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Learning Obstacle of Prospective Mathematics Teacher on Triangle Material

H. Fitriyani[1,2], Y. S Kusumah[1], and V. F. Rianasari[3,4]*

[1]Universitas Pendidikan Indonesia, Bandung, Indonesia
[2]Universitas Ahmad Dahlan, Yogyakarta, Indonesia
[3]Ateneo de Manila University, Quezon, Manila
[4]Sanata Darma University, Yogyakarta, Indonesia
Correspondence: E-mail: harina.fitriyani@pmat.uad.ac.id

ABSTRACTS

The objective study is to produce a description of the learning obstacle of prospective mathematics teachers on the topic of triangles through the problem-solving proses and answers written by students. This study used a descriptive qualitative method and involved students enrolled in a mathematics education study program at a university in Yogyakarta, with a total of 26 students. Data collection is done through written tests and interviews. Data analysis is carried out using a descriptive method, which involves data reduction, presentation, and drawing conclusions. The research results revealed that prospective teachers faced several learning obstacles when solving triangle problems, including ontogenic, epistemological, and didactical obstacles.

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1. INTRODUCTION

Geometry is one of the mathematical studies that has many practical applications in human life. Almost every object around us is a representation of geometric shapes. However, the objects studied in geometry are abstract in nature, which often makes students, or even college students struggle to learn geometry. As a result, learning obstacles in geometry are often encountered during the learning process or when solving geometry problems. According to Duroux (Septyawan, 2019), learning obstacles are gaps in knowledge rather than a lack of knowledge. To understand and explore the learning obstacles, it is necessary to consider various perspectives and their interconnections (Septyawan, 2019). Based on their sources, learning obstacles can be divided into three types: ontogenic obstacles, didactical obstacles, and epistemological obstacles (Suryadi, 2019; Septyawan, 2019).

According to Suryadi (2019), ontogenic obstacles are barriers related to the level of difficulty in didactic situations that can hinder the learning process. In lectures, the limitations of instructors in designing didactics that can accommodate all students' capacities and the limitations of students in adapting their abilities to the designed didactics are inevitable. This then triggers the emergence of learning obstacles among students. Suryadi (2019) divides ontogenic obstacles into three types: psychological ontogenic obstacles, which are related to students' lack of readiness in terms of motivation and interest in a specific subject matter. Instrumental ontogenic obstacles refer to students' lack of technical readiness, which is essential in the learning process and can be revealed, for example, through errors in problem-solving processes. The final type of ontogenic obstacle is a conceptual ontogenic obstacle, which is related to students' lack of readiness based on previous learning experiences, such as insufficient knowledge about prerequisite concepts that support a particular subject matter.

The second type of learning obstacle is an epistemological obstacle, which can be interpreted as a barrier due to students' limited understanding and mastery of a concept, as it is only associated with a specific context (Suryadi, 2019). This type of obstacle arises when students can solve problems that are typically given in class but fail when presented with different contexts. Students can only solve problems that have similarities with example problems or problems from the textbook they have read. The final type of learning obstacle is a didactical obstacle, which occurs due to the didactic system, such as the sequence of presenting materials or the curriculum stages in classroom learning (Suryadi, 2019).

In the study of geometry, research on students' learning obstacles has been conducted at the junior high school level (Cesaria & Herman, 2019; Mawarni & Dahlan, 2019; Febrianto, et al., 2019; Diana, et al., 2019; Adiwinata, et al., 2018) and found that students experience ontogenic obstacles and epistemological obstacles. At the university level, learning obstacles have also been found in geometry courses, as indicated by Unaenah (2017) study, which states that there are ontogenic obstacles, didactical obstacles, and epistemological obstacles among mathematics education students in the study of basic mathematical concepts of geometry. Similarly, Noto et al. (2019) research revealed that students face learning obstacles related to the concept of geometric transformations, including difficulties in applying concepts, visualizing geometric objects, understanding concepts, and providing mathematical proofs.

Investigating these learning obstacles in geometry courses at the university level is intriguing as it can help instructors improve didactic designs and anticipate potential obstacles, thereby enabling students to understand and master geometric concepts effectively. Thus far, students' understanding of geometry still needs further improvement. This can be seen, among other things, in their predominantly visual level of geometric thinking (Fitriyani et al., 2018; Rafianti, 2016; Utomo & Wardhani, 2015; Darta, 2013; Jupri, 2005). Therefore, it is worth exploring the potential learning obstacles faced by prospective mathematics teachers, particularly regarding triangle-related content. To what extent students experience learning obstacles as future mathematics educators is an important aspect to investigate.

