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Analysis of students' difficulties in understanding triangular material

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ABSTRACT

This study aims to describe the difficulties experienced by students in understanding triangular material and the causes of these difficulties. This research is a descriptive research on 7 subjects selected from 23 grade VIII students at MTsS Darul Ihsan, Aceh Besar. The subjects of the study were selected based on the data of the test results of students' ability to solve triangular problems. Based on the test result data, subjects were categorized based on indicators of triangular material then in theinterview to dig deeper into the causes of students' difficulties. The interview results are transcribed and then analyzed qualitatively through the stages of data reduction, data presentation, and conclusion withdrawal. To ensure the validity of the data, a source riangulation is carried out, which compares data from interviews between students and teachers. The results showed that based on the achievement indicators of triangular material, the majority of students experienced conceptual difficulties compared to principle and procedural difficulties. The causes of difficulties experienced by students include: lack of focus during the learning process; lack of understanding of prerequisite material; lack of practice of varied questions; the teacher's explanation regarding the material cannot be easily understood by students; Lack of accuracy in understanding the meaning of the problem and Kurang careful in doing calculations.

Keywords: students' difficulty; conceptual difficulty; principles difficulty; procedural difficulty; triangle

1. INTRODUCTION

Geometry is an important branch of mathematics to learn and needs to be emphasized in learning mathematics. Knowledge of geometry remains a prerequisite for work in fields such as physics, astronomy, art, mechanical drawing, chemistry, biology, and geology (Luneta, 2015). This is in line withHsi, Linn, and Bell (1997); Wai, Lubinski, Benbow, and Steiger (2010) where geometry studies the spatial relationships and properties of shapes. This is critical for students to succeed in science, technology, engineering, and math (STEM) subjects at the college level. Geometry also contributes to developing visualization, critical thinking, intuition, perspective, problem solving, hypothesis, reasoning, logical argument and skills in proofing (Faggiano, 2012; Jones, 2002). Therefore, geometry is important to be studied by all people from kindergarten to college.

In the 2013 revised 2018 curriculum, the scope of mathematics lessons for SMP/MTs covers 4 areas, namely: Numbers, Algebra, Geometry and measurement, Statistics and chance. Based on the 2013 curriculum, geometry at the junior high school/MTs level gets a large portion of the overall curriculum content when compared to several other materials such as algebra, probability or statistics (Syahroni, Trapsilasiwi, &; Kristiana, 2014). Geometry became a medium for representing and solving problems in all areas of mathematics, both in school subjects and real-life applications (NCTM, 2001). Of the several scopes of mathematics, geometry is the branch of mathematics that dominates than other mathematical materials. However, some reports indicate that students' geometry knowledge has not been good and unstructured. In international exams such as PISA and TIMSS, where students are severely lacking in geometry. In addition, the results of the national examination from 2013 to 2016 can be seen that the average national examination of mathematics subjects tends to decrease (Prabowo, Anggroro, &; Rahmawati, 2018). In other words, students' absorption of mathematics materials in SMP/MTs tends to decrease from year to year. Based on the national examination result report, the absorption capacity of UN mathematics from 2015 to the last year of UN 2019, especially in geometry, has an absorption capacity of 52.04 to 41.80 (Balitbang Education Assessment Center of the Ministry of Education and Culture, 2019). This shows that the absorption of geometry material tends to decrease because students have difficulties.

The difficulties faced by students on geometry material tend to be basic geometric concepts such as angles, rectangles and triangles (Fielker, 1979; Hershkowitz, 1987; Lehrer, Jenkins &; Osana, 1998; TIMSS, 1999; Wallrabenstein, 1973). The weak understanding of students' mathematical concepts is found in SMP/MTs, through the teacher's observation

process states that the ability to understand students' concepts in mathematics learning is still very lacking, especially in flat geometry material. This can be seen when students are given examples of problems understanding the concept of flat material, do not understand symbols, students cannot identify the information in the problem, students are still often confused or mistaken in using formulas, often make miscalculations, and are unable to associate one concept with another related concept. Such difficulties can be grouped into conceptual, principle and procedural difficulties.

