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LEARNING OBSTACLE IN GEOMETRY

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Abstract

One of the reasons given for geometry in schools is that children can use visualisation skills, have reasoning abilities and geometric modeling to solve a problem; Yet in reality, the problems lie at the teacher being unprepared in teaching geometry. This study aims to examine middle school students' difficulties in learning geometry, particularly on polyhedron. This study was focused on analyzing learning obstacles, as experienced by students during learning polyhedron. A descriptive qualitative method was employed in this study. The subjects of this research were nine junior high school students in one of the junior high schools in Padang, West Sumatera, Indonesia. The data collection was done using tests, interviews, and documentation. Qualitative data analysis was used to find out the type of learning obstacle identified from some wrong student answers. As a result, two obstacles were obtained, namely ontogenical and epistemological obstacle. Ontogenical obstacle may occur if the students do not have a sufficient understanding towards the materials given. Epistemological obstacle occurs when the teaching materials given do not suit students' individual characteristics. Preparing materials adjusted to the students' characteristics is necessary to minimise the occurrence of these obstacles.

Keywords: Geometry, Learning obstacle, Learning processes.

1. Introduction

Mathematics is a field of study consisting of several sub-fields of study, where one of those is geometry. Geometry is a branch of mathematics that studies points, lines, fields, and space objects as well as the nature, size, and relationship of each other [1]. Learning geometry requires a high level of thinking process; Thus, students must practice frequently in improving their thinking skills [2]. In practice, as in the case of building a flat side space, students find it difficult to understand the surface area that comes from the webs. This condition happened to similarly occur in several previous studies that students made mistakes in solving geometry problems caused by low understanding for geometry concepts and the low analysis of geometric elements related to solving problems in everyday life [3]. Figure 1 indicates how the geometric concepts used in daily life.

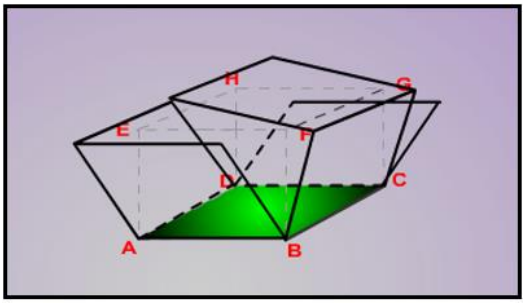


Fig. 1. Concepts of geometry.

Based on the National Council of Teachers of Mathematics, one of the reasons why geometry material is given in schools is that children could use visualisation skills, had reasoning skills and geometry modelling to solve a problem [4]. Hence, geometry can be seen as a knowledge that learns about shape, size, relative position of images, and the nature of space. From the spatial geometry learning, there are still many students who do not understand the concept of geometry particularly solving unusual problems. Lack of geometry concepts understanding becomes one of the causes of emergence of the inability to answer questions correctly because the fundamentals of geometry itself have not been understood by students yet. In addition, poor understanding can be caused by the teacher's method in teaching and learning process in the classroom. This is usually called the learning obstacle. According to Duval [5], there were three types of learning obstacle, namely ontogenical obstacles, didactical obstacle, and epistemological obstacle.

A learning obstacle, according to Brousseau [6], could be caused by several factors, namely the obstacle of ontogenical origin (mental readiness to learn), obstacle of didactical origin (due to the education system) and the obstacle of epistemological origin (knowledge of students who have limited application context). Ontogenical obstacle occurs due to learning processes that are not in accordance with children's readiness. Therefore, ontogenical obstacle is closely relating to students' mental development, which is related to age and developmental factors. If the obstacle arises only because of slow mental development and not because of an inherited disease, the obstacle will disappear by itself along with the growth of the student. Didactic obstacle is an obstacle that occurs as a result of mistakes in the learning process derived from the learning system within the school

itself. Didactic obstacle depends only on the choice or project in the education system. Epistemological obstacle, according to Duval [5], was essentially a person's knowledge, which was only limited to certain contexts. If the person is faced with different contexts, the possessed knowledge becomes unusable, or she or he undergoes difficulty of using it. In this case, students' views on other concepts are disjointed and not comprehensive.

