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The Analysis of Students' Critical Thinking Skills in Determining Plane Figure Properties

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Abstract. The plane figure is compulsory mathematics material at all levels of education, including junior high school. However, students still make frequent mistakes in understanding the plane figures' properties. In understanding this topic, students must have the skill to think critically. Critical thinking is a process of rational thinking before deciding or taking action in a more specific direction. Therefore, this study aims to determine students' skills in defining the plane figure's properties. The method used in this research is a qualitative research method. Tests and interviews were used to determine the students' skills in determining the properties of the plane figure. Researchers determined five indicators used to determine students' skills in determining the nature of the plane figure: focusing and formulating, observing and assessing observation results, making and assessing inductions, defining and assessing definitions, and integrating decisions. Three junior high school students were selected as research subjects with high, medium, and low skill levels, respectively. The data analysis used descriptive analysis using method triangulation and theory triangulation. The research results show two students' mathematical critical thinking patterns based on their skills. The subjects with high and medium skills can solve all problems with a small error rate and fulfill all predetermined critical thinking skills indicators. On the other hand, the subject with low skills has not been able to solve problems, so no critical thinking indicators are met. There is a misunderstanding on high and moderate skills subjects. Neither understand the meaning of opposite angles and parallel lines in specific plane figures. It can be a reference for teachers to improve students' understanding of mathematical concepts.

Keywords: Critical Thinking Skills; Plane Figure Properties; Students' Mathematical Skills

Abstrak. Bidang datar adalah materi wajib matematika di semua jenjang pendidikan, termasuk sekolah menengah pertama. Namun, masih sering terjadi kesalahan di kalangan siswa dalam memahami sifat-sifat bangun datar. Untuk memahami ini, siswa harus memiliki keterampilan berpikir kritis. Berpikir kritis adalah proses berpikir rasional sebelum mengambil keputusan atau mengambil tindakan ke arah yang lebih spesifik. Oleh karena itu, penelitian ini bertujuan untuk mengetahui kemampuan siswa dalam mendefinisikan sifat-sifat bangun datar. Metode yang digunakan dalam penelitian ini adalah metode penelitian kualitatif. Tes dan wawancara digunakan untuk mengetahui kemampuan siswa dalam menentukan sifat-sifat bangun datar. Peneliti menetapkan 5 indikator yang digunakan untuk mengetahui kemampuan siswa dalam menentukan sifat bangun datar, yaitu memfokuskan dan merumuskan, mengamati dan menilai hasil pengamatan, membuat dan menilai induksi, mendefinisikan dan menilai definisi, dan mengintegrasikan dalam menentukan keputusan. 3 siswa SMP dipilih sebagai subjek penelitian dengan tingkat kemampuan masing-masing tinggi, sedang, dan rendah. Analisis data menggunakan analisis deskriptif dengan menggunakan triangulasi metode dan triangulasi teori. Hasil penelitian menunjukkan bahwa ada dua pola berpikir kritis matematis siswa berdasarkan keterampilannya. Subjek dengan keterampilan tinggi dan sedang mampu menyelesaikan semua masalah dengan tingkat kesalahan yang kecil dan memenuhi semua indikator keterampilan berpikir kritis yang telah ditentukan. Di sisi lain, subjek dengan keterampilan rendah belum mampu menyelesaikan masalah, sehingga indikator berpikir kritis tidak terpenuhi. Ada kesalahpahaman pada subjek dengan keterampilan tinggi dan sedang. Keduanya tidak memahami arti dari sudut bertolak belakang dan garis sejajar yang terdapat pada bangun datar tertentu. Temuan penelitian ini dapat menjadi acuan bagi guru untuk meningkatkan pemahaman konsep matematika siswa.

