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Students' Difficulties in Solving Geometric Literacy Problems

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Abstract

PISA is an international assessment that measures students' mathematical literacy. Many observed that space and shape in geometry is one of the most difficult topics in PISA. Moreover, some findings stated that many students have difficulties in solving PISA-model geometry problems. The purpose of this research is to describe students' difficulties in solving geometric literacy problems. The participants selected in this study were six eighth graders in South Sulawesi. Data were collected through observation, interviews, and tests before being qualitatively analyzed. The result indicated that students had a number of difficulties in answering geometry literacy problems. The first difficulty students faced was that most of them could not formulate mathematical models for the problems given. The second problem was that some students could not employ the correct concept to solve the tasks provided. The third difficulty found was that students could not draw a proper conclusion from the given geometric problems. Thus, some efforts are needed to overcome those difficulties in solving geometric literacy problems.

Keywords: *Students' Difficulties; PISA Mathematical Problem; Geometric Literacy Problem.*

INTRODUCTION

The challenges of the 21st Century require students to have mathematical literacy abilities and the ability to solve problems in everyday life. Participation in using and practicing mathematics in various situations is an important part of mathematical literacy (Lailiyah, 2017). Mathematical literacy is essential for solving difficulties in everyday life (Hagan et al., 2020; Setiawan et al., 2014). This statement is aligned with Freudenthal's belief that mathematics must be linked to the realities of everyday life and mathematics as a human activity (Gravemeijer, 1994). In this context, mathematical literacy refers to students' knowledge and capacity to apply mathematics learned in class to real-life situations and understand mathematical problems (Kuswidi, 2017). In addition, mathematical literacy includes the ability to consider 'when' and 'how' to apply mathematics (Sumirattana et al., 2017).

However, the importance of mathematical literacy in the global community's view does not correspond with the achievements of Indonesian students. Understanding of mathematical literacy is still lacking. According to the 2018 PISA survey results, Indonesia was ranked 73rd out of 79 PISA participating countries (OECD, 2019b). This result indicates that students' mathematical literacy abilities are not optimal; they cannot analyze, explain, and solve mathematical literacy problems in everyday life and are also unaware of mathematical phenomena in their environment (Rusdi et al., 2020).

Students face various obstacles in learning mathematics. These difficulties impact their ability to achieve optimal learning results (Kusumadewi & Retnawati, 2020). Individual variables, educator factors, and environmental issues can contribute to learning difficulties (Kiarsi & Ebrahimi, 2021).

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Difficulties in solving problems can lead to a variety of errors (Rafi & Retnawati, 2018), such as mistakes in representing contextual problems (Wijaya et al., 2019), which are caused by students' inexperience with non-routine problems such as the PISA questions [13], [14], [15]. Problem-solving is discovering prior relationships and present difficulties to develop solutions (Jupri & Drijvers, 2016); hence, students must learn the principles, rules, and procedures of problem-solving to understand and determine solutions to these problems (Hadi et al., 2018).

PISA questions cover the following content areas: change and relationship, space and shape, quantity, and uncertainty and data (OECD, 2019a). The most challenging content for students (Wulandari, 2019), (Novitasari, 2019; Oktaviana & Rosyidi, 2019) to comprehend is space and shape content linked to geometric literacy (Sumule et al., 2018). This statement implies that Indonesian students have more difficulty with geometry than other topics.

Geometry, as a branch of mathematics, is a concept that students need (I. Fauzi & Arisetyawan, 2019) to visualize, recognize space and shape, and describe an image (Muhassanah et al., 2014), which cannot be taught solely through teacher-centered learning but must be accomplished through student-led construction or concept formation (Nurhasanah et al., 2017). Geometry, a discipline that covers a large portion of nature or the universe, such as art, architecture, and practically anything made by humans, has the geometric aspects required to inspire students' problem-solving and thinking (Malasari et al., 2017).

