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Students' Errors in Solving Mathematical Connection Problems on Quadrilateral Topics

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Abstract

The mathematical connection ability is the ability to use the relationship of ideas in mathematics and apply mathematical ideas in contexts outside of mathematics so that's important because it can provide opportunities for meaningful learning. The background of this study was the wrong way of students' thinking and understanding so that causing errors in solving mathematical connection problems. This study aims to describe students' errors in solving mathematical connection problems on quadrilateral topics based on the Polya's stages. This type of study was descriptive research with a qualitative approach. The data collection technique was carried out by giving participants tests and then conducting interviews with selected participants. The participants in this study were six students in junior high school, consisting of one student in class VIII and five students in class IX. Based on the results, some participants made several types of errors on the quadrilateral topics. The errors made by the participants occurred at the stage of understanding the problem, developing a plan, and implementing the plan. Students have not been able to optimize the use of knowledge related to mathematical ideas, procedures, or facts from a quadrilateral.

1. Introduction

Mathematical connection ability is one of the important components in the mathematics learning process. This is as stated in the standard of the mathematics learning process according to NCTM (2000), including problem solving, reasoning and proof, communication, connections, and representation. Mathematical connection ability is one of the higher-order thinking skills that must be possessed and developed so that students can connect mathematical concepts, with other fields, and apply mathematical concepts in everyday life (Lestari & Yudhanegara, 2018). With this ability, students will learn mathematics in a meaningful way. This is in line with Hendriana et al (2017) who argues that if students can connect ideas, concepts, procedures, and mathematical principles, students' understanding will be deeper and last longer. Therefore, the ability to connect mathematically is an ability or skill in learning mathematics that must be mastered by students.

In fact, students' mathematical connection skills are still relatively low. As expressed by Hasanah and Aini (2021), that students' mathematical connection skills, especially on the topic of rectangles are still very lacking. Similar thing found by Elsa and Suhendra (2022), that some junior high school students make mistakes in solving mathematical connection problems on the topic of rectangles. On the other hand, García-García and Dolores-Flores (2018) conduct research related to students' mathematical connection ability on the topic of growth rate. The findings show that procedural knowledge is more dominant than conceptual understanding, only a small proportion of students are able to make mathematical connections. The low ability of mathematical connections is caused by various factors, both from outside or from within the students themselves.

One of the causes of the low mathematical connection ability of students can be seen from the way

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students think and understand. Errors in this way of thinking and understanding can cause students to make mistakes in solving mathematical problems (Nurhasanah, Turmudi, & Jupri, 2021). Therefore, there is a relationship between students' mathematical connection abilities and their problem solving abilities. In particular, Syafri et al (2021) revealed that students are said to have good mathematical connection skills when students have the following three indicators: (1) the ability to provide information which is characterized by a critical attitude in evaluating the information; (2) have metacognitive awareness; (3) and have skills in problem solving process. Therefore, we chose problem solving as an indicator in identifying students' mathematical connection abilities.

One of the mathematical topics that many errors are found in the problem solving process is geometry. The topic of geometry is one of the important branches of mathematics for students to learn because according to Walle (2001), geometry is closely related to everyday life, plays an important role in learning other branches of mathematics, and can develop problem solving skills (Suwito, 2017). One of the crucial sub-topics of geometry is the quadrilateral. Rectangle is one of the geometry materials studied by junior high school students. This topic is important to study because it is a prerequisite material for solid figure topics. However, there are still some junior high school students who make errors in solving mathematical connection problems on the topic of quadrilaterals, especially processing skill errors. Based on Elsa's research, it was reported that student made error (Elsa & Suhendra, 2022), following example of this error.