Learning obstacle in geometric material based on epistemological obstacle can be seen in the condition that students do not possess basic knowledge [7], especially the polyhedron material. If students are given non-routine exercise on the polyhedron material, students may become confused. When giving polyhedron material, students are asked to imagine the description of solid figure itself. However, students cannot, at the end, describe what they should imagine. A large and growing body of previous literature has investigated that the favorable outcome of geometry learning is still low. Some students are still found to have weak mastery in the ability to think about geometry in visualisation, analysis, and abstraction [8]. Likewise, from the teacher's point of view, geometry was still considered difficult to teach. One of the main problems was the teacher's difficulty in providing geometric instructions due to the lack of learning media [9]. From some previous studies, the causes of difficulties in geometry learning can be seen from the process that does not involve directly such between the teacher and students that students have not been able to understand the concept of geometry in depth yet. The geometry learning process in Indonesia is still similar to other countries. Geometry learning in Saudi Arabia emphasizes more on the learning system that links traditional learning with geometry learning in the process of algebraic structure [10]. Geometry learning in Canada states that teachers have less than 10% of time to concentrate on geometry learning processes [11]. Geometry learning in Asian countries still put much attention to social and technological factors that influence learning in school [12]. It can be concluded that the problem on geometry learning is not only centered on the teacher but also the learning process that links social relations to the geometrical material itself.

The process of geometrical learning can provide a good learning experience to students where they experience the process of geometry. Learning experiences that are fit with students' thinking stages demand teachers to create a more conducive learning atmosphere. Teachers are demanded to plan a good teaching procedure of geometry, especially in the spatial aspects of geometry. Geometry learning requires a high level of thinking process in that students must often practice in improving their thinking skills [2]. This condition should lead students to improve skills and build creativity in spatial science.

Rahmatina [13] revealed that mathematics learning in Indonesia tends to be taught at a formal level. The teacher only explains the operations and mathematical procedures, gives examples, and instructs students to work on similar questions. After realizing such problems, it might be much better for mathematics learning, especially geometry, to be taught indirectly at the formal level. Mathematical learning must focus on learning that is meaningful for students. Various previous studies show that meaningful mathematics learning requires an active role for students in learning. Geometry learning itself is an active, creative, effective, and fun learning that is accompanied by the use of interesting learning tools that students are able to explore concepts in order to trigger higher-order thinking skills

(HOTS) [14]. A meaningful learning environment where students' geometry skills can be improved requires student involvement in building their own knowledge.

There are four types of identified obstacles, namely cognitive obstacle, genetic and psychological obstacle, didactic obstacle, and epistemological obstacle [15]. This study attempts to focus on the obstacles to student learning in understanding the concept of geometry, especially from the aspect of epistemology. Basically, knowledge formation occurs through subsystem interactions, where one of the learning sub-systems consists of teachers, students, and knowledge systems [6]. In explaining epistemological barriers, it showed that epistemological obstacle occurs in the development of scientific thought and in practical education [15]. Zambrano and Noriega [16] said that epistemological obstacle has two important advantages: 1) they cannot respond to and understand new knowledge gained and 2) they are only able to respond to a few concepts that have been understood previously. This means that epistemological obstacle greatly affects the formation of knowledge that has been studied before. The influence of prior knowledge assists the acquisition of a new knowledge that will be obtained. Thus, the paper aims to investigate middle school students' difficulty in geometry learning, especially on the material of polyhedron.

2. Method

The participants in this study were nine junior high school students in one of the junior high schools in Padang, West Sumatera. Students were given several geometric questions and then the students' answers were analysed based on the students' difficulties in learning geometry. The method chosen for this study was a descriptive qualitative. The reason for choosing a qualitative method is because this study describes written or verbal words from people and behavior that can be observed. Besides that, this method can be useful to explore in depth about learning obstacles to geometrical concepts of junior high school students. In addition, this research attempts to reveal the types of learning obstacles to the geometry concepts of junior high school students as well as the factors that lead to learning obstacles, with data collected were in the form both words and pictures. The data collection was done using tests, interviews, and documentation.

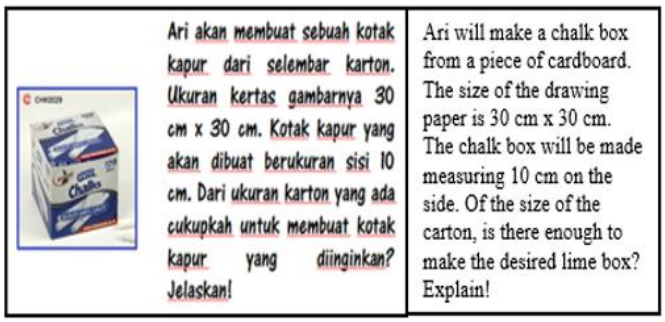
The procedure of this research was began by giving a test of mathematical ability focusing on geometry material, then arranging the interview instrument to reveal learning obstacles and its factors. Learning obstacles analysis, after that, composed hypothetical learning trajectory (HLT) geometric concepts that could be applied to the learning of geometrical concepts.