Several research results revealed that students experience various challenges in solving geometric problems, including research conducted by (Adolphus, 2011), (Fauzan et al., 2013; K. M. A. Fauzi et al., 2019), (MdYunus et al., 2019; Noto et al., 2019). Meanwhile, in his research, Dirgantoro (Dirgantoro, 2019) stated that students experienced difficulties in learning geometry, such as understanding basic concepts, performing arithmetic operations, comprehending problems, and inaccuracy in the problem-solving process. To encourage students' problem-solving abilities, it is necessary to analyze their learning difficulties so that educators can determine the right strategy to overcome them (Kapofu & Naidoo, 2020). Therefore, this research aimed to describe students' difficulties in solving geometric literacy problems. The analysis results obtained in this study were expected to be considered for teachers and education observers to assist students in developing geometric literacy skills.

METHOD

This qualitative research aimed to describe students' difficulties in solving mathematical problems related to space and shape content in geometric literacy taught in the Eighth Grade. This research was conducted in three stages: preparation, implementation, and data analysis. During the preparatory stage, the researcher made several preparations, including selecting research subjects and instruments. At the implementation stage, students' ability to solve problems will be tested by giving geometric literacy questions. The data analysis was the final stage, in which the data collected in the previous stage were analyzed.

This study involved six students of MTs Madani Alauddin in Gowa Regency, South Sulawesi who were considered representative based on their geometric literacy skills. Data were collected through a test, observation, and semi-structured interview guidelines. Three geometric literacy questions are entered on the test sheet, which are arranged based on sufficient indicators used to identify students' abilities. Observation and interview guidelines were developed using the geometric literacy ability indicators. Experts consisting of one mathematics education lecturer at UIN Alauddin Makassar and one mathematics teacher at MTs Madani Alauddin validated the research instruments before being utilized in the implementation stage. The data obtained was then analyzed qualitatively with thematic analysis so that the information collected was in-depth and focused on students' difficulties which was presented descriptively.

The indicators of students' geometric literacy ability were: (1) modelling geometry problems into mathematical form (formulate), (2) applying mathematical concepts (geometry), facts, procedures, and reasoning to find problem-solving solutions in geometry problems (employ), and (3) concluding,

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interpreting, applying, and evaluating the results or solutions obtained (interpret and evaluate). These geometric literacy indicators were derived from the mathematical literacy indicators.

RESULT AND DISCUSSION

Result Research

In the preparatory step, the researcher compiled observation sheets and provided geometric literacy questions. Students were given 80 minutes to solve three geometric tasks related to two-dimensional figures. The following figure is one of the three tasks provided:

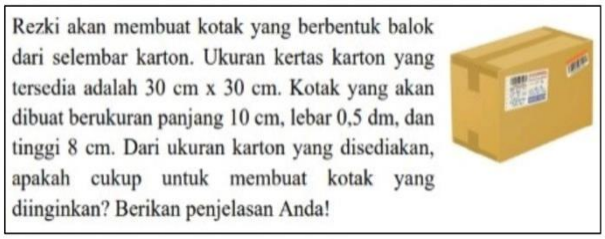

Figure 1. A Task Using the Concept of a Cuboid Surface Area

Translation of Figure 1:

Rezki wants to make a cuboid box from a piece of cardboard. The size of the available cardboard is 30 cm x 30 cm. Rezki wants his box to be 10 cm in length, 0.5 cm in width, and 8 cm in height. Considering the dimension of the cardboard, is the cardboard enough to make a such box? Provide your reasoning!

Figure 1 illustrates a problem in geometry literacy. The question asks students to analyze whether or not the provided cardboard is adequate to create a box.

The three tasks then were used at the implementation stage. At this stage, students solved the problems as presented in Figure 1. The following figure is the answer of one of the students to one geometric literacy problem given.

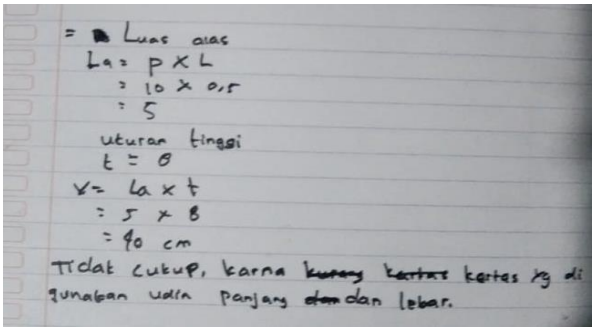

Figure 2. An Answer of Student A, a Student Who Did Not Provide Mathematical Modeling and Apply a Proper Mathematical Concept to the Question

Translation of Figure 2:

Base area (Ba):

Ba = length x width
= 10 x 0.5
= 5

Height (t):

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t = 8
V = Ba x t
= 5 x 8
= 40 cm

Not adequate, because the cardboard is used for length and width.

