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LOWER SECONDARY STUDENTS EPISTEMOLOGICAL OBSTACLE IN SOLVING MATHEMATICAL LITERACY TASK: FOCUS ON PLANE GEOMETRY

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Abstract

This study identified and analysed epistemological obstacles experienced by junior high school students in solving mathematical literacy tasks on plane geometry material. We involved 38 seventh-grade students at a lower secondary school in Cimahi Indonesia, including diagnostic tests, semi-structured interviews, and classroom observations. The data were analysed using a thematic analysis approach to reveal various epistemological obstacles encountered by students, such as misconceptions about the properties of plane figures and difficulties in applying geometric concepts to mathematical literacy tasks. Epistemological obstacles arise due to students' inability to connect abstract concepts with practical contexts and their limited understanding of basic geometric concepts. These obstacles primarily stem from misconceptions about fundamental concepts of plane figures, the inability to apply geometric concepts in contextual situations, and procedural learning approaches that lack depth. This research contributes to developing geometry learning strategies at the junior high school level, which can ultimately improve the overall quality of mathematics education.

Keywords: Case study, Epistemological obstacles, Lower secondary school students, Mathematical literacy, Plane geometry.

1. Introduction

Epistemological obstacles in plane geometry are often related to students' inability to understand the relationships between geometric elements, such as the properties of angles and sides in plane figures. These obstacles can arise due to overly procedural teaching approaches, a lack of applicative contexts, or students' low spatial visualization abilities, closely tied to their mathematical literacy. Mathematical literacy involves the ability to perform calculations. It encompasses an individual's capacity to reason mathematically and formulate, use, and interpret mathematics to solve problems in various real-world contexts. This includes concepts, procedures, facts, and tools to describe, explain, and predict phenomena.

This capacity helps individuals understand the role of mathematics in everyday life, enabling them to make well-reasoned judgments and decisions needed as constructive, participative, and reflective citizens of the 21st century [1-9]. Several studies have been reported in Table 1. From previous research, students struggle to translate contextual problems, understand procedures, and build connections between mathematical concepts, especially in geometry and trigonometry [10-22].

This study identified and analysed the epistemological obstacles experienced by lower secondary school students in solving mathematical literacy tasks on plane geometry material using a case study method. The novelties of this research are: (i) exploring epistemological obstacles encountered by lower secondary school students in solving mathematical literacy problems, an area that has been underexplored in the context of plane geometry; (ii) the focus on plane geometry, in which most studies tend to concentrate on broader mathematical topics such as arithmetic or algebra; and (iii) investigating lower secondary students’ performance in plane geometry, offering valuable insights into their mathematical thinking development and the specific challenges they face.

2. Literature Review

Epistemological obstacles refer to the difficulties students face in understanding and applying mathematical concepts due to incorrect or incomplete understanding. Plane geometry, one of the topics in mathematics taught at the lower secondary level, plays an important role in developing students' mathematical literacy. Understanding basic concepts such as the properties of triangles, squares, circles, and other shapes is crucial for students to solve various problems involving space and shapes. However, many students encounter significant learning obstacles in understanding and applying these concepts, which impacts their ability to complete mathematical literacy tasks focusing on plane geometry [23-25].

Plane geometry is a key element in the mathematics curriculum at the lower secondary level. This topic includes basic concepts such as points, lines, angles, and two-dimensional shapes. Van Hiele explains that understanding geometry develops through different levels of thinking, where students need to progress from recognizing shapes to a deeper understanding of geometric relationships. Epistemological obstacles can cause students to remain stuck at lower levels of understanding, preventing them from advancing to higher levels (Fig. 1) [26, 27].

Table 1. Previous study on epistemological obstacle, mathematical literacy, and plane geometry.