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2. METHODS

This study is descriptive qualitative research. The subjects were selected from first-semester students of the mathematics education study program in 2019 at one of the teacher training institutions in Yogyakarta, with a total of 26 students. The data collection techniques employed were written tests and unstructured interviews. The test given to the students consisted of two essay questions. The questions covered concepts related to triangles, congruent triangles, similarity of triangles, the Pythagorean theorem, and the concept of line bisector of a triangle. Data analysis was conducted using a descriptive approach, including data reduction, data presentation, and drawing conclusions (Miles & Huberman, 2014).

3. RESULTS AND DISCUSSION

The research findings indicate the presence of learning obstacles among students when solving problems related to the concept of triangles. This is evident from the students' responses to the given questions, supported by in-depth interviews conducted by the researcher.

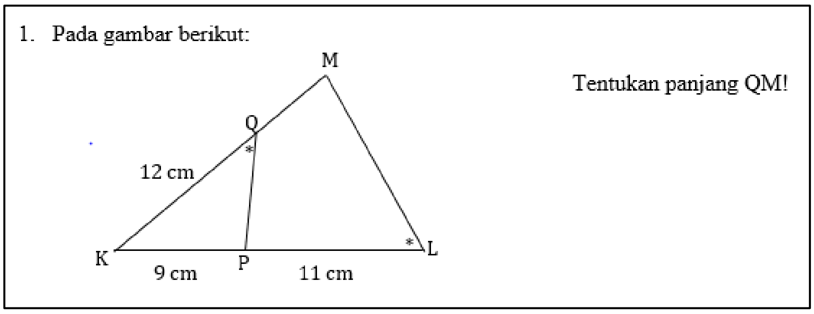

Figure 1. Problem 1

To solve the problem in Figure 1, mastery of the concept of similarity is required. In this case, students need to have sufficient learning experience to identify triangles that are similar by paying attention to the given notations in the triangle. They are also expected to understand which sides and angles correspond in the two similar triangles in order to make comparisons between the corresponding sides and determine the length of the line segment in the problem. Based on the analysis of student responses, it was found that 19.23% of students answered correctly, while 80.77% of students answered incorrectly using various approaches. In general, there were four different incorrect answer variations among students for problem 1.

Based on the students' responses to problem 1, it was found that eight students provided incorrect answers by using the concept of the Pythagorean theorem. Here is an example of one student's incorrect response, namely student 18 (S18), for problem 1.

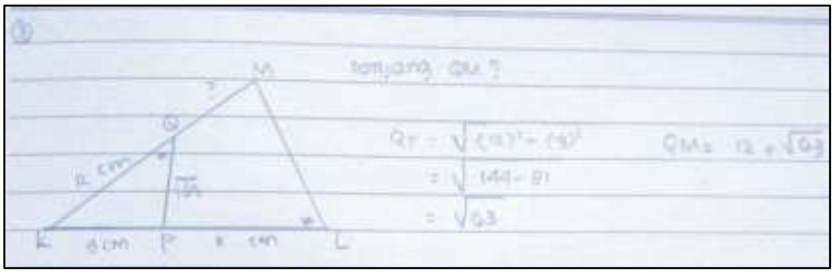

Figure 2. S18's response to Problem 1

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S18's response, as shown in Figure 2, indicates that S18 considered triangle KQP to be a right triangle, leading S18 to use the Pythagorean theorem to find the length of side QP. S18 interpreted the asterisk (*) symbol in the problem as indicating a right angle and assumed that side PQ is equal in length to side QM. Consequently, S18 tried to find the length of QM by adding the lengths of KQ and PQ together. The following is an excerpt from an interview with S18 regarding their initial thoughts upon seeing problem number 1.