3. Result and Discussion

The result of the study includes the findings of learning obstacles identified when the participating students answered questions about geometric material, while the discussion section mainly contains learning factors obstacles in anticipating learning obstacles experienced by students during the learning process and during working on questions. The data obtained in the study will be presented in the following figures about learning obstacles based on the questions that were most unanswered by students.

The question in Fig. 2 is a problem of mathematical reasoning, which focuses on how students calculate the surface area of the cube compared to the area of

cardboard being used. Students must determine the surface area of the chalk box first and calculate the area of the cardboard that will be used to create the chalk box. Most of students' answers indicate their inability to modify the cardboard provided to create chalk boxes. Students could only compare the side of the chalk box with the side of the cardboard. This is evidenced by the response of students who answered incorrectly when working on questions. The following are some of the identified mistakes made by students in answering these questions.



Ari akan membuat sebuah kotak kapur dari selembar karton. Ukuran kertas gambarnya 30 cm x 30 cm. Kotak kapur yang akan dibuat berukuran sisi 10 cm. Dari ukuran karton yang ada cukupkah untuk membuat kotak kapur yang diinginkan? Jelaskan!

Ari will make a chalk box from a piece of cardboard. The size of the drawing paper is 30 cm x 30 cm. The chalk box will be made measuring 10 cm on the side. Of the size of the carton, is there enough to make the desired lime box? Explain!

Fig. 2. 1st matter of mathematical reasoning.

The response of Student 1 in the Fig. 3 is caused by the student having incomplete knowledge on how to use the cube surface area formula. This is supported by several other students' responses. They did not know that the problem must be found in the cube surface area first. Figure 4 is an example of another student's answer who experienced similar errors.

Based on the Fig. 4, it can be said that most students were wrong in calculating the use of existing cardboard to make chalk boxes, because students did not understand what formula was to be used to create from the cardboard. When students were expected to explore much deeper, it turned out that students did not know when to use the volume formula and the exact surface area formula in daily use. Students stated that it was hard to calculate. After given an explanation of how to make a chalk box, students began to develop their thinking skills.

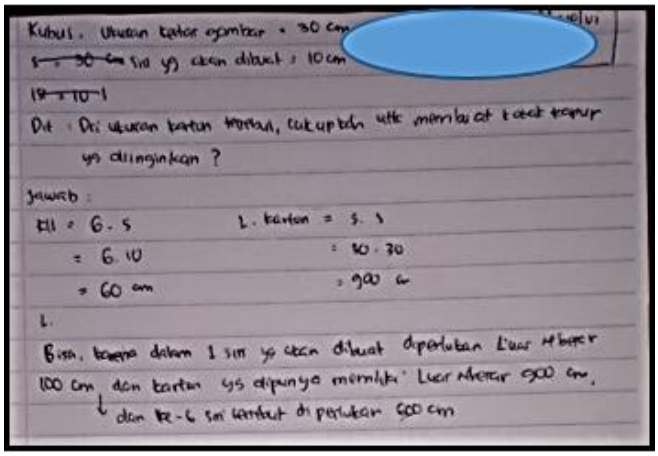


Fig. 3. Response of student 1.

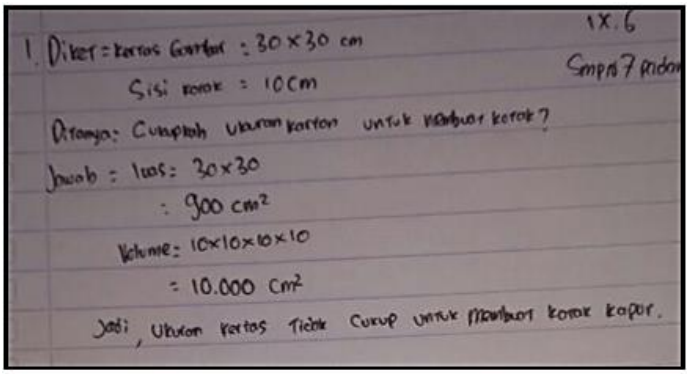


Fig. 4. Response of student 2.