Kata kunci: Keterampilan Berpikir Kritis; Keterampilan Matematis Siswa; Sifat Bangun Datar

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INTRODUCTION

Geometry is a branch of mathematics and is one of the keys to understanding nature in all its forms. Geometry is fundamental to studying advanced topics in mathematics, science, geography, architecture, art, design, engineering, and technology in college or graduate studies (Safrina et al., 2022). In addition, geometry is vital in supporting the learning process of other branches of mathematics and can connect children's thinking processes with the real world. So, of course, elementary school students should understand geometry properly (Nuraini & Ganda, 2021). Geometry generally examines content consisting of points, lines, fields, and space and continues to develop according to the demands of the times. Geometry is taught at all levels of education based on each difficulty level.

Basic geometry, two-dimensional plane figures, was introduced in elementary and middle schools. Plane figures are two-dimensional shapes that only have length and width but do not have height and width that are limited by straight or curved lines. The plane figure is a material that requires students to solve mathematical problems. On the other hand, students are required to ensure the results of each problem and are better prepared to deal with various problems in mathematics and everyday life (Chisara et al., 2019).

The reality that is currently happening is that students' skill to solve geometric problems has not been maximized. Some common mistakes students make in solving geometric problems include not understanding the procedure that will be used to solve the problem. Some barriers to student learning found are barriers to student learning in determining the types of square and rectangular shapes; barriers to students in connecting the concepts of squares and rectangles based on their properties; barriers to learning students in determining the type and describing rectangular shapes based on their properties; students' barriers in determining names and describing rectangular shapes based on their properties; and students' barriers in analyzing similarities and differences in the properties of a plane figure (Nursaidah & Pranata, 2018). Overall from the number of students, students still have not mastered the basic concepts of the properties of square and rectangular shapes.

Some experts have concluded that students make mistakes when solving problems that need their critical thinking skills. Especially in the sub-skills of evaluation, analysis, and self-regulation became the lowest critical thinking sub-skills mastered by the students compared to other critical thinking sub-skills (Basri & As'ari, 2019). In addition (Agoestanto & Sukestiyarno, 2017; Verawati, Hikmawati, Prayogi, & Bilad, 2021) says that The mathematics critical thinking skill of students with Field Dependent cognitive style is a little better than students with Field Independent cognitive style. These experts have different ways of analyzing critical thinking skills.

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Critical thinking is one type of higher-order thinking skill that students must possess to solve their problems (Ashari & Salwah, 2017). Critical thinking is analyzing information based on facts to make reasonable conclusions (Salwah et al., 2020). Critical thinking can also be interpreted as analyzing thought in a more explicit direction, separating something sharply, selecting, recognizing, considering, and creating an ideal purpose (Istianah, 2013). In addition, (Karim, 2014) argues that critical thinking is thinking wisely in assessing something before making a choice or taking a step, then collecting as much data as possible related to something. Thus, one of the essential skills that a student must have is the skill to think mathematically, which will help students deal with math and everyday problems. The critical thinking stage of students in this study refers to (Ennis, 2015), as seen in Table 1.

Table 1. Critical Thinking Stage

Step of Critical Thinking	Indicator	Description
Elementary clarification	Focus on problem	Identifying the questions
The basis for the decision	Observation and evaluating the result of observation	Take notes on things that are needed in order to use the appropriate mathematical formula
Inference	Making inductions and assessing inductions	Making conclusions from the results of the hypothesis
Advances Classification	Define and rate definitions	Seeing the logical relationship of each problem
supposition and integration	Integrate into decision making	Select, combine, and decide on alternative strategies to create problem solutions

Students are motivated to think and solve problems when problems are interesting to them (Ashari & Ilyas, 2018). In this research, the researchers developed critical thinking problems based on the student's understanding of plan figure properties. These problems will deliver the student to think more critically when they understand the properties first. This study aims to determine students' critical skills in defining the plane figure's properties. The student's critical thinking skills were also analyzed according to the student's initial performance, like low, medium, and high levels.