P : Why did you use the Pythagorean theorem?
S18 : There are two overlapping triangles, triangle KLM with a right angle at L and triangle KQP with a right angle at Q, so I used the Pythagorean theorem.
P : How did you know there were right angles at L and Q?
S18 : There is an asterisk (*) symbol indicating it

Additionally, there is another student, namely S6, who interpreted triangle KPQ as a right triangle based on the position of sides KP and PQ, which appear to be almost perpendicular. Here is an excerpt from the conversation with S6:

P : Can you explain the reason for solving problem 1?
S6 : Honestly, I was confused about how to solve it. So, I used the Pythagorean theorem.
P : What made you think of using the Pythagorean theorem and not any other formula?
S6 : Because the Pythagorean theorem is closely related to triangles. So, I used the Pythagorean theorem.
P : What type of triangle is it then?
S6 : It's a right triangle QKP, so I used the Pythagorean formula
P : How did you know it was a right triangle?
S6 : If you look at the shape, triangle QKP appears to be a right triangle. However, I'm still confused about how to solve it.
P : What do you mean by "look at the shape"? Are there any symbols or indications of a right angle?
S6 : There are no symbols, but the hypotenuse is longer than the other sides
P : Where is the hypothenuse?
S6 : KQ
P : Where is the right angle?
S6 : At P

Based on the results of written responses and interview quotes, it is evident that students are unprepared in key technical aspects related to understanding triangle concepts. As revealed in their responses, several students have overlooked important prerequisites for understanding a concept, such as misinterpreting the symbol "*" as an indication of a right angle. The interview quote with S6 further supports the written response, indicating indications of unprepared thinking in learning, particularly in the given problem about the similarity of triangles. This observation led the researcher to identify the presence of instrumental ontogenic obstacles in the concept of triangles. Additionally, the unpreparedness in previous experiences related to prerequisite materials and the insistence on using the Pythagorean theorem as the basis for solving the problem indicates the presence of conceptual ontogenic obstacles among the students.

In addition to using the concept of the Pythagorean theorem, there were also five students who attempted to solve problem 1 using the concept of similarity, but with errors in comparing the corresponding sides of the triangles. This has resulted in a learning obstacle.

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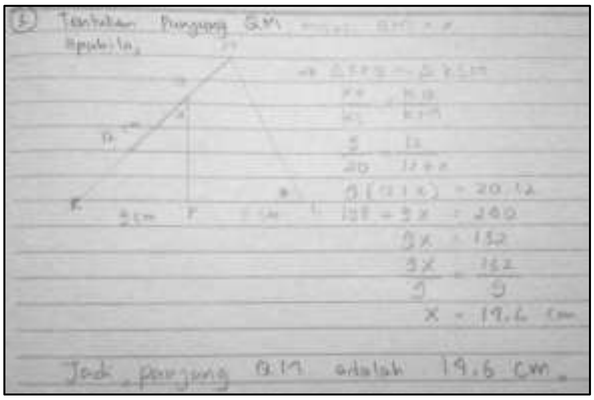

Figure 3. S22's response to Problem 1

The response from S22, as shown in Figure 3 above, indicated that the student did not have a comprehensive understanding of the concept of triangles similarity. The student should compare the corresponding sides by examining the angles at the ends of the sides in order to determine the length of QM. However, in their answer, S22 compared the adjacent sides, which are not actually the corresponding sides of the two similar triangles. The mistake made by the student in making the comparison of corresponding sides in similar triangles indicates the presence of instrumental ontogenic obstacles. To ensure the students' responses, the researcher conducted interviews with several students who had similar responses, and it was found that the students encountered difficulties when solving problem 1. The students believed that problem 1 should be solved using the concept of similarity, but they were still confused in determining the comparison of corresponding sides. The students' unpreparedness in their previous experiences related to similarity in order to solve problem 1 indicates that they are experiencing conceptual ontogenic obstacles.

In addition to the errors in comparing the corresponding sides in similar triangles, two students made errors in their arithmetic calculations. Conceptually, they correctly applied the concept of similarity, but the inaccuracy in calculations led to mistakes in their arithmetic operations. Furthermore, some students were not careful in reading the information in the problem, resulting in errors when substituting the measurements of the triangle sides in comparing the corresponding sides of similar triangles.

