



Analyzing Students' Learning Obstacles on Distance Material in Three Dimensional

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Abstract: This study was intended to identify learning obstacles faced by students on the distance between two points and the distance between point-to-line materials. The data in this study was obtained through a test, interview, and documentation of students who have learned the materials. The research method used was the qualitative method with a case study approach. This study involved 33 students of class XII and a teacher as a participant. Learning obstacles found in this study were ontogenical, didactical, and epistemological obstacles. The ontogenical obstacles were the students' lack of basic geometry ability and counting operations of the square root which caused the students to make mistakes in applying the Pythagoras formula, determining the position of perpendicular lines, as well as completing arithmetic operations of the square root. The didactical obstacle was the fact that students were only emphasized on using a quick formula to solve three-dimensional problems. This fact resulted in the uncompleted concept received by students. Consequently, the students forget the proper procedure for solving the problems easily, and they tend to make mistakes in applying the quick formula. The epistemological obstacle was the lack of students' comprehension of a concept to determine the distance between a point to a line if the triangle which is formed is not a right triangle. This lack of comprehension caused the students can't solve a mathematics problem. The implication of this study is learning materials used by students should be arranged based on students' needs which consider the analysis of learning obstacles so that the learning objectives can be achieved.

Keywords: Didactical Obstacle; Epistemological Obstacle; Geometry; Learning Obstacle; Ontogenical Obstacle; Three Dimensional.

Introduction

Learning mathematics intends that students have mathematics abilities, there is problem solving, communication, connection, reasoning, and representation (Mundy, 2000; Wu, 1996). The same thing was also stated by Widana (2018) that learning mathematics can train students' critical thinking and reasoning to make a conclusion, make good evaluations and decisions on problem solving, and develop the ability to communicate ideas through various ways and forms.

Geometry becomes an important aspect of learning math that must be understood by students because geometry concept is very closely related to daily life (Clements & Sarama, 2011; Panaoura & Panaoura, 2014; Rofii et al., 2018). This fact was supported by the

statement stated by Hogg (2006); Tall (2008) regarding important reason of studying geometry. First, geometry uniquely connects mathematics with the real physical world. For example, pyramid which is the representation of rectangular pyramid. Second, geometry uniquely enables ideas from other areas of mathematics to be pictured. For example, presentation of many members of a set using a Venn diagram consisting of rectangle and circle form. Third, geometry nonuniquely provides an example of a mathematical system. For example, proofing Pythagoras formula in a right triangle using area concept.

The collective statement above implies the impression of the importance of having good geometric abilities. But, the results of students' mathematics learning, especially in geometry material, are still relatively low. Bailey et al. (2014); MdYunus et al. (2019)

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stated that students' mathematics achievement in the world on the geometry material still becomes things that are not easily achieved by students at school. This is supported by several studies conducted previously showing that even high school students have only little knowledge or experience related to geometric properties (Jiang, 2008). This is in line with the research that has been conducted by Babys (2017) on high school students, revealed that the high school students' comprehension about geometry concept was still belong to low especially on the material about distance and angles between two objects. Besides, an information was also obtained from report by National Assessment of Educational Progress (NAEP), less than 50% of students class medium could solve problems involving on seeing picture of three dimensions represented on the surface of two dimensions (Ben-Haim et al., 1985).

According to Alghadari et al. (2020) one of the factors which cause students' achievement in geometry not yet satisfying is the lack of quality and activity-oriented geometry learning materials which can lead students in using geometry concept systematically. As happened in one of high schools in Bandung, the cause of the learning obstacle was the lack and the error presentation of learning materials on the book as well as learning materials used by the students (Setiadi et al., 2017). Referring to the literature Kusumaningsih et al., (2020), obstacle were found in learning congruence in one high school caused by the teacher taught only with books used in school, while the books only present basic theory. Based on that description, then the learning materials or the book used in the learning process turns out could give impression on results of students' achievement.

Hermanto and Santika (2016); Noto et al. (2019) stated that high school students are expected to learn reasoning geometric when they face evidences. This is in accordance with the demand of high school curriculum that expects students to be able to leap to the high-level development and focus on the three-dimensional material which include connection among points, lines, planes in three dimensional objects, and various thing that appears as the consequence of the existence of the connection. Study in geometry was mentioned in line with Travers opinion in Dadang and Roskawati (2015) which stated that: "Geometry is the study of the relationships among points, lines, angles, surfaces, and solids".