Figure 2 illustrates that Student A did not write the information given and the question asked and could not formulate the problem into mathematical modeling. Student A's answer did not correctly state the size of the cuboid box. Student A did not write down the cuboid's length, width, and height, and did not calculate its surface area. It seems that the student had difficulty modeling the problem into a mathematics form (*formulate*). Besides, Figure 2 indicates that the student applied a non-relevant concept to solve the problem. The student tried to solve the problem by applying the formulae of the area of a rectangle and the volume of a cuboid. On the other hand, the student should use the formula of the surface area of a cuboid so that they can compare the surface area with the area of the available cardboard to determine the adequacy of the cardboard to create a cuboid box. Thus, Student A might have difficulty applying mathematical, especially geometrical, concepts, facts, procedures, and reasoning to find the solution if this geometry problem (*employ*). When Student A's answer in Figure 2 was analyzed, some mistakes in drawing inferences were found. The student stated that the cardboard was not enough to make a box. If Student A presented correct calculations, they would find that the area of the cardboard is larger than the box's space area, so the cardboard is sufficient to create a box. Therefore, the student had difficulties in concluding, interpreting, applying, and evaluating the results or solutions *obtained (interpret and evaluate)*. This hypothesis is supported by the interview script conducted by the researcher (R) to the following student (S).

R : From the task, what information is given and what information is asked?
S : 30 cm x 30 cm and the width of the cardboard.
R : Is that all given?
S : The cardboard is 30 cm x 30 cm.
R : From the question, what is asked?
S : Considering the dimension of the cardboard, is it adequate to create a box?
R : Based on the given information, what is the shape of the cardboard?
S : Rectangle.
R : What is the shape of the box?
S : Cuboid.
R : Is it possible to make a box from that cardboard?
S : No.
R : Why is it not possible to make a box from the cardboard?
S : Because the solution is through the formula of length x width x height.

Based on the interview script above, Student A mentioned the shape of the cardboard correctly. However, they were not able to model the problem in a mathematical form (*formulate*) and find the solution to the problems given. Besides, they did not seem to be able to provide proper reasoning and conclusion.

In addition to those difficulties, a problem in concluding is found, such as in student B's answer in the following figure.

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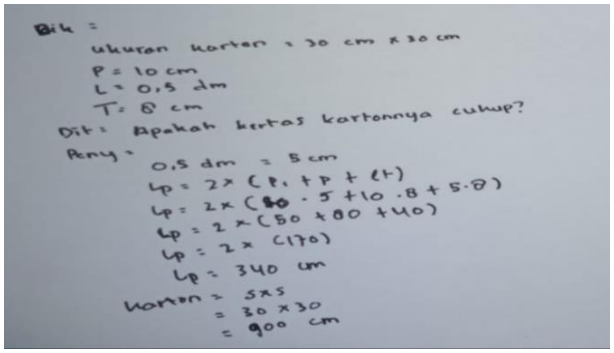

Figure 3. An Answer of Student B, A Student Who did Not Provide a Conclusion to Their Solution

Translation of Figure 3:

Hints:
Cardboard area = 30 cm x 30 cm
Length = 10 cm
Width = 0.5 dm
Height = 8 cm
Question: Is it possible to make a cuboid?
Analysis:
0.5 dm = 5 cm
Lp = 2 x (p+p+ p.t)
Lp = 2 x [(10x5) + (10x8) + (5x8)]
Lp = 2x (50+80+40)
Lp = 2x (170)
Lp = 340 cm
Carton = s x s
=30 x 30
= 900 cm.