METHOD

The type of this research is descriptive research with a qualitative approach. That is, it qualitatively describes events that are the center of attention of critical thinking skills and are based on qualitative data. The resulting data will be in words or descriptions obtained from interviews and writings or numbers obtained from interviews. This research was conducted on seventh-grade students in junior high school—the subject was selected by choosing three students according to their mathematics learning achievement. Students learning achievements are grouped into three categories. The category of learning achievement is shown in Table 1 (Fuadah, 2016).

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Table 2. Learning Achievement Category

Subject Categories	Subject Characteristics
Score ≥ X + SD	High Skill Subject
X + SD < Score ≤ X – SD	Medium Skill Subject
Score ≤ X – SD	Low Skill Subject

Thus, subjects consisting of three junior high school students were selected with high, medium, and low skills, respectively. The students are classified based on their seventh-grade report. The selected subject gave a written test about plane figures to identify their critical thinking skills. The critical thinking skills test consists of five statements about the plane figure. The students were asked to determine the truth of these statements.

1. A rectangle has two pairs of parallel sides, equal opposite angles, and one symmetrical axis.
2. A kite has four sides of the same length, equal opposite angles, the two diagonals intersect perpendicularly, and have two folds symmetrical axis.
3. A rhombus has four sides, two pairs of parallel sides, opposite angles are the same size, and the two diagonals are not the same length and are not perpendicular.
4. A trapezoid has a pair of parallel and equal sides, opposite angles are equal, and diagonals are not the same length.
5. A square has four sides of the same length, equal opposite angles, the diagonals intersect perpendicularly, and have two folds symmetrical axis.

The researcher triangulates each student's answers by interview to confirm the validity of the data according to the results of tests conducted previously and to strengthen the researcher's assessment of students' unreachable critical thinking skills. Students are asked to explain based on understanding while working on the problem-solving process, to be analyzed based on the level of critical thinking.

The interview process allows researchers to more easily conclude the extent to which students' critical measuring skills are based on critical thinking indicators. Therefore, it is expected to be able to answer all interview questions based on what was experienced when solving the given problem. The result of the interviews transcribed, categorized, and coded. The following steps are performed reduction, abstraction, transformation, and categorization of the first and second data. The first and second data are compared. All data related to consistent research objectives are used as a reference for conducting data analysis. Then, the inconsistent data with the research objectives are omitted.

We used thematic analysis to analyze the data. This analysis aims to identify patterns from individual answers based on the instrument (Braun & Clarke, 2013). We chose this method because This method is flexible and can answer research questions, especially about what meanings are made by the subject during the problem-solving process based on the level of critical thinking, and

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this method allows us to find patterns that are accompanied by unique names. The contribution of this research becomes important through thematic analysis because there are still few investigations in the field of mathematics education involving this method.

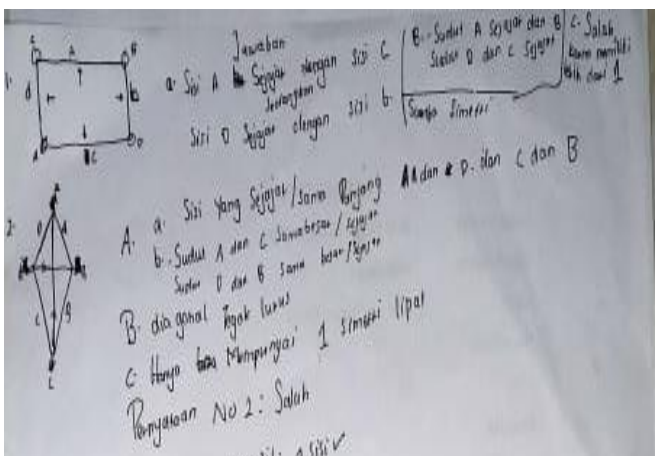
Data analysis was carried out by examining all data from test results in descriptions or interview tests. In data reduction, the student statements that are not under the research objectives are removed. Data validation is carried out during data collection, namely, using verification. Presentation of data includes classification and identity of data, namely writing organized and categorized data sets so that it is possible to conclude the data. This study categorized interview data about reduced critical thinking skills based on indicators in each observed aspect. Making coding or codes that aim to facilitate the exposure of students' mathematical strategic competitive analysis data, then the coding is carried out on excerpts of research subjects' answers during interviews.