High developmental leap in learning for most students are impossible to be done so it causes their geometric development thinking hindered (Kereh et al., 2013). The blocked geometric development thinking indicates the existence of error experienced by the student during the learning process. Every students' error in learning is the impact of the existence of learning obstacles. Before making mistake, students must be

experiencing learning obstacles. This is in line with the description of Hermanto and Santika (2016) that students in class XII of senior high school sometimes experience learning obstacle in learning geometry material, specifically three dimensional material.

Some of the facts above are complemented by the teacher's ignorance of student learning obstacles in learning geometry material. Learning obstacles may be caused by the existence of learning difficulties experienced by students. According to Kereh et al. (2013), learning difficulties in mathematics may happen in every stage/level during the students' school period, even in adults (collage students). Learning obstacle which is experienced by students in comprehension material cause them not capable in answering question correctly. Mistakes which are made by students indicates the existence of learning obstacles that they experience. Brousseau (2002), divide learning obstacle into 3 types, namely: (1) ontogenical learning obstacles that occur because of mental readiness factor, (2) didactical learning obstacles that occur because of error presentation that cause misconceptions, and (3) epistemological learning obstacles which is caused by the students' comprehension about a concept which is incomplete.

Based on description above, researchers consider there is a need for analyzing students' learning obstacles in solving three dimensional questions because the results from this analysis may be used as a reference and evaluation for teachers to reanalyze every textbook they use as well as in preparing learning design to minimize learning obstacles. Based on the description that has been stated, the objective of this study is to identify learning obstacles faced by students on distance between two points and distance between a point to a line material.

Method

Based on objective of this study, the research method used is qualitative research method with case study approach. Qualitative research with case study approach aims to obtain more in-depth data with natural condition about learning obstacle experienced by students on the three-dimensional material, sub material distance between two geometry objects. The amount of research subject involved in this research were 33 students of class XII originating from the same class in one of Madrasah Aliyah in Tolitoli, Central Sulawesi. This research subject was chosen regarding the diversity ability of the students in one class, and the students who have learnt three dimensional material. Data collection techniques carried out in this research include observation, test, and interview. The subjects of the interview were the students who have done the test, and the result of the test indicates the existence of learning

obstacle experienced by the students. Then four students were selected for interview using semi-structured interview in order to obtain more in-depth information.

The data obtained were then processed and analyzed using qualitative data analysis techniques as follows: identifying students' errors in tests, choosing a number of students' answers suspected to have the indication of the existence of learning obstacles, identifying learning obstacles on the results of observation of the learning process on the sub material distance between two geometry objects on three dimensional, doing interview, identifying learning obstacle on the result of the test and students' interview, presenting the result of data analysis descriptively, and drawing conclusion. Overall, the research process can be seen in the following scheme:

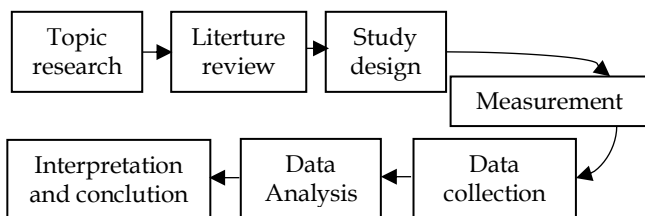


Figure 1. Research stage scheme

Result and Discussion

Ontogenical Obstacle

Researchers found there were students who experienced ontogenical obstacle in three dimensional material. This can be seen from a number of mistakes made by a student in answering question numbers 1a, 1b, and 2a:

a. Jarak titik A ke P dimana P adalah titik tengah GS

$AC^2 = AP^2 - CA^2$

$= \sqrt{5^2 - 2^2}$

$= \sqrt{25 - 4}$

$= \sqrt{21}$

$= 4\sqrt{5}$

Annotations:

- Error in determining the length of AP.** To determine the length of AP, the length of AC need to be found by considering ABC or ADC triangle.
- Error in determining the length of CP.** It should be: $CP = \frac{1}{2}CG = 5$
- Error in simplifying the root form.**

Figure 2. The 4th student's answer on Number 1a

$\Rightarrow HB^2 = AB^2 + HA^2$

$= \sqrt{2^2 + 5^2}$

$= \sqrt{4 + 25}$

$= \sqrt{29}$

$= 5\sqrt{4}$

Error in simplifying the root.