The type of errors is because students do not own an understanding of the polyhedra concept. This happened because of the differences in thinking skills required as reflected on the teaching materials. Then, it can be concluded that students experienced ontogenical obstacle, where it is in line with what Suryadi (2008) stated that "ontogenetic obstacle is the obstacle faced by students because of differences in thinking demands on teaching materials that can lead to under achievement." The difference of thinking demands on teaching materials is a factor that makes students undergo learning obstacles. Teaching materials that are too challenging do not build students' mindsets as expected. Teaching materials that are too uncomplicated may also cause learning barriers. This is because teaching materials that are too easy will lead to intelligent students having less achievement.

The second question as seen in the Fig. 5 is a case of mathematical reasoning, which includes students' knowledge of comparing the volume of two tubes if they are known to have the same tube height and comparison of the tube radius. Students must have prerequisite abilities to solve the question above, namely the students' ability to identify the formula of the tube volume. Based on the analysis of students' answers from the sample that worked on the above question, some students were not able to explain the process of how to find a comparison of the two existing tube volumes. Figure 6 is another student answers.

From some of the students' answers, it can be concluded that students did not have the prerequisite ability. This is proved by the response of students who answered incorrectly when solving the question in Fig. 6. Most students did not make a comparison based on the formula of tube volume. Most students just compared the tube radius directly because the tube was known to have the same height. However, some other students could already know the process of comparing the two tubes. Figure 7 is the correct answer.

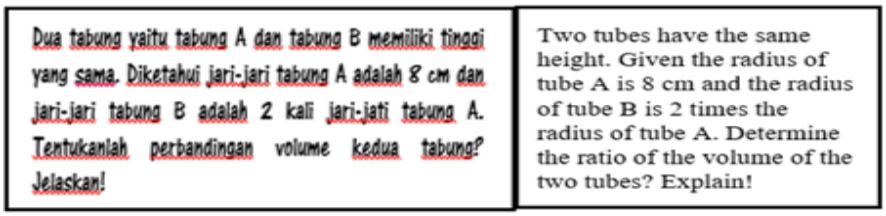


Fig. 5. 2nd matter of mathematical reasoning.

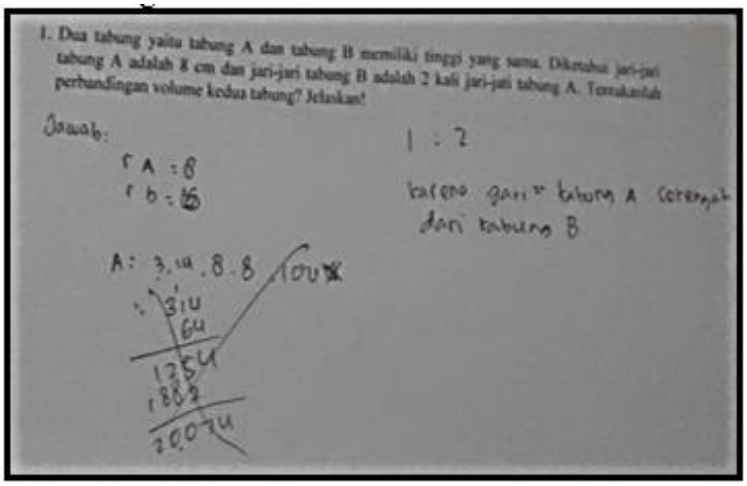


Fig. 6. The response of student 1.

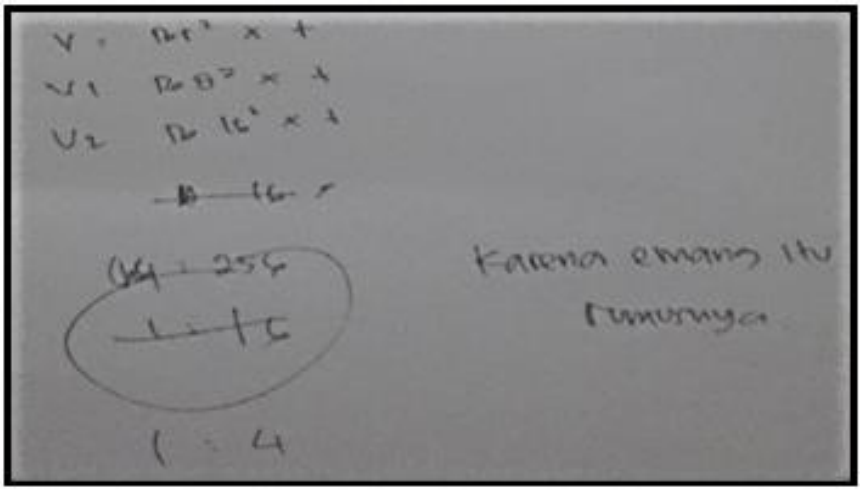


Fig. 7. The response of student 2.

