concepts in solving problems because they are only used to memorizing formulas so that students still find it difficult to work on non-routine questions, and (3) Epistemological Obstacle identified from students' errors in answering questions can be caused by students' lack of ability to understand formulas and lack of thorough understanding of the questions. The teaching materials used are related to literacy, but do not support learning because students are not yet able to understand the concept of the surface area of cubes and cuboids given.

Based on the conclusions obtained, it is highly recommended to design a learning plan based on previously identified learning obstacles by providing a variety of questions, especially HOTS type questions or questions that link the material being studied with other mathematics materials, facilitating students to find their own concepts, and considering learning models that are suitable for students. In addition, further research is needed to identify learning obstacles experienced by students in other materials so that the learning that will be carried out by teachers can be a solution to the obstacles experienced by students.

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