Analysis of students’ error in solving mathematical word problems in geometry

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Abstract. Solving mathematical word problems are still considered as a difficult matter for the students, because the word problems are related to many mathematical concepts. This study aims to identify students’ error in solving the word problems deal with plane geometry. The method used in this study was descriptive-qualitative approach. The subjects were 23 grade 7 students from one of Junior High School in Subang, Indonesia. The wrong answer was the analysis. The analysis of students’ error base on Polya strategy. The results showed that most of the student made mistakes in transforming the word problem related to plane geometry into a mathematics model; both formulas or illustrations with pictures. In this study, it was also found that the ability to calculate operations was the most common error found in students’ answers. It is expected that there will be other research that can be minimize students error related to the plane geometry topic.

1. Introduction

Mathematics learning activities can not be separated from mathematical problems. In learning mathematics, students often give error answers, especially in solving problems related to mathematical word problem. Mathematical word problems are very important in the daily life of students, because the word problem of putting forward real issues that fit with daily life. Word problem as a form of evaluation of the students’ ability to the basic concepts of mathematics that have been studied in the form of application of the formula.

However, solving mathematical word problem is still considered difficult for the students. The sources of errors with word problems are well documented. For instance, Santoso, Farid, & Ulum reveal the results of their research that the most error experienced by student in solving mathematical word problem or mathematical problem caused by transformation errors and process skill errors [1]. In addition, Angateeah reveals the results of his research that students who have high achievement experience errors in solving non-routine word problem due to careless errors, students who have average achievers experience procedural errors, while students who have low achievers face difficulties mainly in visualizing and representing the problem [2]. A case study of 9th grade students’ errors regarding mathematical word problems was done by Sepeng & Sigola [3]. Their data obtained proved that the errors made by the students in the solution of the word problems appeared as a result of the lack of understanding of the mathematical vocabulary used in a problem statement. Meanwhile, based on
results Tong & Loc revealed that the errors of students in solving mathematical problems are caused by many different reasons such as carelessness, subjectivity, wrong application of the calculation rules, incorrect identification of problem kinds and inaccurate calculation [4]. Considering these findings, the purpose of this study was to clarify students’ error in solving mathematical word problem. As a focus, we chose the error experienced by students in Indonesia in plane geometry topic.

Geometry is one topic that is closely related to a problem in daily life and problem solving. Geometry linked all topics in mathematics and also linked mathematics topics and real world [5]. Geometry is one of the most important topic in learning mathematics. Given the importance of the role of geometry, then geometry topic is introduced and taught from an early age. One of the geometric concepts taught is about the plane geometry. Based on Fujita & Jones research shows that it is very important for students to master the concept of a quadrilateral plane geometry [6]. In their research reveal that studying the topic of quadrilateral plane geometry can help students develop deductive reasoning and proofing abilities. Learning geometry goals is to developed students problem solving skill. Problem solving skills is the heart of learning geometry and be a focus development in mathematics and also geometry learning [5]. This skill can increase higher order thinking of students such as logic, critical thinking, creative thinking, and reasoning thinking [5]. Such as the Irsal, Jupri & Prabawanto research, was found, almost all student have a low problem solving skill because students did not do the process of re-examining their answer solutions [5]. Those researches mostly focus on the rectangles with a quite similar type question. This study relatively similar to the previous research regarding the analysis of errors might occur in students’ answer. However, this study provided a different type of questions cover analysis of element adequacy on a square and rectangle, analysis of the costs required for the problem plane geometry, and validation of element adequacy for triangular problems. Thus, this study will gave contribution to the mathematics education areas regarding the students’ error in solving mathematical word problem are related to the plane geometry topic.

2. Method
To identify students’ problem solving skill in mathematical word problem in this study, descriptive qualitative approach was being used. The subject consisted of 23 grade 7 students (13/14 year-old) in one of Subang Junior High School, Indonesia. All of students have learned the plane geometry topic. Written test on plane geometry were given to students. The students were asked to solve mathematical word problems in plane geometry task for approximately 80 minutes. During the test, the students were told that this test does not effect their assessment, so they feel free to express their answer based on what they think. In conducting a written test, students do not use calculator or other electronic devices. Descriptive analysis taken to analyzing the results obtained by students answersheet. Polya strategies [7] were used to assess students problem solving skills in solving on some word problems about plane geometry. There are three items given to the students that can be seen in bellow.