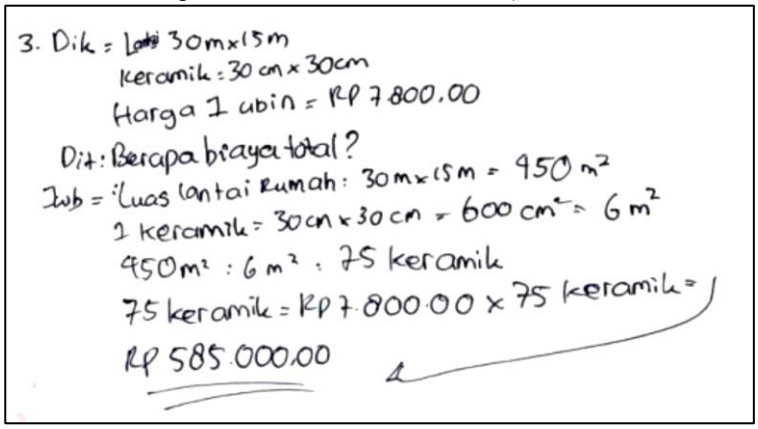

Figure 1. Example of student error

The error made by student is an error in calculating the are of a square ceramic tile. Then in this case, the student cannot change the unit of length, namely convert cm^2 to m^2. Therefore, according to Newman Error Analysis, the error is included in the category of processing skill error. Moreover, research from Setiawan and Widodo found that there were errors based on Polya's stages (Setiawan & Widodo, 2019).

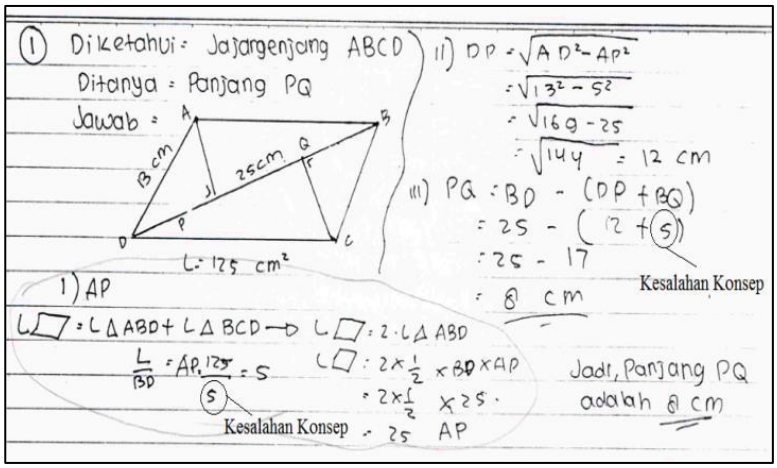

Figure 2. Another example of student errors

The errors made by student are error in executing the solution plan and do not re-check the answers that

have been done. The student can make a plan for solving the problem but didn't understand the concept. Afterwards, the student can understand the problem but didn't write the information based on the question given.

Relying on research conducted by Nurhayati & Asikin (2022), in the last nine years found 12 articles related to mathematical connections. The details are described in the following table.

Table 1. Previous Research on Mathematical Connections

Journal	Author	Research purposes
European Journal of Educational Research	Baiduri, Octavina Rizky Utami Putri, Ikrimatul Alfani (2020)	This study focuses on the process of students' mathematical connections in solving problems in terms of gender using a qualitative approach
EURASIA Journal of Mathematics, Science and Technology Education	Karen Gisel Campo-Meneses, Vicenç Font, Javier García-García, Alicia Sánchez (2021)	This research focuses on intra-mathematical connections that will grow if it is related to exponential and logarithmic functions
Al-Jabar: Journal of Mathematics Education	Nanang Supriadi (2015)	This research focuses on developing mathematical connection skills through interactive electronic textbooks that are integrated with Islamic values
School Science and Mathematics	Jennifer A. Eli, Margaret J. Mohr-Schroeder, Carl W. Lee (2013)	This study focuses on the mathematical knowledge of middle grade teacher candidates in teaching geometry and making mathematical connections
Scientific Journal of Mathematics Education	Ratna Septia Lestari, Euis Eti Rohaeti, Ratni Purwasih (2018)	This study focuses on the description of the profile of students' mathematical connection abilities in solving flat-sided geometry problems in terms of learning styles and basic mathematical abilities
International Journal of Mathematical Education in Science and Technology	Javier Garcia-Garcia, Crisologo Dolores-Flores (2018)	This study focuses on exploring students' intra-mathematical connections during completing calculus assignments, especially derivative and integral materials
	Crisologo Dolores-Flores, Martha Iris Rivera-Lopez, Javier Garcia-Garcia (2018)	This study focuses on exploring the mathematical connections of pre-university students when solving problems related to the rate of change
	Camilo Andres Rodriguez-Nieto (2020)	This study focuses on theoretical reflections on the mathematical connections made by teachers when teaching derivative material
	Javier Garcia-Garcia, Crisologo Dolores-Flores (2020)	This study focuses on students' mathematical connections to derivative concepts based on two different theoretical perspectives
Prism	Ari Septian, Elsa Komala (2019)	This study focuses on improving mathematical connection skills using the Geogebra-assisted PBL model
Juring: Journal for Research in Mathematics Learning	Fitri Rahmadeni, Depriwana Rahmi, Depi Fitraini (2020)	This research focuses on the ability Students' mathematical connection in CTL and conventional learning models