Figure 3. The 4th student's answer on Number 1b

$PV^2 = 4p^2 + AP^2$

$= \sqrt{64 + 0^2}$

$= \sqrt{64\sqrt{3} + 64}$

$= 10\sqrt{3}$

$= 11\sqrt{10}$

Annotations:

- Error in applying Pythagoras formula.**
- Error in adding root form.**
- Error in simplifying root form.**

Figure 4. The 4th student's answer on Number 2a

From Figure 1, Figure 2, and Figure 3, it can be seen that the prerequisites theory possessed by Student 4 (S4) in studying three-dimensional material is still less. After an interview done with that particular student, it is obtained a number of information, namely: S4 was still confused in choosing which triangle should be used to determine the distance between the two points. Besides, S4 also found difficulty in seeing the straightness between two lines on geometry, S4 even used Pythagoras formula on a triangle which is not a right triangle. Then S4 also admitted that he still felt confused in addition and subtraction operations in the form of the root as well as simplifying root form, for example $\sqrt{21}$ changed to $\sqrt{16 + 5} = 4\sqrt{5}$. He did the same thing in simplifying the form $\sqrt{29}$ to $\sqrt{25 + 4} = 5\sqrt{4}$.

Sidik et al. (2021) explain that ontogenical obstacle is a type of difficulty related to students' readiness in learning, consisting of psychological, instrumental, and conceptual. Psychological obstacle (students' dislike), instrumental obstacle (less comprehension of prerequisites theory related), and conceptual obstacle (demand for students to think higher or lower than their capability). In accordance with the errors description and learning obstacles experienced by the student, then it is concluded that the student experienced instrumental obstacles.

Didactical Obstacle

Based on the results of data collection, researchers found a number of suspected students who experienced didactic obstacles on sub-material distance between two geometric objects, three-dimensional material. This can be seen from a number of mistakes made by students in determining the distance between two points:

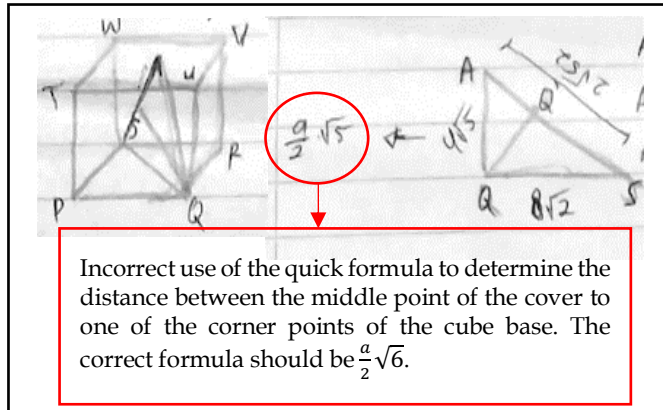


Figure 5. The second student's answer on Number 2b

In figure 4, it can be seen that student 2 (S2) did error in using the quick formula. In the interview, it is revealed that S2 did not use Pythagoras formula since during the learning process in class, the quick formula is more commonly used. Besides, S2 admitted that he did not remember the formula certainly when solving that question. Error in this question was also found in some other students, one of them is as follows:

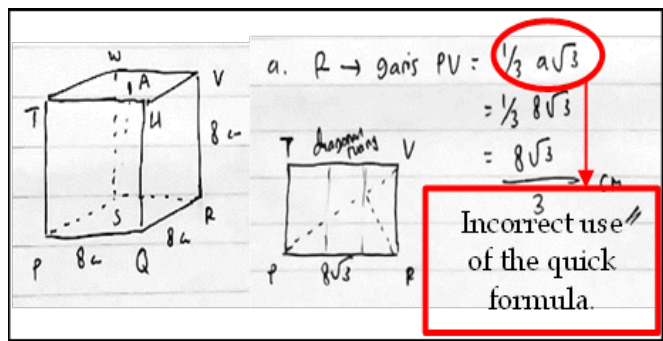


Figure 6. The third student's answer on Number 2a

In figure 5, it is clearly seen that student 3 (S3) did error in using quick formula. In the interview, it is revealed that S3 used quick formula in order to complete the question quickly, however, he did not even know where the formula was obtained from. He just knew that quick formula from what the teacher taught. This habit of using quick formulas may cause students to get less experience in constructing the distance between one point to other geometric objects, whereas in determining the distance between point R to PV we can use $L_1 = L_2$ by reviewing the PRV triangle.