No.	Title	Ref.
1	Pembelajaran matematika realistik di sekolah dasar: Antara harapan dan kenyataan	[10]
2	Mathematics education research: A new approach for understanding and addressing epistemological obstacles	[11]
3	Developing mathematical literacy: Key competencies for the 21st century	[12]
4	Epistemological obstacle in learning trigonometry	[13]
5	Analisis kesulitan belajar geometri materi bangun datar pada siswa SMP	[14]
6	Prototype of greenhouse effect for improving problem-solving skills in science, technology, engineering, and mathematics (STEM)-education for sustainable development (ESD): Literature review, bibliometric, and experiment	[15]
7	Augmented reality for cultivating computational thinking skills in mathematics completed with literature review, bibliometrics, and experiments for students	[16]
8	Motivation and ICT in secondary school mathematics using unified theory of acceptance and use of technology model	[17]
9	Difficulties encountered by the students in learning mathematics	[18]
10	Global research trends of mathematics literacy in elementary school: A bibliometric analysis	[19]
11	Learning mathematics formulas by listening and reading worked examples	[20]
12	Effect of guided inquiry and explicit-instructional strategies on lower basic students' academic performance in mathematics	[21]
13	Self-efficacy as a correlate of pupils' academic achievement in mathematics	[22]

3. Method

This study employed a qualitative approach using the case study method to 38 seventh-grade students selected through purposive sampling at a lower secondary school in Cimahi, Indonesia, in completing mathematical literacy tasks, particularly those focusing on plane geometry. The results of data analysis were obtained through classroom observations, semi-structured interviews, and diagnostic tests from 4 questions, there were 2 questions in which many epistemological obstacles were found in general related to understanding basic geometric concepts (Figs. 2 and 3). Data were collected through questionnaires, interviews, and classroom observations.

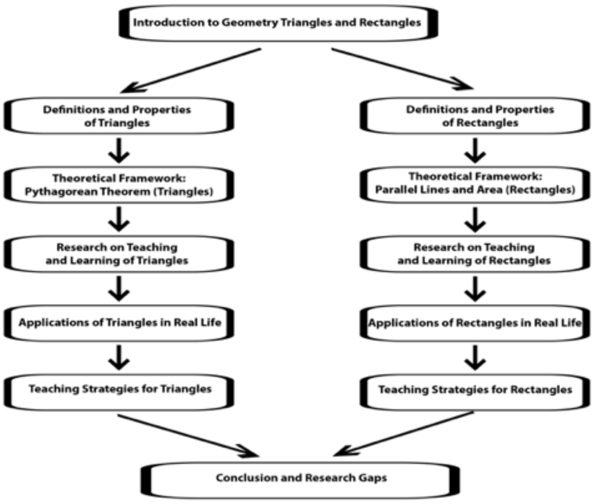


Fig. 1. Geometry of triangles and rectangles.

4. Results and Discussion

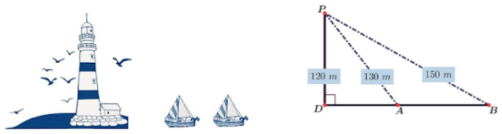
As shown in Figs. 2 and 3, data analysis revealed several findings: (i) conceptual misunderstanding (most students showed difficulties in understanding the relationships between various geometric shapes. 78% of students made errors when asked to calculate the area and perimeter of triangles and rectangles, often due to a lack of understanding of the formulas used); (ii) lack of connection to real-life experience (only 22% of students could relate geometric concepts learned to real-life situations. Students struggle to apply their geometric knowledge in everyday life contexts); (iii) limited problem-solving strategies (based on interview results, students tend to use simple and sometimes inappropriate problem-solving strategies. Only 13% of students demonstrated the ability to apply more than one method when solving geometric problems); and (iv) impact on mathematical literacy skills (these epistemological obstacles contribute to students' low mathematical literacy skills. 87% of students reported a lack of confidence in completing tasks involving plane geometry).

Epistemological obstacles related to proofs, generalizations, alternative solutions, and problem-solving in online learning. They found that students' epistemological obstacles often stem from how they understand basic concepts and connect them with practical classroom experiences [28].