Based on table 1, it is found that in the last nine years, research on mathematical connections has not been widely studied but is in great demand in 2020 and above. This shows that research related to mathematical connections is a current research trend. Furthermore, based on the table, there has been no research related to student errors in completing mathematical connections that are reviewed based on Polya's theory, especially on the topic of rectangles. Therefore, this research aims to analyze and describe students' errors in solving mathematical connection problems based on Polya's theory on the topic of quadrilaterals.

2. Methods

This study follows the research of Elsa and Sudihartinih (2020), which is a descriptive qualitative research using data triangulation (test results, interviews, and theory). The purpose of this study was to analyze and describe student errors in solving mathematical connection problems on the topic of quadrilaterals. The steps in this study include (1) conducting a test in the form of a description consisting of three descriptions, (2) checking answers based on the Polya's stages, (3) conducting interviews with selected students, and (4) documenting the results of student work. Participants in this study were six junior high school students with five female and one male consisting of one grade VIII student and five grade IX students. They were labeled S1, S2, S3, S4, S5, and S6. Participants work on the question individually (question in Indonesian) for approximately 45 minutes followed by an interview.

The research instrument used was the researchers, test questions, documentation, and interviews. This research was carried out directly and online by using the WhatsApp and Zoom applications. The data obtained were then processed and analysed using qualitative data analysis techniques as follows (1) identified student errors, (2) interviewed some students who make errors, (3) analyzed the results of mathematical connection tests and the result of interviews, (4) presented the data descriptively, (5) made the conclusion of the study. The questions in this study are arranged based on indicators of mathematical connections, i.e. (1) Students can use the concept of a rectangle and a rhombus, (2) Students can connect the concept of a rectangle with the concept of expansion of the area, and (3) Students can apply the principle of tiles to everyday problems. The following questions are arranged based on these indicators in sequence (the source of these questions adapted from Elsa (2020)).

1. A rectangular plot of land with a length of 15 meters and a width of 11 meters will be made a fish pond in the shape of a rhombus with a diagonal of 7 meters. If the remaining land area is to be planted with grass, what is the area of the land?
2. An aluminum piece 25 cm long and 16 cm wide is heated from 50ºC to 150ºC. If the coefficient of area expansion is 0.000005/ºC. Calculate the area of the aluminum plate after it is heated!
3. The floor of a school library is rectangular with a size of 9 m × 17 m. The floor will be covered with ceramic tiles measuring 30 cm × 30 cm. If the price of one ceramic tile is Rp. 6,700.00, what is the total cost of tiling the floor of the library?

3. Results & Discussions

After testing and interviewing the participants, one out of six students can answer all the questions correctly. The following are some of the results of the tests of students who made errors sequentially according to the number of questions.

3.1 Students work on the first question

Based on Figure 3, students make errors at the stage of implementing the plan where students have not been able to use the relationship of mathematical concepts to solve problems correctly. This can be seen in students' answers when determining the final result of the land area to be planted with grass by reducing the area of the rectangle with the area of a rhombus. After conducting interviews, the reason students made these errors was cause students were still weak in performing decimal number subtraction operations.