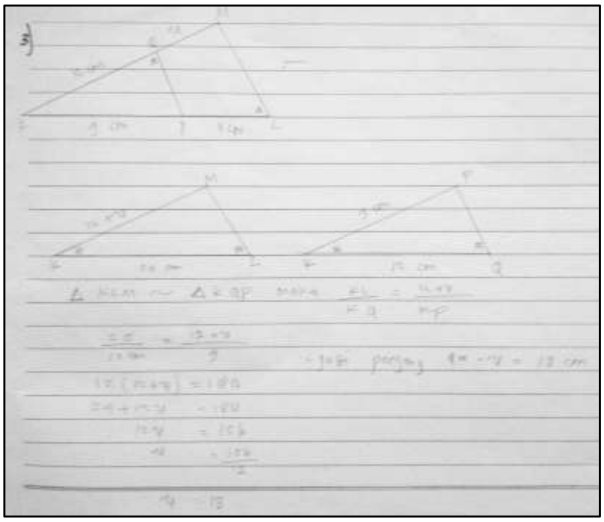

Figure 4. S5's response to Problem 1

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Based on S5's answer shown in Figure 4, it is evident that the comparison of corresponding sides in similar triangles is correct. However, S5 made an error in the multiplication operation of 12 by 12, where the correct result should be 144, but they wrote 24, leading to an inaccurate final answer. The student's mistakes in performing arithmetic operations and in substituting values corresponding to the triangle side lengths indicate the presence of instrumental ontogenic obstacles.

Another variation of errors in the students' approach to problem 1 includes using comparisons of triangle sides without a proper basis. The students merely arranged the comparisons arbitrarily to obtain an answer. Meanwhile, some other students did not attempt to solve the problem due to confusion and uncertainty about which concept to use. The presentation of students' responses to problem 1 above indicates limitations in their understanding of the concept of triangles similarity, which hinders their success in solving the first problem.

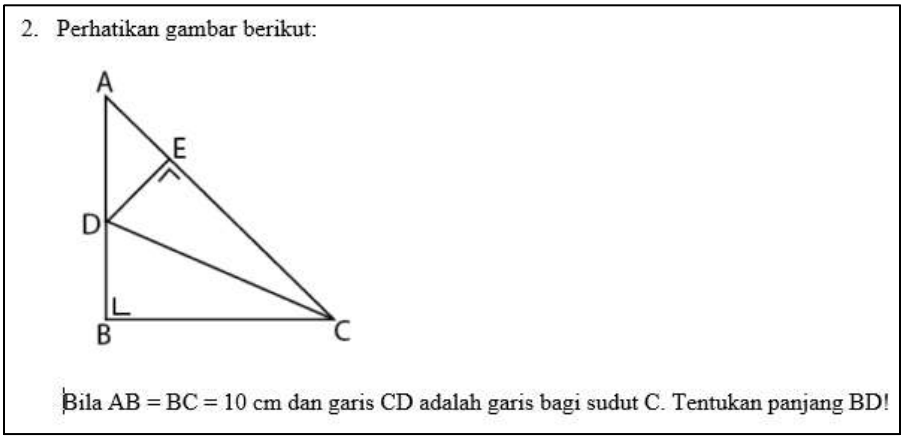

Figure 5. Problem 2

Problem 2, as shown in Figure 5, given by the researcher, encompasses the mastery of concepts such as congruent triangles, line bisector of a triangle, and the Pythagorean theorem. Students employ various approaches to solve this problem. There are at least seven different variations in the methods used by students to solve problem 2. However, out of all these variations, none of the student's answers are correct.

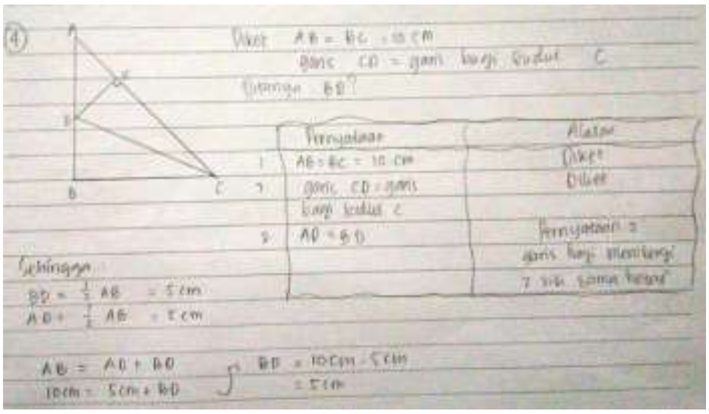

Figure 6. S2's response to Problem 2

There are a total of 11 students who answered problem 2 in a similar approach to S2 (Figure 6). This student used the information about the angle bisector of angle C and thought that

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the angle bisector divides the side in front of it into two equal lengths. The following interview excerpt supports the written response from S2:

P : Why did you answer problem 2 like that? What is your reasoning?