In the next step, the researcher presents the interview results from the critical thinking skill test results about students' critical thinking skills and interprets the data or draws research conclusions from the data that has been collected and verifies the conclusions. Conclusions are drawn based on an analysis of the data collected through tests or interviews with the subject. It is done by comparing the results of the subject's work with the results of interviews.

RESULTS AND DISCUSSION

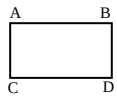
High Skill Subject (ST)

The student with high skill, namely ST, can evaluate statement 1 correctly. It means ST knows the properties of the rectangle well. Nevertheless, ST can not evaluate statement 2 correctly or define the equal size of the angle. The student answers are shown in Figure 1.



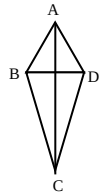
Solution:

1



a. Side A is parallel with side C
Side D is parallel with side B
b. Angle A is parallel with angle B
Angle D is parallel with angle C
c. Wrong because it has more than 1

2



a. The parallel side are identical in length
b. Angle A and C are the same sizes
Angle D and B are the same sizes
c. Only has one symmetrical
The second statement is wrong

Figure 1. The Answer of High Skill Subject for Statements 1 and 2

ST evaluates statements 3 and 5 correctly. ST explains these statements with some examples according to the properties of given shapes. Nevertheless, the answer for statement 4 is wrong; ST

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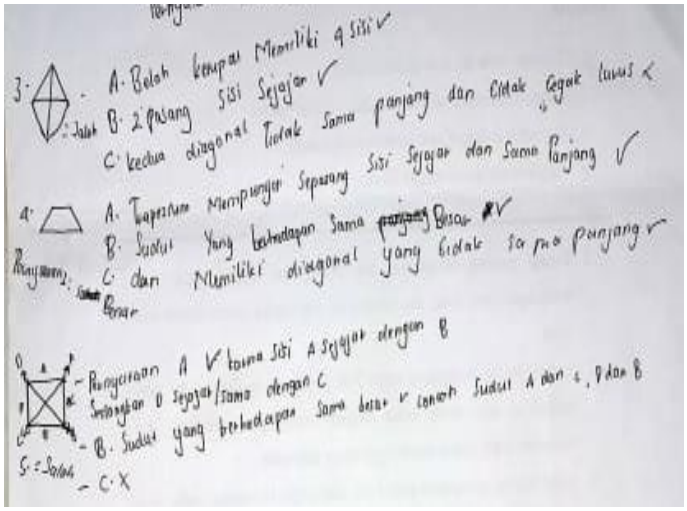
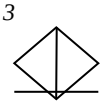
assumes that the parallel side must be the same in length and the opposite side must be the same in size. It is shown in Figure 2.



Solution:

3



a. The rhombus has four sides (√)
b. Two pairs of Parallel sides (√)
c. The diagonals are not identical in length and not perpendicular ***(X)***

4

a. The trapezoid has a pair of parallel sides and is identical in length (√)
b. The opposite angle is the same size (√)
c. Do not have the same length diagonal (√)

5.

a. The A statement (√) Because side A parallel with B, also D parallel with C
b. The opposite side are same (√) Example A and C, D and C
c. ***(X)***

Figure 2. The Answer of High Skill Subject for Statements 3, 4, and 5

Based on interviews, ST can determine needed information to prove whether the statement was true or false in focusing and formulating indicators. ST took the first step to ensure that every statement was false or true by writing down every property of the plane in the statements. It can be seen in student work. At the observation stage and assessing the results of observations, ST can make observations for each problem. ST has been able to explain statements 1, 3, and 5 about the properties of rectangles, rhombuses, and squares. For 4 and 2, ST was wrong to define angles equal in size.