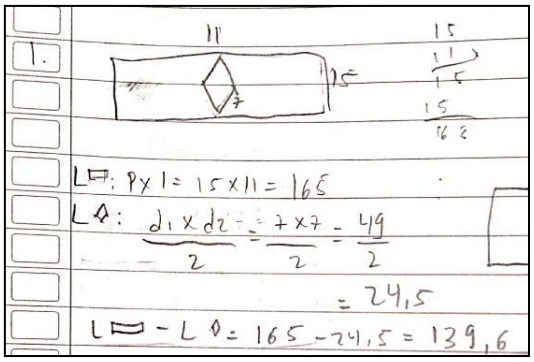

Figure 3. S1's answer to question number 1

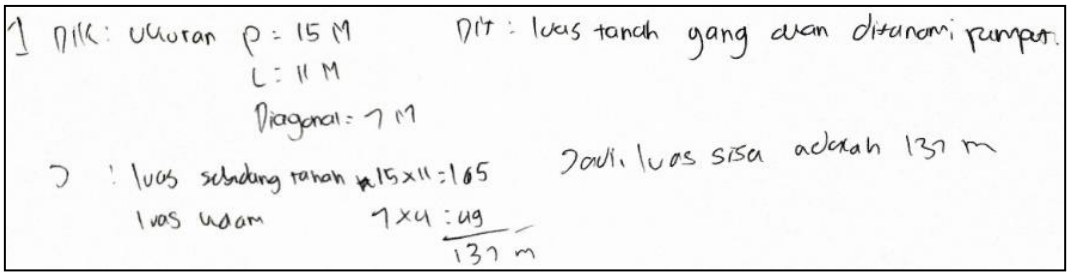

Figure 4. S5's answer to question number 1

Based on Figure 4, students made an error at the planning stage where the student had not been able to determine the right formula to solve the problem. This can be seen in the students' answers that were not correct when looking for the surface area of a rhombus-shaped pool. After conducting the interview, the student considered that the diagonal referred to in the problem was a side so he wrote down how to find the surface area of a rhombus-shaped pool with the formula for the circumference of a rhombus ($7 \times 4 = 49$), even though the formula used and the results of the multiplication operation carried out by the student is wrong.

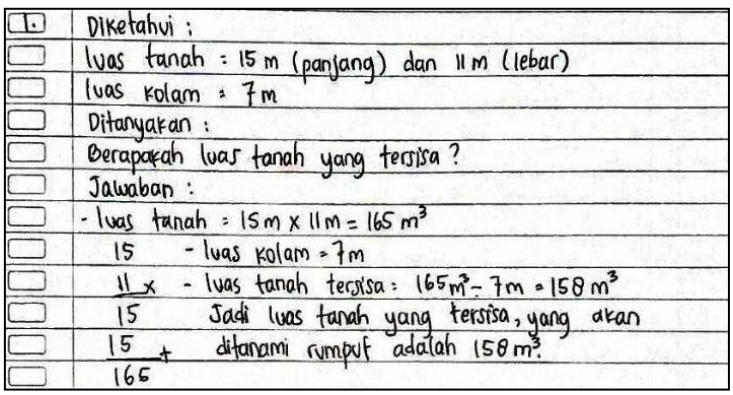

Figure 5. S3's answer to question number 1

Based on Figure 5, the two students made a error at the stage of understanding the problem where the student had not been able to write down the information contained in the problem. This can be seen in the students' answers that have not been correct in writing information on the area of the pool whose surface is a rhombus.