S2 : In my opinion, because line CD is the angle bisector of C, it divides AB into two equal lengths, so AD = BD. Since the length of AB is 10 cm, then the length of BD is ½ of AB, which is ½ × 10 = 5. So, the conclusion is that the length of BD is 5 cm.

The interview excerpt with S2 above further strengthens the suspicion of the presence of learning obstacles among the students. The students' lack of technical readiness in interpreting the angle bisector of a triangle, where the angle bisector is also considered to divide the side in front of it into two equal lengths, indicates the presence of ontogenic instrumental obstacles. The students struggle to differentiate between the angle bisector and the median of a triangle. They only focus on the information about the angle bisector without utilizing other concepts. However, to solve problem 2, at least a prerequisite understanding of congruent triangles and the Pythagorean theorem is required. This indicates the presence of ontogenic conceptual obstacles, specifically a lack of mastery of the prerequisite material concerning congruent triangles.

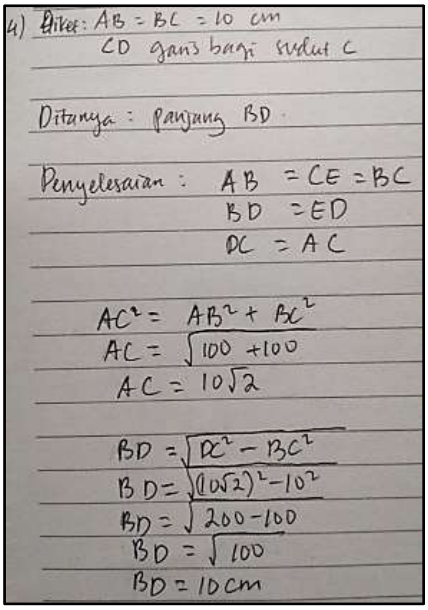

Figure 7. S9's response to Problem 2

In addition to using the concept of the angle bisector to solve problem number 2, six students approached problem number 2 using the Pythagorean theorem, as seen in the response of S9 in Figure 7 above. S9 utilized the Pythagorean theorem by first applying it to triangle ABC to find the length of side AC and then to triangle BCD to find the length of BD. The result obtained was that the length of BD was 10 cm. This means that BD = AB = 10 cm, even though point D lies between points A and B. The following is an excerpt from the interview with S9 to explore the reasons why S9 used the Pythagorean theorem in solving problem 2.

P : Why did you answer problem 2 using this method?

S9 : I found CE = BC because I observed the kite-shaped figure BCED, so the length of side BC = CE and BD = DE

P : Why is $DC = 10\sqrt{2}$?

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S9 : Because DC = AC, that's my own conclusion, as I see DC is not only an angle bisector but also the hypotenuse of triangle BCD

P : What is your reason for this conclusion?

S9 : I said that AC is equal to DC because both of them are hypotenuses

P : What is the reason? Do two hypotenuses imply having the same length?

S9 : Not necessarily, but I noticed that side BC is adjacent, and both triangles ABC and DBC have a right angle at B. Therefore, I think DC=AC.

P : What is that relationship called?

S9 : Maybe it's congruence

Based on the excerpt from the interview, it indicates the presence of an ontogenic obstacle instrumental in the form of the absence of logical thinking abilities of students when obtaining the calculation result that BD = 10, even though point D lies between points A and B while the length of AB = 10, as well as the inconsistency in interpreting the angle bisector in the triangle. Meanwhile, the unpreparedness of students related to prerequisite knowledge about congruent triangles indicates the presence of an ontogenic obstacle conceptual within the students. From the written responses of the students and supported by the interview results, it is evident that the students are not yet accustomed to interpreting multiple concepts within a single problem, such as the concept of congruent triangles, the meaning of the angle bisector in a triangle, and the application of the Pythagorean theorem in different forms and contexts.

Additionally, there were also three students who used the concept of congruent triangles to solve problem 2. However, their problem-solving steps were not completed. In fact, some were able to prove that triangles BCD and ECD were congruent but were unable to continue their solution to find the length of BD.