At the stage of making induction and assessing induction, ST can correctly evaluate three odd statements (1, 3, and 5) and can correctly analyze the properties of the plane in statements. However, for statements 2 and 4, ST has not been able to explain the types of angles, and ST assumes that each opposite angle is the same size. For indicators defining and assessing definitions, ST has been able to describe every shape that is asked for in the given statement. Besides that, ST has been able to show the properties of the plane for statements 1, 3, and 5. For statements 2 and 4, ST can draw a flat trapezoidal kite and show opposite angles on a trapezoidal image. The error occurs because ST assumes that each opposite angle is equal. It can be seen from the interview excerpts. ST has been able to draw decisions for each given statement in the indicators of combining and determining decisions. ST determines the decision based on the analysis for each plane in each question. ST is wrong in determining statement 4 because of the understanding that each opposite angle is the same.

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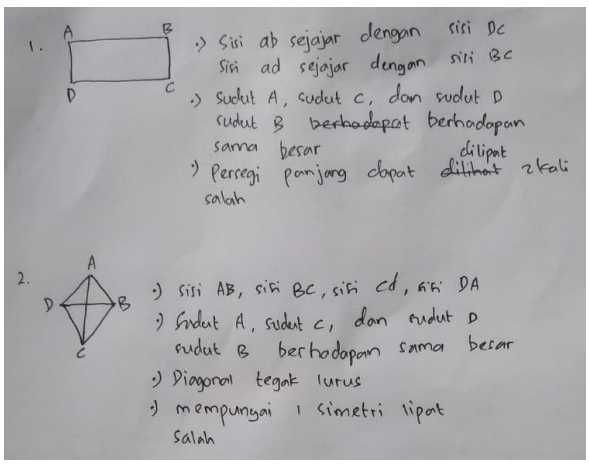
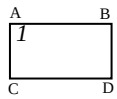
Medium Skill Subject

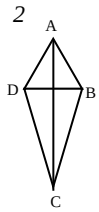
The student with medium skill, namely SS, can evaluate two statements correctly. SS concludes that the properties of a rectangle that wrote on the problem are wrong. It is especially on the statement that the rectangle has only one fold symmetric. SS also concludes that the kite properties in statement 2 are wrong. It is especially on the statement that the kite has one fold symmetric. The student answers are shown in Figure 3.





Solution:

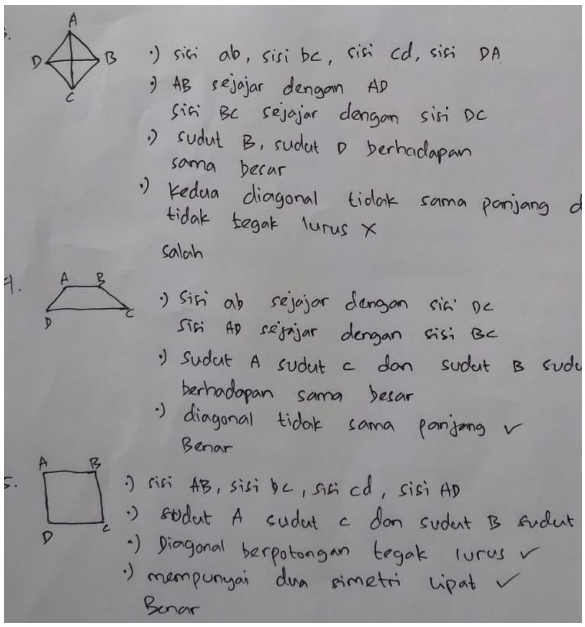
- *Side ab parallel with Side dc*
  Side ad parallel with Side bc
- *Angle A, Angle C, and Angle D, Angle C are opposite and the same in size*
- *The rectangle can fold two times*
  Wrong

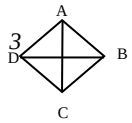


- *Side AB, Side BC, Side CD, and side DA*
- *Angle A and C are the same sizes*
  Angle D and B are the opposite and the same size
- *The diagonals are perpendicular*
- *Have one fold symmetric*
  wrong

Figure 3. The Answer of Medium Skill Subject for Statements 1 and 2

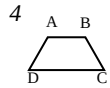
SS can evaluate statement 5 correctly but is wrong in evaluating statements 3 and 4. SS concludes that the rhombus has diagonals that are not identical in length, and the trapezoid has two pairs of parallel sides. It can be seen in Figure 4.