The difficulty of the concept has indicator criteria: 1) the inability to restate the concept that has been learned; 2) inability to give examples or not examples of the concepts studied; 3) inability to classify objects based on mathematical concepts; 4) inability to associate various mathematical concepts; 5) present concepts in various representations. Principle difficulties include: 1) inability to understand mathematical symbols; 2) inability to understand the properties of mathematical concepts. Meanwhile, procedural difficulties include: 1) inability to apply concepts algorithmically; 2) inability to follow appropriate resolution steps (Anderson &; Krathwohl, 2010; Killpatrik et al, 2001).Mathematics learning in grade VII junior high school in the even semester of the 2013 revised 2018 curriculum contains several geometry materials, one of which is a triangle consisting of types of triangles, lines on triangles, the size of the angles of the triangle, and the circumference and area of the triangle. Triangles are one of the basic concepts in geometry and are often encountered in everyday life. Among two-dimensional shapes, the concept of triangle is one of the most recognizable images in early childhood and elementary school math curricula (Miyakawa, 2017; Ubuz &; Aydn, 2018). The concept of triangles is often used in more complex geometric concepts (Kaplan & Hızarc, 2005). An understanding of triangles also helps students understand other concepts in mathematics (e.g. unit circles, trigonometry) and science (Ubuz & Aydın, 2018), making proofs and argumentations. Although triangles are one of the most frequently discussed topics in the math curriculum from the early years through the middle school level, students lack a strong conceptual understanding of triangles.

Studies reveal that students do not critically understand the features of triangles, they face various obstacles in understanding triangles (Burger &; Shaughnessy, 1986; Tsamir et al., 2008; Vinner & Hershkowitz, 1980) and triangular auxiliary elements (Guo & Pang, 2011). For example, students easily identify equilateral triangles but they are unsuccessful in identifying isosceles triangles (Clements, Swaminathan, Hannibal, &; Sarama, 1999; Tsamir et al., 2008). Similarly, students find it difficult to identify the concept of the types of triangles because they focus on the visuals of triangles and certain common characteristics (Hershkowitz, 1989; Tsamir et al., 2008). In addition, the problems faced by students in the triangle material are students are less skilled in using the nature of the number of angles in the triangle to solve problems, students do not understand the meaning of the inner angle of the triangle, and students are less skilled in using the relationship between the inner angle and the outer corner of the triangle to solve the problem. The ability of students tends to only memorize the formula of the circumference and area of the triangle, so the ability to solve problems related to the circumference and area of the student's triangle is still weak (Rahayu, 2013). This indicates that students have difficulty in understanding geometry which is more conceptual. If students have difficulty in understanding geometry concepts, it is possible that students will have difficulty in understanding the next geometry concept because students are unable to associate one concept with other concepts.

Several studies related to students' learning difficulties in understanding triangles have been examined by several researchers. Rahaju et al (2019) about misconceptions on triangular matter through epistimology where it was found that there is a lack of understanding of the base and height of the triangle concept. Islami et al (2019) analysis of students' difficulties in solving math problems on congruence and congruence   material where 40% of students have difficulty doing calculations in doing problems, 60% of students have difficulty in calculations and difficulty in understanding the concepts of congruence and congruence. Biber (2020) also examined the difficulties of students in understanding the same triangle where the findings in this study were that most students had difficulty in understanding the types of overlapping triangles. Some of these studies show that students' difficulties in understanding triangular material have been studied before, but the study only examined some indicators of triangular material. According to the 2013 curriculum in grade VII at the junior high school/MTs level there are five indicators that must be understood by students, namely: understanding the concept of types of triangles, solving angular problems in triangles, understanding special lines in triangles, in the form of height lines, weight lines and dividing lines, solving problems related to the circumference and area of triangles. Research covering all five indicators does not yet exist. Research on triangular matter in depth is still very limited. Previous research has only revealed misconceptions and types of student difficulties on two indicators but has not looked at the causes. While this study wants to continue up to the five indicators and explore further in addition to looking at the types of difficulties also find the cause. Therefore, researchers want to dig deeper through qualitative research.

Researchers need to analyze students' difficulties in understanding triangles as well as dig deeper to find the causes of difficulties experienced by students in understanding triangular material.This is very useful as information for researchers and mathematics educators to find the right solution in learning geometry. In other words, the results of this study can be a reference for teachers in order to optimize learning assistance in understanding geometry, especially triangular material to encourage minimum completeness standards in mathematics learning.

2. RESEARCH METHOD

This study is a descriptive-research using a qualitative approach conducted at MTsS Darul Ihsan Aceh Besar. The subjects of this study were selected 7 out of 23 students who had taken the triangle test. Subject selection is based on the results of students' answers that have unique difficulties and varied answers when answering essay questions. The data collection techniques used are test and interview methods. This test instrument consists of 10 multiple-choice questions and 5 essay questions that have been validated by validators. Methods are carried out on the subject   in order to obtain more in-depth information about the difficulties experienced by students in understanding the triangular material and its causes.The stages of a data analysis are carried out through the stages of data reduction, data presentation, and conclusions.Furthermore, researchers triangulate sources to ensure the validity of the data, namely   by conducting interviews with mathematics subject teachers in order to obtain valid data   about the difficulties experienced by students in understanding triangular material and its causes.