1. School A holds the test for 220 participants. Each participant will be given a participant card measuring 10cm x 6cm which will be made from paper prepared administration. Administration provides 20 sheets of paper, each sheet of paper measuring 21cm x 30cm. Investigate whether the paper prepared by administration is enough to create a card for all participants. Explain your answer.

2. In the picture on below is a floor plan of a garden. In the middle of the garden is a fish pond whose surface is rectangular. In every corner of the garden is planted with flowers, and the rest area will be made a playground that is covered with tiles. Assuming the cost of tile installation per meter of square is Rp.11.000, -. Calculate the cost required for the installation of tiles in the playground. (Adapted from [8]).
3. Mrs. Dwi has a right triangle-shaped land with one of the side length of the land is 3 meter in size, the length of the oblique side is 5 meter, and the area is 6 \text{ m}^2. Around the land will be installed fences at a cost of Rp 80,000, - per meter. Mrs. Dwi has the money for the installation cost of the fence of Rp 900,000, -. Investigate whether the money owned by Mrs. Dwi is enough to pay the cost of fencing around his property. Explain your answer.

3. Results and Discussion
This section gives the analysis result and discussion regarding the answers given by the participating students to each of the three questions that were prepared in the subject of plane geometry. Table 1 is the percentage of students' answer results from the sheet of mathematical word problem on plane geometry classified in true, false, and unanswered.

| Number Test | 1 | 2 | 3 |
|-------------|---|---|---|
| Subject     | 23| 23| 23|
| Correct (%) | 26| 9 | 30|
| Incorrect (%)| 61| 91| 57|
| Blank (%)   | 13| 0 | 13|

Table 1 is the percentage of students' answer results from the sheet of mathematical word problem on plane geometry classified in true, false, and unanswered. Table 1 shows that 26% of the students answered question number 1 correctly, whereas 61% answered incorrectly and 13% did not answer. Number 1 is a word problem that identifies the adequacy of data for problem solving. So, if identifying the adequacy of the data is accompanied by the correct reason, then the answer will be 100% correct, but if the answer is not accompanied by the correct reasons or wrong in identifying the adequacy of the data, then the result will be less perfect. In the wrong answer, students answered number 1 in the form as in Figure 2 and 3.

![Figure 1. Floor plan of a garden.](image1)

**Figure 1.** Floor plan of a garden.

![Figure 2. Student ‘A’ answer for number 1.](image2)

**Figure 2.** Student ‘A’ answer for number 1.

![Figure 3. Student ‘B’ answer for number 1.](image3)

**Figure 3.** Student ‘B’ answer for number 1.
Written student work in Figure 2 shows that students understand the problem and realize that to facilitate the resolution of this problem, it should be illustrated first with the picture. However, there are students who illustrate the problem incorrectly and consequently, are unable to apply the correct mathematical formula. In terms of problem solving according to Polya, this student’s work is only at the stage of understanding the problem. This is in line with the research results of Hidayat, Sugianto, & Pramesti who revealed that the students made a mistake in illustrating the problem into the image form [9]. As a result, the answer is wrong. The cause of the error is because the student has never worked on that type of problem.

The written student work in Figure 3 shows that students understand the problem given and are able to illustrate the problem with the correct picture. However, the location of most students’ mistakes is that the students are not able to make further solutions properly. In terms of problem solving according to Polya, this student's work is only up to the devising a plan stage, but has not done carrying out the plan and looking back. This is in line with the research results of Hidayat, et al. reveals one of the errors that students make on the topic of geometry is the students do not give a complete answer of the given problem, thus causing the answer to be wrong [9].

From Table 1, it can be seen that 9% of the students answered question number 2 correctly, whereas 91% answered incorrectly, and none of the students left the question blank. Number 2 is a problem of identifying a strategy that can be pursued. So, if you identify a strategy that can be followed with the correct calculation, then the answer will be 100% correct, but if the strategy is not right and there are calculations error, then the result will be less perfect. In the wrong answer, the students answered number 2 in the form as in Figure 4 and 5.

