Student’s learning obstacle on understanding the concept of prism surface area

Y F Aziiza and D Juandi

1 Department of Mathematics Education, Faculty of Mathematics and Natural Sciences, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No. 229, Bandung 40154, Indonesia
2 Department of Mathematics Education, Faculty of Mathematics and Natural Sciences, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No. 229, Bandung 40154, Indonesia
3 yushilatufa@upi.edu

Abstract. This study was a preliminary study to develop a didactic design of the concept of a prism surface area. This study aimed to identify the learning obstacle experienced by students on the material of a prism surface area. The learning obstacle obtained was based on the ability test of the respondents, interviews, and documentation of students who had studied the material of the prism surface area. The method used was a qualitative method with data triangulation. This study involved 52 students in the 9th grade at one of junior high schools in West Bandung Regency and a teacher as a participant. The learning obstacle found in this study were 1) ontogenic obstacle, 2) epistemological obstacle, and 3) didactical obstacle. The ontogenic obstacle found was that students had difficulty in determining the names and elements of the prism, in which the difficulty was caused due to forgetfulness, doubt, and misconception of the prism surface area. The epistemological obstacle found was that students tended to memorize the definitions and formulas of the concept of the prism surface area, so they did not understand the concept as a whole. The didactical obstacle found was that the learning process was procedural and did not consider the difficulties and misunderstandings experienced by students while learning, as well as the lack of experience to construct geometric shape models, such as prisms.

1. Introduction
The purpose of learning mathematics in Indonesia, which are 1) understand the concept of mathematics, 2) reasoning the pattern of the nature of Mathematics, 3) solve mathematical problems, 4) communicating the argument or idea of mathematics [1]. Studying mathematics especially on material geometry will allow students to analyze and interpret the world they live, and equip them with tools that can be used in other areas of mathematics [2,3], as well as stimulate students to communicate about the language of mathematics, possess thinking skills, and problem-solving skills [4,5].

Basically an ideal purpose. Unfortunately, with the current learning system that adopt by mostly all school in Indonesia, those ideal purpose seem very far to achieve. The unidirectional learning process, leads to lack of communication between teachers and students. Limited usage of learning media, means not maximizing learning process. Heavy tendencies from both teachers and students to follow the teaching book, minimizing opportunities for students to develop their own abilities. According to [6] to teach mathematics, teachers must be active and establish a relationship between students and mathematical ideas, thus the problems and questions given can be used for learning purposes. Teaching
approaches tend to concentrate on verifying and assessing or eliminating explorations and explanations, another reason is that students cannot prove a concept that has just been introduced [7].

Research by [8], stating that the error of student’s answers in learning geometry are based on a number of things which are: (1) while student’s determine the form of geometry, they do not consider its geometry traits, (2) students fail to connect the geometry properties of the images he knows with other knowledges, (3) students generalize properties that only apply to certain conditions over different situations, and (4) students misunderstand the concept of parallelism on the subject of angles. Based on research [9] and [10], students are found experiencing difficulties in understanding the given geometry problem, in addition, there are errors caused by lack of ability of students to understand the concept, identifying the problems given.

The errors that arise because of the erratic and unpredictable basic understanding called the obstacles. Error is not only caused by ignorance, uncertainty, or coincidence but also because of previous knowledge that could not be implemented on new knowledge [11]. There are three factors causing the emergence of learning obstacle, which are; ontogenic obstacle (student’s mental readiness), didactical obstacle (due to teaching), and epistemological obstacle (limited contexts) [12]. Based on this, researchers are interested in conducting a study by analyzing learning obstacle in students, in order to be a consideration in the next improvement of prism surface area learning concept.

2. Methods
2.1 Methods
This research uses qualitative methods, which is methods that include the activity of asking questions, collecting data specifically, analyzing, interpreting the data, and translating the complexity of the problem [13]. Later, researchers use triangulation techniques; using written tests and interviews with students, interviews with teachers, and analyzing their textbooks. The subject of this study was 52 students in 9th grade in one of the schools in Bandung Barat district.

2.2 Instruments
Researchers searched for student difficulties, especially in concept understanding aspect, related to prism surface area. This was done by giving the student preliminary test, that are 3 problems test. The problems are designed to identify student’s understanding about prism surface area concept. This test is developed based on the Van Hiele’s phase understanding of Geometry. As for the problems we can see in the following table 1.

| Indicators                                                                 | Question number |
|---------------------------------------------------------------------------|-----------------|
| Group the shapes of the flat side space up into two parts; Flat side prism and which are not flat side prisms | 1a, 1b          |
| Form analyzing based on components and geometric relationship observed in Problem No. 1, student should describe their answer toward problem no. 1 | 1a, 1b          |
| Identifying flat sides prism’s element, associate its properties, and construct the prism into nets | 2a, 2b, 2c, 2d  |
| Problem solving, associating prism properties, prism surface area concept introduction | 3               |

3. Result and Discussion
3.1. Result
3.1.1 The first indicator. The students were given the first problem to determine their ability in recognizing the shapes of flat-sided prisms.
Look at the image of geometry bellow!

a. Which number from the flat side prism! Give the reason!