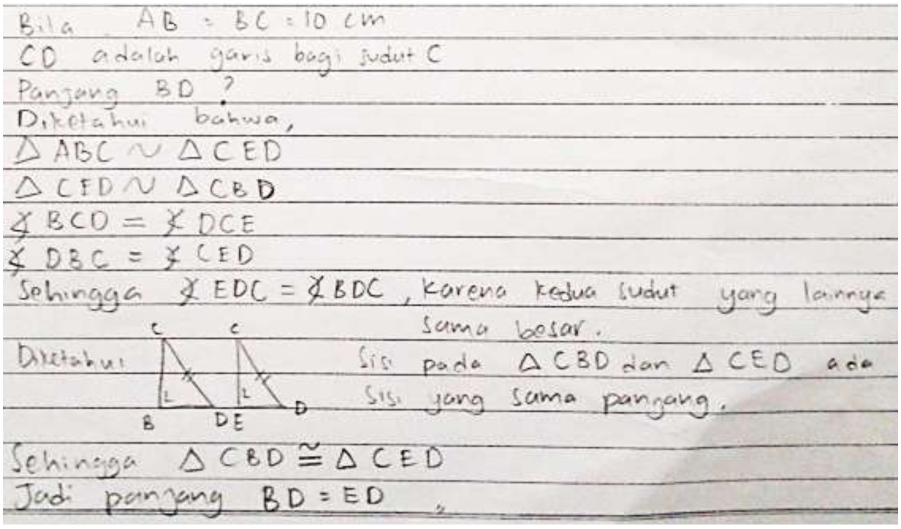

Figure 8. S22's response to Problem 2

The written response from S22, as shown in Figure 8 above, indicates that S22 has understood the fundamental concept used in problem-solving, which is the concept of congruent triangles. However, S22 overlooked the concept of the Pythagorean theorem, which could be applied to the right triangles ABC and DEA to find the length of BD. This demonstrates the unpreparedness of the student in identifying symbols in geometric figures, such as the notation for right angles and the presence of right triangles in the geometric figure, and subsequently using the concept of the Pythagorean theorem to solve the problem. Therefore, there is an ontogenic obstacle conceptual for the student. Additionally, the

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unpreparedness of the student regarding the prerequisite knowledge of the Pythagorean theorem, which should be used in problem-solving, indicates the presence of an ontogenic obstacle conceptual for the student.

In addition to the student's responses and in-depth interviews regarding their work on the given problems, the researcher also explored students' perspectives on the Plane Geometry course through interviews. This can be seen in the following excerpt from an interview with one of the students.

P : How interested are you in the topics taught in the Plane Geometry course? Please explain.

S1 : Not very interested because I am weak in this subject.

Similar sentiments were expressed by several other students. Some other students stated that they were quite interested in learning plane geometry, which includes the concept of triangles. Additionally, the researcher conducted interviews regarding the students' readiness to participate in the Plane Geometry course. The following is an excerpt from an interview with one of the students:

P : How prepared are you to take the Plane Geometry course? For example, did you study the material beforehand, or how did you prepare? Please explain.

S9 : I did not study the material beforehand because I still struggle to understand it when studying on my own

In addition to student S9, several other students also expressed similar sentiments regarding their readiness to learn before taking the Plane Geometry course. Both of the above interview excerpts explicitly indicate that the enthusiasm and interest of some students in taking the Plane Geometry course are not sufficiently high. Some students did not prepare for their studies beforehand, citing difficulties in understanding the material when studying alone. This can actually be addressed by forming study groups. During the class, it is also observed that some students are not actively engaged. Therefore, the researcher notes the presence of ontogenic psychological obstacles in the concept of triangles, where students are unprepared due to their low interest and readiness to learn.

The overall presentation above, both from the student's written responses and the interview results, actually leads to the limited ability of students to connect several concepts to solve a problem related to the concept of triangles. Moreover, there is a lack of skills in solving problems using various concepts. The implication is that students face difficulties and confusion when confronted with problems outside the context they are accustomed to. This indicates the presence of epistemological obstacles in the concept of triangles.

Various misconceptions regarding right triangles, the concept of line segment division, congruence, and similarity of triangles that have been discussed above can also be influenced by external factors such as the availability of learning resources and the teaching methods of the lecturer. In relation to this, the researcher suspects the presence of potential didactic learning obstacles in the concept of triangles, especially in the Plane Geometry course. Based on interviews with several students, it was found that students are not provided with enough exercise problems, especially those related to calculations, and the pace of delivering the material is fast. Regarding the availability of learning resources, the following is an excerpt from an interview with one of the students:

P : Is there anything lacking in relation to the learning resources for the Plane Geometry course?