Figure 3 illustrates that Student B could create a mathematical model (formulate) for the problem that can be seen from how they wrote the dimension and calculate the surface area of the cuboid using the information given in the task. In addition, Student B applied correct mathematical concepts to solve the problem (employ) for them using the formula of a cuboid surface area to justify the area of the box that will be made. Although some small errors in the notation of the surface area of a cuboid were found, the values input and the calculation presented were correct. When the answer in Figure 3 was analyzed, Student B did not conclude whether or not the cardboard is adequate to make a cuboid. Therefore, it is assumed that the student had a difficulty in concluding and interpreting the results or solutions obtained. This student's answer is then clarified as shown in the following interview script between the researcher (R) and student (S).

R : In your opinion, what information is given in the task?
S : The size of the cardboard is 30 x 30 cm, the size of the cuboid to be made is length = 10 cm, width = 0.5 dm, and height = 8 cm.
R : Based on the task, what is the question?
S : Is there adequate cardboard to make a cuboid?
R : Is it possible to make a box based on the available cardboard?
S : Yes.
R : Why is it possible to make a box from the cardboard?
S : Because the size of the cardboard and calculation are matched.
R : Which size and calculation do you mean?
S : The cardboard has more (space).
R : Is there any cardboard left after being used to make a cuboid?

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S: Yes.
R: How do you find out?
S: I don't know, ma'am.

The interview script above confirms that student B believed that the size of the cardboard is sufficient to make a box. However, Student B could not provide justification for their answer.

Discussion

Based on the research results, the students faced several difficulties, especially in modelling problems into mathematical form (formulate). The findings indicated that students did not understand the problem well, so they could not produce solutions. This result is in line with the research of Kurniawati & Rosyidi (Kurniawati & Rosyidi, 2019), that students failed in modelling mathematical problems due to their inability to understand and construct real problems in the form of mathematical models. The same view was also expressed by Novalia & Rochmad (Novalia & Rochmad, 2017), that the inability of students to comprehend the problem made them unable to make proper plans for solving problems, so they produced an incorrect final answer. The most common difficulty is the students are unable to understand the context of the questions, making them difficult to apply the formulas (Abrar, 2014). As a result, the students have difficulty in applying mathematical concepts, facts, procedures, and reasoning to find solutions to problem-solving in geometry questions (employ). Applying formulas and theorems is the most challenging for students (Sholihah & Afriansyah, 2017).

In addition to difficulties modeling problems into mathematical form, several students also struggle with drawing inferences, interpreting, applying and evaluating the results or solutions obtained (interpret and evaluate). Most students can only perform mathematical calculations in determining the box's space area to be constructed. However, students cannot interpret the results of the calculations they get to solve the problems in the questions. That occurs because students do not understand well the solution to the problem. This finding is in line with the results of research conducted by Utamia, Sukestiyarno, & Hidayah (Utamia et al., 2020) that most students' literacy skills are at the less literate level, namely, students are unable to solve problems correctly. They can only use formulas, while the final results do not reflect the correct answer. In general, students cannot provide good solutions in dealing with open problems, they can only imitate the way the teacher gives answers (Mulyati, 2016). Their conclusions are frequently irrelevant to the facts provided (Rosyidah et al., 2022).

Various studies related to students' difficulties in solving mathematical problems, Jupri and Drijvers (Paul, 2016) in their research described students' abilities in mathematics problems in algebra. Meryansumayeka, Zulkardi, Putri, and Hiltrimartin (Meryansumayeka et al., 2021) describe students' difficulties in solving HOTS level geometry problems. Meanwhile, Zhang, Indyk and Steven researched schematic chunking on students' difficulties in solving math problems. In contrast to previous studies, in this study geometric literacy as one of the abilities measured in PISA became the variable studied regarding students' difficulties. With this research, it is hoped that teachers can recognize student errors so that they can be handled according to these conditions.

CONCLUSION

Based on the results of data analysis, it was concluded that students had difficulties solving geometric literacy problems. The first difficulty is that students cannot model the problem into mathematical form, so they are considered to have difficulty modelling the problem in mathematical form (formulate). The second difficulty encountered is using the incorrect concept to find a solution to the problem. They are considered to have difficulty applying mathematical concepts (geometry), facts, procedures, and reasoning to solve problem-solving in geometry problems (employ). The first difficulty experienced by students is that most of them are unable to give proper conclusions from the given geometry problems, so they are considered to have difficulty drawing conclusions, interpreting, applying, and evaluating the results or solutions obtained (interpret and evaluate).

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