Figure 1. Problem number 1

The results of student’s answers in determining the geometric shape of flat-sided prisms and non-flat-sided prisms are summarized in Figure 2.

Figure 2. Student’s answers in grouping pictures for problem number 1

In answers of problem number 1, the varied answers in the grouping of flat-sided prisms is considered due to the limitations of the student’s experience in grouping geometric spaces. The following is an answer of a student (S17) for problem number 1.

Translate:
1. A. b and g because b and g are prisms that have flat and equilateral sides, while a and f are not prisms but rather cuboid and cubes

Figure 3. Student’s (S17) answer for problem number 1

Figure 3 show result that the students have varied answers because in the learning process, they recognize the shape of prism as shown in number b and number g, while for number a and number f, they are better known as cuboids and cubes. The student’s errors is worsened due to the provision of the material during the learning process which was divided into four materials, including cubes, cuboids, prisms, and pyramids. This finding is in line with the results of the study by [14, 15] which stated that from a number of analysis results, some errors and mistakes were found in the concept of flat-sided geometric shapes in high school students, for example, the prism was considered as pyramid, or the cube was considered as cuboid, and vice versa. This shows the poor understanding of students in the three dimensional concept.
3.1.2. The second indicator. Students were expected to be able to associate the relationship between the geometric shapes that had been grouped with their properties.

Translate:
1. a, b, dan g
   -because it has sides perpendicular to parallel sides
   -have …

b. (a) is a prism, because it is bounded by an identical base and an n-faceted cover and the vertical sides are square. whereas (f) is not a prism, because it is limited by 6 congruent square sides

Figure 4. Student’s (S36) answer for problem number 1

Based on Figure 4, the S36 student had been able to describe a geometric shape based on its properties. The student expressed their reasons for choosing picture number a as a part of prism group because the definition of the prism that they know is a geometric shape that has vertical sides that are perpendicular to the base, and have sides (base and lid) that are aligned. Besides, the base and lid have identical n-sides and the upright side is ‘square’ in shape. The use of the word ‘square’ has a different meaning from the real meaning. Once reconfirmed about the word ‘square’ they used, S36 explained that the ‘square’ referred to ‘rectangular’.

Then, the researcher confirmed to 73% of students who stated that the figure of number f was not a shape of prism. The answers given by these students varied, including 1) the students understand that the geometric shape consisting of six equal and congruent sides is a cube and not a prism, 2) the students understand that the upright side of a prism is rectangular rather than square in shape, and 3) based on the student’s views, the base in figure number f is not a square, but a parallelogram, and 4) the students recognize the figure as a cube and not a prism.

The error of students who view the ‘lid’ in figure number f has a parallelogram shows the lack of ability to “read” and visualize information about geometric shapes. According to [16] one aspect that must be mastered by students in learning geometric shapes is a visual spatial ability, that is the ability of “reading” and visualizing information about solid objects, the ability to mentally manipulate, rotate, or reverse a line and figures that are sometimes isometric and horizontal in shape used in textbooks. According to [16] it showed that their study still found that students in grades 5 to 8 had difficulties related to isometric type figures of rectangular geometric shape.

3. The third indicator. The next problem is conditioned as a follow-up to the first indicator and the second indicator. This problem is given to determine student’s understanding in identifying the elements of the flat-side prism and linking its properties, as well as constructing the prism into nets of prisms. The majority of students answered correctly for problem number 2, but there were some students who had incorrect answers.

Translate:
a. triangular prism
b. it has 7 sides, 5 sides that are rectangular, and 2 other sides are on the base and a pentagon-shaped roof
c. 10 corner points, 7 sides, 15 ribs

Figure 5. Student’s (S43) answer for problem number 2
Based on Figure 5, there was a student (S_{43}) who made an error in answering problem number 2a. The student wrote a triangular prism, but after an interview was conducted, S_{43} realized that the written answer was wrong. Then, the researcher explored information on the student’s answer to problems numbers 2b and 2c. Overall, S_{43} had known the number of elements of the pentagonal prism, but in mentioning examples of elements on each side, the student had quite a doubt. The researcher anticipates by directing the student to name the lid and base with an example. After giving an example, the student was fluent enough to name the whole side of the pentagonal prism. Moreover, for the answers to problem number 2d, the majority of students drew nets of the prism as done by the S_{43} student who drew nets of pentagonal prism with irregular size. Another error was also made by the S_{50} student. The student made irregular and inaccurate figure of pentagonal prism nets, seen from the number of rectangular upright sides with more number than the actual sides. When confirmed about the answer, S_{50} was confused to explain the answer they had written. This can be seen in the following conversation.