![Figure 4. Student ‘A’ answer for number 2.](image)

![Figure 5. Student ‘B’ answer for number 2.](image)

To illustrate these findings, two representative examples of written student work on number 2 show. Figure 4 shows that students understand the purpose of the given problem, understand what strategies to look for and what solutions are required in this issue, but Figure 4 shows that the sample of the written student work contains errors in fractional and integer multiplication operations causing student inaccuracy. For example, $4 \times \frac{1}{2} \times 4 \times 3 = 14$. In addition, there is an error in writing numbers that do not match the results already obtained, e.g. $729 - 114 = 50$. Another error in integer subtraction operation, e.g. $585 - 50 = 530$. The second student's error concerns the use of an undesirable dot (·) like in Figure 5. The student's work errors are like $27 \times 27: 729$. There are still students who have not used the equal sign correctly. Another error is that many students make mistakes in calculations on the area of triangles, e.g. $4 \times \frac{1}{2} \times 2.3: 108$.

In term of problem solving based on Polya, this student's work has been up to the stage of looking back, but the process of solving the problem is still not perfect. This is in line with the problem results of Jupri & Drijvers who suggested that in solving mathematical word problems, students understand the problem and can interpret the problem into the mathematical model, but there is a mistakes in the solution process concerning an improper use of the equal sign [10]. It can be seen that some student’s errors are procedural due to lack of familiarity with mathematical notation [11]. Setiawati, Herman, &
Jupri [12] suggested that there are still students who have errors in performing calculations on the operation of fractions and integers. The error in arithmetic operations corresponds to Newman’s category, that is error in process capability, in which the student does not perform mathematical calculations correctly [13]. Students make error because there are inaccuracy in performing the counting operation, that is multiplication between fractional and integer [12].

From Table 1, it can be seen that 30\% of the students answered question number 3 correctly, whereas 57\% answered incorrectly and 13\% did not answer. Number 3 is a word problem that identifies the adequacy of data for problem solving. So, if identifying the adequacy of the data accompanied by the correct reason then the answer will be 100\% correct, but if the answer is not accompanied by the correct reasons or wrong in identifying the adequacy of the data then the results will be less perfect. In the wrong answer, the students answered number 3 in the form as in Figure 6.

Written student work in Figure 6 shows that students are able to read the problem, but do not understand the intent of the problem, proven by the students not writing down what is known and asked from the problem, just writing back the question given on the worksheet. Based on Figure 6, it can be seen that there are student errors in drawing right triangles, and students also experience errors in presenting appropriate answers in accordance with the purpose of the given problem.

In term of problem solving based on Polya, this student’s work has done the carrying out the plan stage, but there is an error in understanding the problem and not yet doing the process of checking the answer. This is in line with the research results of Mulyadi, Riyadi, & Subanti revealed that there are still students who have misunderstandings, that students are wrong in writing is known and asked questions [14]. Irsal, et al. reveals that only few students who experience errors checking back on their answers, they only re-examine the quantification not the validity of the procedure [5]. The research results of Santoso, et al. reveals that there are still a few students who make a encoding error stage: write down the answers based on the Newman category [1]. Based on the results of their research, students have succeeded until the stage of data processing, however failed to write the final solution. These errors are because of clerical errors and students less understand about issues in question.

4. Conclusion
Based on the results of this study, it can be concluded that (1) in terms of problem solving according to Polya, students’ ability to solve word problem on plane geometry topic is still low. Nevertheless, there are 6 students who have been able to use all four problem solving strategies based on Polya well from the three given problem. (2) the main error encountered by students who deal with solving word
problems concerns the solution processes; especially when performing calculation operations, and transforming problems into mathematical model; both the formulas and illustrations with the picture.

The topic of plane geometry is a prerequisite topic that must be possessed by students before studying the topic at the next level. Therefore, teachers should have an active role to create meaningful learning in helping students to master the concepts and skills of procedures relating to plane geometry to students who should be encouraged through use solving non-routine word problem.

Deeper observations need to be done to find out what treatment can reduce each of these errors. We recommend teacher to make an error analysis to understand what is the most error experienced by student and make accurate treatment on that problem. We also recommend teacher to familiarize students with mathematical word problems so that students’ problem solving skills can be improved. In the process of learning planning on geometry topic, especially the solving mathematical word problem in the plane geometry for the 7th grade, the teacher can make the results of this research as one of the empirical basis to anticipate students’ thinking possibilities.

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