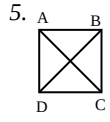


Solution:

- *side ab, side bc, side cd, side DA*
- *AB parallel with AD.*
  Side BC parallel with side DC
- *Angle B and Angle D are opposite and the same in length*
- *The two diagonals are not identical and not perpendicular (X)*
  Wrong



- *Side ab parallel with side DC*
  Side AD parallel with side BC
- *Angle A and angle C also angle B and angle D are opposite and the same in length*
  A. Do not have the same length diagonal
  Right



- *side ab, side bc, side cd, side AD*
- *Angle A Angle C and Angle B Angle D*
- *The diagonal intersects Perpendicular*
- *It has two fold-symmetries*
  Rigt

Figure 4. The Answer of High Skill Subject for Statements 3, 4, and 5

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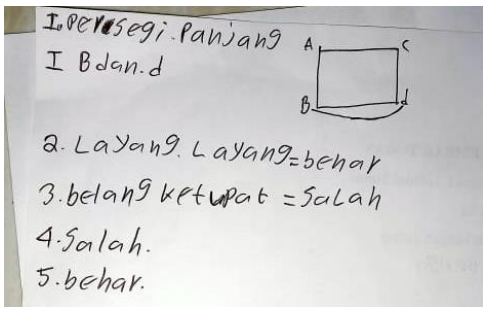
In the indicator of focusing and formulating, SS has determined the solution to all statements. SS stated that the question aims to prove whether the statement is true or false. To ensure that every statement is true or false, SS takes the first step by writing down every property of the plane in the problem. In the indicator of making observations and assessing the results of observations, SS can observe each property of the figure well. SS has been able to explain the nature of a square, kite, rhombus, and square. However, SS is wrong in defining parallel sides; SS assumes that parallel sides have the same length. As a result, SS incorrectly determines the parallel sides of the kite and trapezoid.

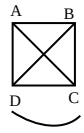
For indicators of making induction and assessing induction, SS could answer statements 1, 2, and 5 correctly. However, for statements 3 and 4, SS has not been able to explain parallel sides; SS assumes that the parallel sides have the same length. For indicators of defining and assessing the definition, SS can describe all shapes. Besides that, ST has been able to show the properties of the plane for statements 1, 2, and 5. For statements 3 and 4, SS can draw a rhombus and a trapezium, but SS incorrectly showed the parallel sides of the two planes. SS determines the decision from the analysis results for each of the properties of the flat shape. In combining and determining decisions, the SS can make decisions for each given statement. However, SS made a mistake in determining statements 3 and 4 because of the misunderstanding of the parallel sides.

Low Skill Subject

The student with low skill, namely SR, can not describe the problem given. The student answers are shown in Figure 5.



1. *Rectangle*
I. *B and d*



2. *Kite = Right*
3. *Rhombus = wrong*
4. *Wrong*
5. *Right*

Figure 5. The Answer of Low Skill Subject for Whole Five Statements

In focusing and formulating indicators, SR did not know what he wanted from every question asked. The interview results also showed that SR preferred to remain silent and did not answer the researcher's questions. In observing and assessing the results of observations, SR cannot make observations for every trait asked in the question. SR's answer does not show the observation process. SR's answer only rewrites the shape's name and determines whether it is true or false. The interview results also showed that SR could not answer the question when the researcher tried to find information about the answer.