3.2 Students work on the second question

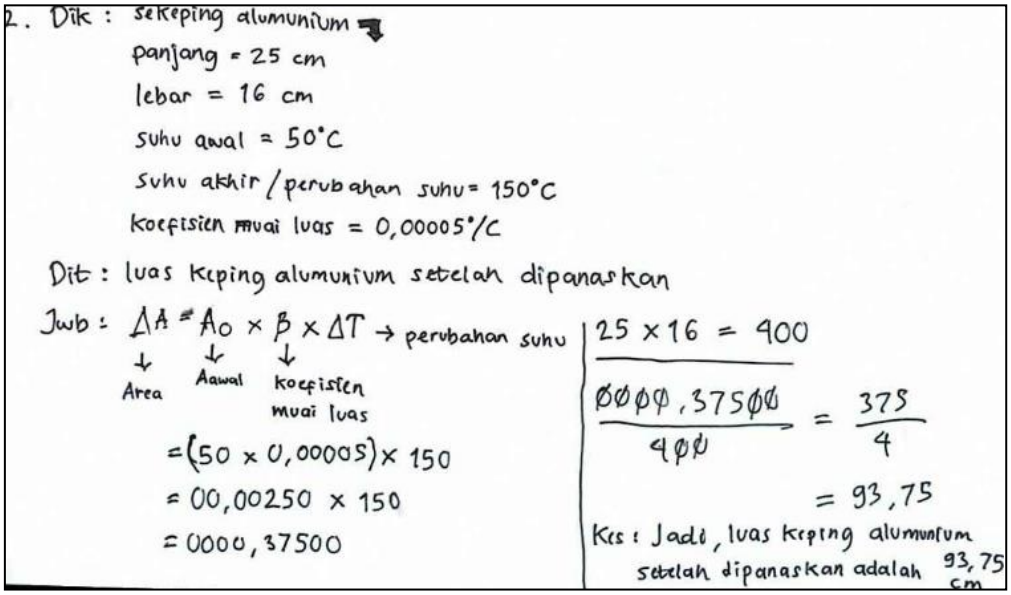

Figure 6. S6's answer to question number 2

Based on figure 6 that is one of the examples students answer, students make errors at the planning stage where students have not been able to use concepts in the field of physics, namely broad expansion to solve problems correctly. As a result, students fail at the implementation stage of the plan. This can be seen in the answers of students who use the wrong formula.

3.3 Students work on the third question

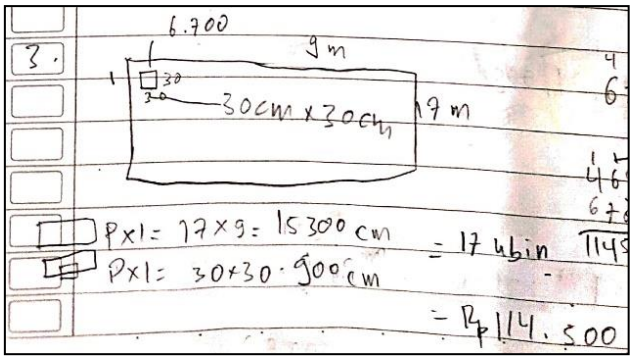

Figure 7. S1's answer to question number 3

Based on Figure 7, students make errors at the stage of implementing the plan where students have not been able to solve problems using appropriate strategies in the application of daily life. This can be seen in students' answers when changing the size of the area. On the answer sheet, student intended to change the unit of meters to centimeters.