3. RESULTS AND DISCUSSION

The conceptual difficulties experienced by students are: difficulties in giving examples and not examples based on the properties of the type of triangle; difficulty in understanding the concept of the number of angles in a triangle; difficulty in understanding the meaning of the problem in terms of understanding the image of triangles and angles in the picture; difficulty in relating various mathematical concepts, especially relating the concepts of comparison and the number of angles in a triangle; difficulty in restating the concept of special lines verbally or in writing; difficulty determining the exact height line on each existing triangle; difficulty in determining the formula for the area of a triangle, base and height of a triangle; difficulty in associating known information to plan a problem-solving strategy; and difficulties in manipulating algebra due to the known length of the side of the triangle in the form of values *x*. While the procedural difficulties experienced by students are: errors in determining the final results/calculations. Weak understanding of concepts causes students to be unable to solve problems correctly. The ideal mathematical understanding of students is determined by the understanding of concepts, so if students experience conceptual difficulties, mathematical understanding will not be obtained on the material. Thus, in learning mathematics students must understand mathematical concepts first in order to solve problems and be able to apply the learning in the real world so it is very important to understand mathematical concepts from an early age. Students who experience principle difficulties, namely difficulty in understanding mathematical symbols and difficulty in understanding the properties of mathematical concepts such as the magnitude of the angle at each point, right and obtuse angle, are unable to determine the relationship between the image and the known value on the problem and cannot determine the formula for the area of a triangle. Some other students have been able to understand the meaning of the question well and are able to apply existing concepts to solve the problem but experience procedural difficulties, namely difficulty in finding answers not following rules such as wrong in writing the final answer. This is in line with other studies that the error that obtained a percentage with a very high error rate was the error of writing the final answer by83.7% (Islamiyah, et al, 2018; Khaidir & Rahmi, 2016). Here are some difficulties students have in understanding triangular material.

1. The indicator of understands the concept of types of triangles
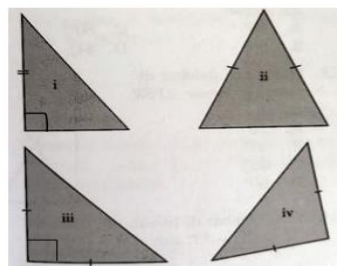
For indicators of understanding the concept of types of triangles, the difficulties experienced by students include; difficulty in distinguishing the types of triangles based on their properties; and difficulty in giving examples instead of examples based on the properties of the types of triangles. Some students have difficulty because they don't understand concepts well. One of the causes is lack of focus during the learning process and lack of understanding of prerequisite material, namely about angles (Hidayah &; Fitriani, 2021). Some already understand and can distinguish the types of triangles but do not understand the size of the angle for pointed triangles, right or blunt, and some others are wrong in determining answer choices because they are not careful in understanding the problem.

Perhatikan tabel berikut.

Segi-tiga	Banyak Sudut			Banyak Sisi	
	Lancip	Siku-Siku	Tumpul	Sama	Berbeda
i	3	0	0	2	1
ii	2	1	0	0	3
iii	2	0	1	2	1
iv	2	0	1	0	3

Dari tabel di atas, yang merupakan jenis segitiga tumpul sama kaki adalah . . . .
  A. I   C. iii
  B. Ii   D. iv

Dari gambar di atas, yang merupakan jenis segitiga lancip sama kaki adalah . . . .
  A. i   C. iii
  B. ii   D. iv

2. The indicator of solves the problem of the number of angles of a triangle

For indicators to solve the problem of the number of angles of a triangle, the difficulties experienced by students include: difficulty in understanding the concept of the number of angles in a triangle; difficulty in remembering formulas; difficulty in understanding the meaning of the problem in terms of understanding the image of triangles and angles in the picture; and the difficulty inrelating various mathematical concepts internally or externally, especially relating the concepts of comparison and the sum of angles in a triangle. Some students are wrong in calculating the final results because they are not careful in understanding the meaning of the problem. Some students are oriented only to grades even though the question is not limited to finding grades, others already understand the meaning of the question and understand the concept of the number of angles in a triangle but cannot apply it in answering the question. There are also students who guess the answer just by looking at the known numbers on the question contained in one of the answer options, even there are still students who find it difficult to distinguish which is angle and side *XX*. The cause of the students' difficulties is the lack of practice of varied questions; lack of understanding of the prerequisite material *(comparison and angle)* to solve the problem and teacherexplanation related to the material cannot be easily understood by students (Islami et al, 2019).