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SR can give a "right or wrong" answer without going through a thought process or just answering. In making and assessing induction, SR can give right or wrong answers to specific problems. The same thing is also found in indicators defining and assessing definitions and indicators shown in determining decisions.

Based on the previously stated results, several significant findings were obtained from the three predetermined subjects. The findings are presented in Table 3.

Table 3. Research Finding for Subject Characteristics

Subject Categories	Subject Characteristics
High Skill Subject	The subject understands the steps that must be taken to solve the given problem. The subject's understanding of opposite angles is still wrong.
Medium Skill Subject	The subject understands the steps that must be taken to solve the given problem. Subjects do not understand the definition of parallel sides.
Low Skill Subject	The subject does not know the steps to answer the questions given.

The three subjects above still find difficulties solving problems, especially critical thinking. The three subjects have the same problem, namely the minimal understanding of the concept of angles and parallel lines. It is in line with the opinion (Dahniar et al., 2021) that students' understanding of concepts is minimal and results in students often making mistakes in working on the questions given. Teaching tends to emphasize the skills of working on questions while understanding the concepts is only given in a short time, considering the limited lesson hours.

This study shows that high and medium subjects have been able to work on and understand the steps in solving the problems given. The student can check the truth of the statement, observe and provide explanations for the answer, evaluate the mathematical situation on the problem, and be able to analyze and make statements from the problem situation at hand because he believes in his skills so that he can solve all the questions given to the maximum. Khoirunnisa & Malasari, 2021). The subject cannot determine what concept he will use to solve the problem. In this case, the subject is confident in his skills because he already understands the material. The subject does not hesitate to take action, as shown by making the mathematical model he understands. The subject is sure of the strategy/method he uses to solve the problem correctly. Subjects use strategies taught by the teacher (Prajono et al., 2022).

Conversely, subjects with low skills have not been able to understand and work on the steps given in the statements that have been given. Such students have not mastered the indicators of giving simple explanations by writing information on the questions, but students have understood the meaning. Students are also still not able to explain the reasons why they chose the answer. The answers given seem to be guesswork. It can be seen in the answers of students who only repeat or rewrite the information of the statements in the question (Lestari & Roesdiana, 2021).

The subjects student with critical thinking can be disposed to pursue and offer clear reasons (Ennis, 2015) from their answer. Our studies show the opposite of that concept. They cannot

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perform the reason according to their answer. The subjects in this study believed that their answers or reasons were correct even though they were wrong. It may occur due to misunderstanding the concept or forgetting about the definition. In this study are parallel lines and opposite angles. Teachers should provide a learning strategy to see how students give reason to math problems instead of focusing on students' final answers.

As a consideration, teachers in learning should deepen students' knowledge about the main parts of plane figures, such as points, lines, planes, and angles, including their development. Learning mathematics should start from simple problem solving and develop into activities that require critical thinking skills. It is in line with the opinion (Isrokatun et al., 2020) that learning mathematics must start from simple concepts. Although the examples presented in the previous description are simple, they can change a routine habit in the classroom into a teaching and learning activity with a critical and creative nuance (Sabandar, 2013).

Students working on mathematic problems are usually less careful, so they always have minor errors that can be fatal to the answer. Students must be trained to always be careful in working on problems in mathematics. It will become a habit to always be precise and accurate in doing anything. This habit will affect critical thinking and student performance in their environment. Therefore, in learning mathematics, we must practice thinking habits, one of which is always trying to be precise and thorough (Salwah, 2018).

CONCLUSION

This research show two patterns of students' mathematical critical thinking based on their skills. First, high and medium skills students can solve all problems with a small error rate and can fulfill all predetermined critical thinking indicators. The second is that subjects with low skills that have not been able to solve problems; no critical thinking indicators are met. There is a misunderstanding on students with high and moderate skills. Both do not understand the meaning of "opposite angles" and "parallel lines" in specific two-dimensional shapes. It can be a reference for teachers to focus the learning on improving students' understanding of concepts.

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