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S1 : Maybe the student handbook, which contains a wide range of topics in plane geometry, including both problems sets and examples.

Similar sentiments were also expressed by several other students, stating that the learning resources are insufficient in terms of problem sets and proof-related problems. Indeed, for the Plane Geometry course, the researcher provides learning resources in the form of summarized material in a book. However, students are encouraged to use other references if they align with the topics discussed in the syllabus. The researcher believes that the learning obstacles experienced by students are also related to didactic obstacles.

Based on the description above, the limited concept image of students regarding the concept of triangles, including the concepts of similarity and congruence of triangles, leads to learning obstacles. The students' lack of preparedness in technical aspects that are key to understanding the concepts of similarity and congruence, misconceptions regarding right triangles, line bisector of a triangle, similarity, congruence, and the Pythagorean theorem, indicates the presence of ontogenic instrumental obstacles in students. This includes cases where students make errors in performing arithmetic operations, which aligns with Adiwinata et al., (2018) research findings. Furthermore, the lack of readiness in previous experiences related to prerequisite materials required to solve the given problems indicates the presence of ontogenic conceptual obstacles. The given problems indeed require the ability to connect several mathematical concepts and deal with problems of different contexts compared to typical classroom problems, intending to enhance students' experience and thinking skills. However, it turns out that this confuses students, preventing them from successfully solving the given problems. Students are not accustomed to applying multiple concepts in a single problem, such as the concepts of congruence and the application of the Pythagorean theorem in different forms and contexts to solve problem 2, as found in the research by Febrianto (2019). Therefore, the researcher believes that there are epistemological obstacles for the students. The learning obstacles that occur due to unfamiliar problem types align with the research findings of Cesaria and Herman (2019), Mawarni and Dahlan (2019), and Unaenah (2017).

In order to strengthen students' meaning-making and understanding of geometric concepts, it is necessary for students to engage in solving various geometry problems by actively seeking and utilizing structures, strategically using appropriate tools, and constructing valid arguments (Contreras, 2015). Students' experiences in solving geometry problems they have not encountered in class will help them gain a deeper understanding of geometric concepts (Bjuland, 2004). Additionally, lecturers can assist students in minimizing learning obstacles by improving their teaching approaches, starting with the development of a didactic design for geometry instruction. Furthermore, instruction should emphasize the development of students' geometric reasoning skills (Brown et al., 2004).

4. CONCLUSION

There are learning obstacles that students encounter in understanding the concepts of triangles. Among the identified learning obstacles are ontogenic, epistemological, and didactical obstacles. Ontogenic instrumental obstacles are manifested in students' lack of technical readiness, which is crucial for problem-solving. On the other hand, ontogenic conceptual obstacles are indicated by students' unpreparedness regarding the prerequisite concepts necessary for solving the given problems. Psychologically, ontogenic obstacles are characterized by students' limited interest and readiness to attend the course. Epistemological obstacles are indicated by students' limited understanding of the required

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concepts for problem-solving, their inability to connect multiple concepts in problem-solving, and their difficulty in solving problems that differ from the typical problems given in the classroom. Furthermore, didactical obstacles are observed in the limited learning resources provided by lecturers, insufficient practice problems, and a teaching approach that some students perceive as fast-paced.

Based on the research findings revealing the presence of learning obstacles in students' understanding of triangle concepts, there are several suggestions that can address those obstacles. First, regarding the ontogenic obstacles, it is crucial to identify and address the specific prerequisite concepts that students struggle with and provide targeted instruction to fill those gaps. Moreover, lecturers can provide more engaging and relevant learning material to students' lives by incorporating real-life applications, practical examples, and interactive activities through hands-on activities, group work, or projects. Second, to address the epistemological obstacles, lecturers need to offer ample practice problems that vary in complexity, going beyond the typical classroom examples; to help students develop a deeper understanding of the concepts and improve their problem-solving skills. In addition, lecturers must encourage students to think critically and engage in metacognitive strategies, such as reflecting on their problem-solving processes. Lastly, to address the didactical obstacles, lecturers need to consider adapting the teaching approach to accommodate different learning styles and paces, providing opportunities for individualized or differentiated instruction. Moreover, lecturers can seek feedback from students regularly to identify areas of improvement in the teaching methods.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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