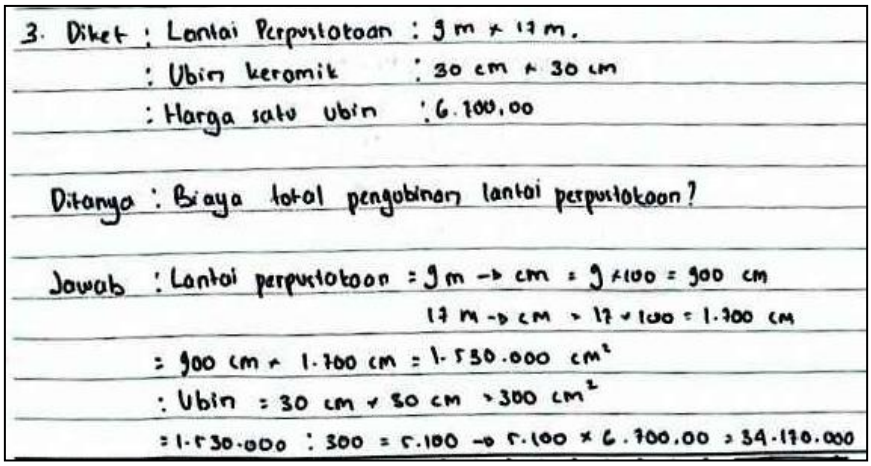

Figure 8. S4's answer to question number 3

Based on Figure 8, students make errors at the implementation stage where students have not been able to solve problems using the right strategy in the application of daily life, namely when determining the area of ceramic tiles in the form of a flat square shape. This is because students do the multiplication operation incorrectly. After conducting the interview, the student realized that he had made a error in performing the operation.

The following is the data for the categorization of student errors based on the Polya's stages, which are presented in the table below.

Table 2. Categorization of Student Errors

Participant	The First Question	The Second Question	The Third Question
S1	3rd stage error	2nd stage error	3rd stage error
S2	True	True	True
S3	1st stage error	2nd stage error	No Answer
S4	True	2nd stage error	3rd stage error
S5	2nd stage error	2nd stage error	3rd stage error
S6	1st stage error	2nd stage error	2nd stage error

Note: 1st stage error : misunderstanding the problem
2nd stage error : errors in making a plan
3rd stage error : errors in executing the solution plan

Based on the results of students' work on the first question, students' ability to connect between mathematical concepts, especially at the stage of understanding the problem. This can be caused by a lack of understanding of the concept of a rectangle and rhombus. Meanwhile, students' ability to connect mathematical concepts with physical science concepts on the second question is still deficient in making a plan. This can be caused by the steps or thinking strategies used are wrong. Then, students' ability to solve problems related to applying mathematical concepts to everyday life in the third question is still deficient at the stage of implementing the plan. This can be caused by students' errors or inaccuracy in the algorithm or calculation process.

Therefore, students' ability to solve mathematical connection problems on the topic of quadrilaterals is still low. This means that students have not been able to optimize the use of knowledge related to mathematical ideas, procedures, or facts from a quadrilateral. Based on the test results in this study, showed that students were still lacking in connecting mathematical ideas with contexts outside of mathematics and in applying mathematical ideas to real-life problems. This is in line with research conducted Hasanah & Aini (2021), where students' mathematical connection skills in solving quadrilateral problems are still very lacking.

Moreover, this is in line with research conducted by Elsa & Suhendra (2022) that students still made errors in solving mathematical connection problems on the topic of a quadrilateral, as well as research form Setiawan & Widodo (2019) regarding student's errors in solving quadrilateral ploblems. However, what distinguishes these researches from previous are many errors made by students occur when preparing plans, where students have not been able to make plans that will be used to solve problems related to building rectangular data; students have not been able to relate facts, concepts and mathematical principles to

quadrilateral problems; students have not been able to make mathematical models in the form of symbols and determine formulas; students have not been able to make a connection between the concept of building space with other fields of science, namely physics on broad expansion; and students have not been able to plan the relationship of objects, concepts, and mathematics to build data with problems of daily life.

4. Conclusion

Based on the results of the study, it can be concluded that some students still make errors in solving mathematical connection problems on the topic of quadrilaterals, especially in the second indicators, namely students can connect the concept of a rectangle with the concept of expansion of the area. The errors identified were student errors in understanding problems, planning strategies, and implementing strategies, with the most errors being errors in planning strategies. These can be caused by the steps or thinking strategies used by students are incorrect.

Some several recommendations and suggestions can be used for further research and professional practitioners related to student error analysis, i.e.: (1) Students need to be trained on questions based on higher-order thinking skills, especially mathematical connection skills because they can help students to have thoughts and insights which is increasingly open and broad to mathematics; (2) Before making mathematical connection test questions, it is necessary to thoroughly explore the quadrilateral concept to find possible errors that will be made by students; and (3) Teachers can use error analysis to identify the location of student errors as information on the causes of errors so that teachers can overcome them to prevent the same error.

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