This research also referred to findings from praxeological analysis in previous studies on how Indonesian students learn the concept of functions through textbooks [29]. Epistemological obstacles are often caused by inadequate or inappropriate delivery of concepts that do not align with students' experiences, highlighting the importance of understanding how students construct their understanding of taught mathematical concepts.

Finally, the impact on mathematical literacy skills indicates that to improve students' abilities, it is essential to comprehensively address these epistemological obstacles, so educational interventions must be tailored to the stages of students' conceptual understanding development.

Observe the following image!



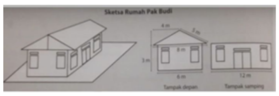
An observer is at the top of a tower at a height of 120 m. He sees the Safir ship at a distance of 130 m and the Lofura ship at a distance of 150 m. The story is illustrated with the diagram, If the base of the tower (D), the Safir ship, and the Lofura ship are collinear, then:

a. What is the formula to determine the lengths of AD and BD?
b. What is the distance between A and B?
c. What can you conclude based on the answer to part (b)?

Fig. 2. Question 1.

For Alternative answer to the question in Fig. 2(a) The length of AD observe triangle ADP: $AD^2 = AP^2 - DP^2$, the length of BD observe triangle BDP: $BD^2 = BP^2 - DP^2$; b) $AD = \sqrt{AP^2 - DP^2} = \sqrt{(130)^2 - (120)^2} = 50$; $BD = \sqrt{BP^2 - DP^2} = \sqrt{(150)^2 - (120)^2} = 90$, the distance between A and B : $AB = BD - AD = 90 - 50 = 40$; c) Thus, the distance between the two ships, or the distance between the Safir Ship and the Lofura Ship, is 40 *m.* Analysis for question 1: a) Since the student begins answering by using the triangle area formula, this indicates that the student does not use an epistemic process in generating the answer, this tends to be an epistemological obstacle; b) Performing calculations according to answer a, resulting in less accurate results. c) When concluding, the student does not replace A with the Sefir Ship and B with the Lofura Ship. Epistemological obstacle: Incorrect understanding of basic concepts; lack of mastery of prerequisite material; and limited ability to perform algebraic manipulation.

Observe the following image!



Mr. Febri has a house with a sketch as shown above. The roof of the house consists of 2 identical rectangular sections. The size of the roof tiles installed on the house is 30 cm x 20 cm per piece. Mr. Febri wants to make roof support pillars from wooden materials in the form of isosceles triangles so that the front view of his house's roof will appear sturdy.

a. If the length is up and the width is all, determine the formula for the area of the roof and the area of the tiles!
b. How many tiles are needed to cover Mr. Febri's roof?
c. What can you conclude based on the answer to part (b)?

Fig. 3. Question 2.

For Alternative answer to the question in Fig. 3(a) The roof and tiles have the same shape, which is rectangular, so the way to determine the area is by using the formula, $area = p \times l$; b) Roof area= $p \times l = 12 \times 10 = 120\ m^2 = 1200000\ cm^2$, Tile Area = $p \times l = 30 \times 2 = 600\ cm^2$, number of Tiles = $\frac{Roof\ Area}{Tile\ Area} = \frac{1200000}{600} = 2000$; c) Therefore, the number of tiles needed to cover Mr. Febri's house roof is 2,000 pieces. Analysis for question 2: a) The student considers the formulas for the area of the roof and the tiles to be different, indicating that the student does not use an epistemic process in generating the answer, tending towards an epistemological obstacle; b) The student does not convert the unit of roof area, Number of tiles = $30 \times 20 = 600$; c) Conclusion based on calculations in a and b. Epistemological obstacle: Incorrect understanding of basic concepts regarding the area of a rectangle; limited ability to perform algebraic manipulation; lack of mastery of prerequisite material.

5. Conclusion

This study successfully identified the main epistemological obstacles faced by students in understanding and applying the concepts of plane geometry. Students tend to struggle with connecting abstract geometric concepts to practical contexts in real life, which ultimately hinders their ability to solve more complex mathematical literacy problems.

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