Based on the response of the second student, they provided the right answer but still questioned the process. By doubting the student's process of answering the question, an interview was then conducted. After conducting the interview to both students who answered correctly and incorrectly, the study found that students with incorrect answers were confused on the above question. This is because the problem was known with the same height, and the fingers are twice of the other tube fingers. Then, the students concluded directly by comparing the radius. Students who answered correctly but did not know the process, most likely the student cheated or just made an answer that happened to be the number of the answer was correct. However, to all students asked about the tube volume formula, they could answer correctly.

Brousseau [6] defines the origin of the epistemological obstacle is essentially a person's knowledge, which is limited to certain contexts, in which, it can be

concluded that while students could understand in certain contexts, the students' ability in different contexts did not function well, leading to the condition called the epistemological obstacle. If the person is faced with a different context, the knowledge owned will become unusable, or he or she will undergo difficulty of using it. In this case, students' understanding on one concept with another concept are fragmented or not comprehensive. From the two questions that had been given, the following Table 1 showed the recapitulation of the errors made and learning obstacles found in each problem number.

Table 1. Error recapitulation and learning obstacles found.

No.		Identified errors and learning obstacle
1	1	Errors caused because of not knowing when to use the cube formula (ontogenical obstacle)
	2	Errors caused because of not understanding the process of using the cube formula in the problem (epistemological obstacle)
2	1	Error because of not understanding the purpose of the problem (ontogenical obstacle)
	2	Errors caused because of not understanding how to solve the problem (ontogenic obstacle)

Based on Table 1, it is clear that two types of learning barriers were found in geometry learning. In order to improve the quality of learning, a preventive measure is required to overcome the occurrence of learning barriers. Hence, this section will discuss how to overcome the learning constraints found. There are two proposed preventive measurements.

First, to overcome the ontogenical obstacle in understanding the concept of geometry, the students must pay attention on how the didactic situation is able to bring up the understanding of students' concepts related to the basic concepts of geometry in polyhedron. It is necessary to pay attention to the prerequisite material that is closely related to being able to master the concept of geometry, namely geometric formulas, both solid and plane figure. Prerequisite materials play an important role because if students do not have these prerequisite abilities, students will find it difficult to continue to the next material. In addition, to anticipate the ontogenical obstacle in the learning process, teaching material preparation must consider students' learning experiences.

Second, based on the cases that appear on the problem, main problem in the epistemological obstacle is that the student's knowledge is limited only to certain context. This condition results in the emergence of difficulties when students are given problems in a different context. This may occur due to the teachers or the students. First, if it occurs due to the teacher, the teacher tends to provide a single way or knowledge to the students when teaching a concept. Second, if it occurs due to students' problem, it is because students are incapable to keep their pace with the teacher's explanation. There are many occasions that the teacher teaches and explains to students, but students understand only one-sidedly. Each material has different levels of difficulties and it is undeniable that every student has different difficulties for each mathematical concept that they get from the learning process in the classroom.

Based on the above problems, the anticipation of solving the required problem is a way to bridge students in students' mathematical reasoning. How the teacher explains must extend to several contexts, which provide several examples students can reflect upon in order to improve their thinking skills. The role of the teacher in providing scaffolding is very important [17], especially for some students who experience difficulties in both understanding mathematical reasoning and understanding other different contexts for students. Therefore, bridging students' understanding must be arranged by Hypothetical Learning Trajectory where the learning is in line with the expected goals.

4. Conclusion

Learning obstacles are a learning of geometric concepts faced by junior high school students. The identified obstacles faced by the students are ontogenical obstacle and epistemological obstacle. Ontogenical obstacle the students face in the geometry learning are shown by the students' responses, namely the confusion of working on the given questions. Epistemological obstacle is revealed when students cannot use their knowledge because teaching materials are not in accordance with the characteristics of junior high school students. The problem found are students' inability to employ the problem solving method in a different way. The evidence suggests that learning obstacles provide an overview to the teacher to be used as a source in making Hypothetical Learning Trajectory or learning designs that can be used in the learning process to improve the quality of planned learning. In preparing a didactic design, it is necessary to analyse the potential learning obstacles that are in accordance with the stages of students' development. Then, in giving geometry questions, the teacher should ensure that students have sufficient experiences in working on mathematical reasoning questions because this may possibly result in an epistemological obstacle.

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