3. The indicator of understands the privileged lines on the triangle

For indicators of understanding the special lines in triangles, namely the height line, the weight line, and the divide line, most students do not understand and cannot yet provide the difference between the height line, the weight line and the divide line. Most of the students assume that these special lines are the sides of the triangle itself and there are even students who mention that the special lines are slashes, vertical lines and straight lines. The difficulties experienced by students in this indicator are: difficulty in restating the concept of special lines verbally and in writing; difficulty in relating various mathematical concepts internally or externally; difficulty in finding relationships between known numbers in pictures and problems and difficulty determining the exact height line in each existing triangle. This is in line with Fischbein and Nachlieli (1998) who state that many students in grades 9–11 cannot correctly determine the height of a triangle or draw the required height in a right triangle or obtuse triangle. The cause of this difficulty is students' lack of understanding of how to paint high lines on a triangle; the number of practice questions that vary and thelearning about the material is not discussed in depth (Acharya, 2017).
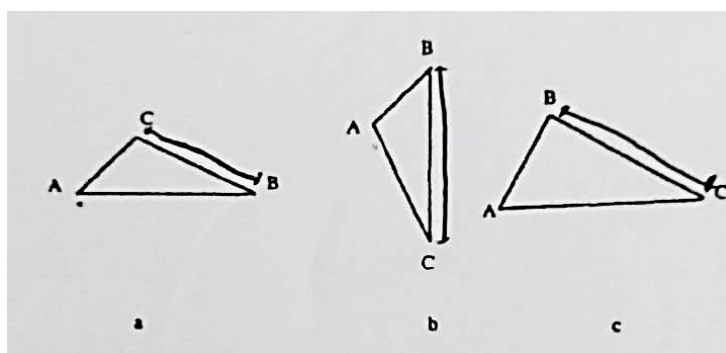
4. The indicator of solves problems related to the circumference of a triangle

For indicators of solving problems related to the circumference of a triangle, some students have not been able to understand the concept of the circumference of a triangle and the formula for determining the circumference of a triangle. Others have been able to understand the meaning of the problem and solve problems related to the circumference of the triangle. However, the student still mistakenly determines the final answer, which should not be finished but he assumes it is finished until there. The difficulties experienced by students include: difficulty in manipulating algebra due to the known length of the triangle side in the form of values x caused by the lack of understanding of basic concepts or prerequisite materials, namely algebraic material, especially linear equations of one variable and errors in calculating the final result of the answer because they understand the meaning of the question.

5.   The indicator solves problems related to the area of a triangle

For indicators to solve problems related to the area of a triangle, most students do not understand the concept of the area of a triangle and the formula for determining the area of a triangle because students no longer remember the material of the triangle and instead mention the area formula for building flat and building other spaces. But there are also those who have been able to understand the concept of the area of a triangle, are able to determine the formula for the area of a triangle, however, have difficulty in calculating at the end of the answer because theyare careful in doing calculations. Other difficulties experienced by students include: difficulty in determining the formula for the area of a triangle, base ad height of a triangle; difficulty in associating known information to plan a problem-solving strategy; difficulty determining

strategies to solve the problem and difficulty in manipulating algebra due to the length of the known side of the triangle in the form of values x caused by k The understanding of the concept of triangular matter is mainly in determining the area of a triangle; lack of practice with varied questions; and theneed for understanding basic concepts or prerequisite materials, namely algebraic material, especially one-variable linear equations. The ability of students tends to only memorize the formula of the perimeter and area of the triangle, so the ability to solve problems related to the circumference and area of the student's triangle is still weak (Rahaju et al, 2013).

After conducting interviews, it was found the cause of the difficulties experienced by students in understanding the triangular material, including internal factors and external factors. The cause of internal factors is that students are less motivated to answer questions, lack of student interest in mathematics so that students answer just as long as they choose answers without any reason underlying their choice. Another cause of external factors is lack of mastery of triangular material, material that has been taught for a long time, and is not taught by the teacher. This is in line with previous research that several factors that cause learning difficulties are caused by students, teachers, materials and infrastructure (Pawestri, Soeyono, &; Kurniawati, 2013; Widyasari, Meter, &; Negara, 2015).

4. CONCLUSION

This study has found that the majority of students experience conceptual difficulties compared to principle and procedural difficulties. The causes of conceptual difficulties experienced by students include: lack of focus during the learning process; lack of understanding of prerequisite material (i.e. about angles, comparisons and linear equations of one variable); lack of varied practice questions; The teacher's explanation of the material cannot be easily understood by students; lack of understanding of the concept of triangular matter of the five indicators; and learning that is not covered in depth. While the causes of principle difficulties are: students do not understand the properties of mathematical concepts well and procedural difficulties experienced by students, namely: lack of accuracy in understanding the meaning of the problem and careful indoing calculations. Students have the most difficulty on indicators of understanding special lines. Therefore, teachers are expected to be able to emphasize or strengthen students' understanding of these indicators. One of the causes of student difficulties is students' lack of understanding of prerequisite material (i.e. about angles, comparisons, and linear equations of one variable). Therefore, before starting learning triangular material, teachers are expected to maximize the perception for prerequisite material by providing more realistic examples.

CONFLICT OF INTEREST

There are no conflicts of interest declared by the authors.

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