The didactical obstacle is a learning obstacle that is caused by didactic design circumstances used or teacher didactic intervention (Suryadi, 2013). By teaching quick formulas to students, indirectly the teacher has intervened in the discovery process as well as the students' concept comprehension. Whereas a teacher actually needs to own ability to create didactical relations between students and learning materials so that an ideal didactic situation for students may be created (Suryadi, 2013; Winsløw et al., 2013).

Epistemological Obstacle

Based on the results of data collection, researchers found a number of suspected students who experienced epistemology obstacles. This can be seen from a number of errors they made, as follows:

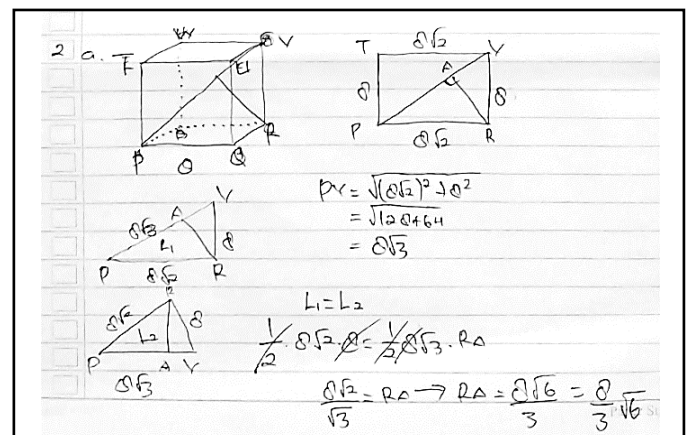


Figure 7. The first student's answer on Number 2a

It can be seen in figure 6, S1 has answered the question related to determining the distance between point R to the line segment PV on the cube PQRS.TUVW correctly. In the interview, S1 stated that the length of line RA is the distance between R to PV which can be calculated by using the area of triangle concept. This is in accordance with what the teacher has taught in class. However, S1 made an error in completing question Number 2b, as follows:

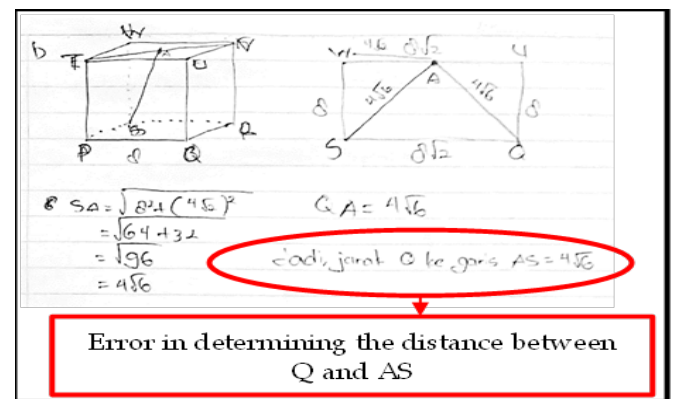


Figure 8. The first student's answer on Number 2b

It can be seen in figure 7, S1 made error in determining distance between point Q to the AS line. Based on the results of the interview, S1 stated that SAQ triangle is a right triangle and QA is the distance between Q to the AS line. From the interview, it is revealed that even though S1 has been able to answer questions related to the distance between a point to a line on geometry (seen in answer number 2a) using the triangle concept, S1 faced obstacles because of his less comprehension related to the concept of determining the distance between a point to the line if the triangle formed is not a right triangle. S1 is able to finish this kind of problem only if the triangle formed is a right triangle, however, even if the triangle formed is not a right triangle, the student still tried to finish it using the right triangle concept. So, it is suspected that S1 experienced epistemological obstacles. Another student who experienced an epistemology obstacle namely S2. The mistake can be seen as follows:

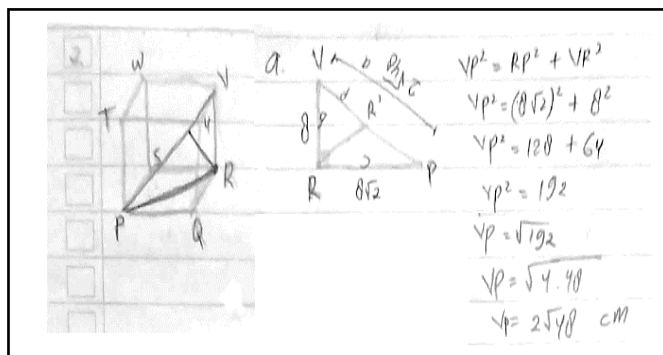


Figure 9. The second student's answer on Number 2

It can be seen in figure 8 that S2 has been able to determine the length of VP in the triangle formed in number 2a. In the interview, S1 stated that RR' is the distance which is being questioned in 2b and because QRVU and PQRS plane is upright straight, it formed a right triangle. However, RR' could not finish his calculation since he did not know what he should do next to finish it. This fact shows that S2 has understood the concept of a right triangle so that he could use it to find out the length of one side which is still unknown if two other sides are known. However, S2 experienced an obstacle which is caused by limited comprehension, in which he only understands one concept in certain content, it causes the student experienced a limited way of thinking on another matter. Besides, it is also obtained that S2 student experienced other epistemology obstacles which can be seen in his work on question number 2b. The mistake can be seen as follows:

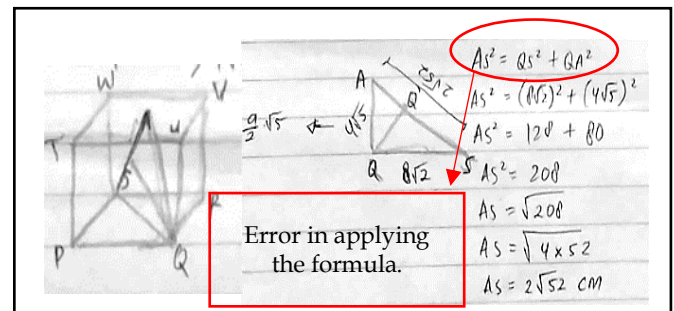


Figure 10. The second student's answer on Number 2b

It can be seen in figure 9, S1 made error in determining the type the AQS triangle formed. In the interview, S2 stated that AQS triangle is a right triangle whose right angle is in Q. So, to find out the length of AS line segment, S2 solved it using Pythagoras formula. From the interview it was also revealed that S2 could not continue looking for QQ' which he thought that it was the distance between Q to AS. Based on the result of S2's test and the interview against him, it can be concluded that S2 experienced epistemology obstacle in completing question number 2b.

According to Duroux in Brousseau (2002), epistemological obstacle is learning obstacle that appears because of the limited knowledge of someone in certain context. If students are faced by different context, then the knowledge they possessed cannot be used or they will experience difficulty in using it. Fitria & Maarif (2021) stated that the indicators of epistemology obstacle are conceptual obstacle, procedural obstacle, and operational technique obstacles. On two cases of epistemology obstacle that has been mentioned, the two students experienced conceptual obstacle.

Conclusion

Based on the results and data analysis, it can be concluded that there are a number of learning obstacles experienced by high school students in learning three-dimensional material, on sub-material determining the distance between two geometry objects, including (1) Ontogenical obstacle, the lack of base ability on the geometry and counting operations in the form of root owned by the students which cause them to make an error in applying Pythagoras formula, determining the perpendicularity location of the lines as well as completing counting operation in the form of the root. (2) Didactical Obstacle, the students were only emphasized on using a quick formula to complete three-dimensional questions. This fact resulted in the incomplete concept received by the students. The students then easily forget the proper procedure for solving the problems, and the students tend to make mistakes in applying a quick formula. (3) Epistemological obstacle, this is related to the lack of students' comprehension related to the concept of

determining the distance between a point to a line if the triangle which is formed is not a right triangle. This lack of comprehension caused the students unable to complete the given question. The findings of this research may be a fundamental description to create a didactic situation that considers the students' needs so that learning obstacles that may be experienced by the students can be minimized, so the student's comprehension of learning three-dimensional material can be more optimal. Moreover, the existence of the obstacles may also be the consideration for the teachers to do book analysis on sub-material geometry since the characteristics of books used by teachers and students may be the reasons how and why the learning obstacles exist.

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