\[ R : \text{Do you think the answer to problem number 2d is correct?} \]
\[ S_{50} : \text{I’m confused, Ma’am, how’s the picture?} \]
\[ R : \text{Why are you confused? Try to look carefully, this picture! Which are the sides?} \]
\[ S_{50} : \text{This, this, this, Ma’am (pointing to the sides of the pentagonal prism)} \]
\[ R : \text{How many sides are there?} \]
\[ S_{50} : \text{The rectangle are one, two, ..., five. The lid is one, the base is one. The side is seven, Ma’am.} \]
\[ R : \text{Take a look again! the picture of the nets you have made, try to make new nets again} \]
\[ S_{50} : \text{(drawing) Argh... it’s not easy, Ma’am, this one, Ma’am, I can’t draw, Ma’am.} \]
\[ R : \text{Have you ever drew a net like this before?} \]
\[ S_{50} : \text{Hmm... I’m not used to, Ma’am, I rarely asked to make a picture of nets.} \]

Based on the transcript of the conversation, it can be seen that the student find it difficult to draw nets of a pentagonal prism. This is also seen in the S_{43} and S_{50} who formed a pentagonal prism net with a similar pattern, but which has an incorrect size.

3.1.3. The fourth indicator. The third problem directs students to solve problems regarding the concept of the surface area of a prism. The problem is as follows.

In the third problem, it is found that only 14% of 52 students who answered right. The student’s solved the third problem by determining the length of the base of the triangle using phytagorean formula. Procedurally, the students have known the initial steps to determine the surface area of the prism, which is seen that students have used the phytagorean formula and found the length of a part of the base. However, the error was to determine the overall length of the base on the triangle. This resulted in wrong student’s answers about the length of the base of the triangle which was 9. The students should multiply the length of the base by adding the number 3, so the length of the base is 6.

The next error is to determine the surface area formula of prism, in which the formula used by students was \(2 \times \text{vertical side area} + 2 \times \text{slant side area}\). The formula is based on student’s knowledge of the surface area formula of prism \((2 \times \text{base area}) + (\text{circumference of base} \times \text{height})\). The researcher explored student’s knowledge about the various surface shapes that form the tent, in which the students explained that there are two upright sides (pointing at the triangle figure) and two slant sides (pointing at the rectangle). From the student’s statements, it is known that the students have understood the shapes of flat-sided prism surfaces.

3.2. Discussion

In the first indicator, it is found that student’s misconception show that the cuboids and cubes are not prisms, identified as epistemological obstacle, most students feel confused to group geometry, because it is based on concepts they know. Based on the results of interviews with Mathematics teachers, the mistake found are likely from the learning process that lacks emphasis on the visual shapes of flat sided geometric shapes so the students are confused to determine the names and groupings of geometric shapes. Besides, the learning process emphasizes more on calculation of the prism surface area and
volume. Another reason of the students is because of the provision of known learning material which is divided into four materials, including cubes, cuboids, prisms, and pyramid, so that the students understand that the four shapes of the flat-sided geometric shapes are different, which is included as the didactical obstacle.

In the second indicator, the student’s errors in determining the name of the geometric shape of pentagonal prism is mistake that is included as an ontogenic obstacle. The students have actually known the difference between the pentagonal prism and the triangular prism, but because of their readiness in working on the problem, it makes errors in the process.

Misconception found in the second indicator show the limitations of student’s knowledge to obtain the knowledge they are looking for. These limitations are related to the learning process of students to obtain knowledge, so that when given problems to connect a geometric shape of prism and their properties, students are expected to have different context, so that they experience difficulties. This difficulty is called the epistemological obstacle.

In the third indicator, the cause of students cannot correctly draw prism nets is the lack of experience of students to do the practice of drawing prism nets, the lack of facilitation of students in learning prism nets, which is a didactical obstacle. The implication of the theory stated by Van Hiele [17] states: (a) A student cannot understand something adequately at their level without having the experience to think intuitively at each of the previous levels, and (b) If the instruction language is at a higher level than student’s thinking processes, the students will not understand the instruction [18].

In the fourth indicator, the researcher explores student’s knowledge by asking problems about the terms of the upright side. The students answer that the upright side is like a triangle in the tent. This shows that the students do not understand the basic concept of prism, which should be the upright side which is perpendicular to the base. Lack of student’s understanding of the shape of the triangular prism shows that there is an epistemological obstacle, in which they do not understand the geometric shapes in the problem. The next error is to determine the ‘slanted side’ which should be the ‘upright side’ on the triangular prism, in which the students see that the slanted sides of the tent are two rectangles. Results study by [19] which stated that errors that occur in students are caused because teachers are more focused on errors made by students. If there is no errors found, the teachers will continue to further learning. Moreover, the exam type used in schools uses multiple choice, which encourages students to solve a number of problems in a limited amount of time, so teachers tend to direct students to memorize formulas.

4. Conclusion
In this research, errors encountered were learning difficulties, misunderstanding, misconceptions, and not achieving student’s knowledge in understanding the form of prisms and the use of formulas will produce errors in the learning process that are identified as epistemological barriers. the limitations of students in receiving information because it is not in accordance with their mental readiness or there are differences in the level of thinking knowledge between teachers and students who are identified as ontogenic obstacle. Habits are caused because the learning sequence is called as didactical obstacle. Based on the results and discussion above, it can be concluded that students experience various obstacles, especially on the concept of the surface area of the prism. Solutions are needed to help students reduce learning barriers that occur, one of which is didactic design.

5. References
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