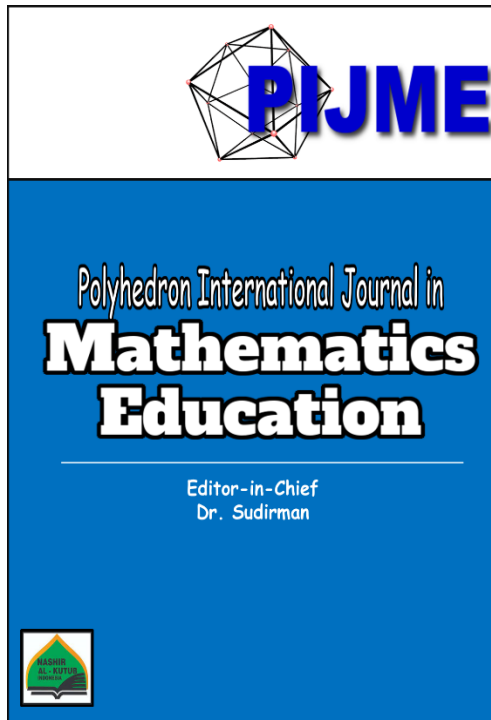


Polyhedron International Journal in Mathematics Education

Journal homepage: <https://nakiscience.com/index.php/pijme>



Level of critical thinking of junior high school students in solving mathematical problems

Mellawaty^{a*}, YL Sukestiyarno^b, Zaenuri^c, Isnarto^d

^{a*}Universitas Wiralodra, Indonesia,
mellawaty@unwir.ac.id

^bUniversitas Negeri Semarang, Indonesia,
sukestiyarno@mail.unnes.ac.id

^cUniversitas Negeri Semarang, Indonesia,
zaenuri.fmipa@mail.unnes.ac.id

^dUniversitas Negeri Semarang, Indonesia,
isnarto.math@mail.unnes.ac.id

To cite this article: Mellawaty, Sukestiyarno, Y.L., Zaenuri & Isnarto. (2023). Level of critical thinking of junior high school students in solving mathematical problems. *Polyhedron International Journal in Mathematics Education*, 1(1), 53-61

Original Article

Level of critical thinking of junior high school students in solving mathematical problems

Mellawaty^{a*}, YL Sukestiyarno^b, Zaenuri^c, Isnarto^d

^{a*}Universitas Wiralodra, Indonesia, mellawaty@unwir.ac.id

^bUniversitas Negeri Semarang, Indonesia, sukestiyarno@mail.unnes.ac.id

^cUniversitas Negeri Semarang, Indonesia, zaenuri.fmipa@mail.unnes.ac.id

^dUniversitas Negeri Semarang, Indonesia, isnarto.math@mail.unnes.ac.id

Abstract

Critical thinking ability is a crucial ability in mathematics, both at the elementary, secondary, or college level. However, this critical thinking ability is still low. Therefore, the researchers want to study the problem at what level the students are doing in solving mathematical critical thinking problems. The research method used a qualitative method, with the implementation analyzing students who deal with mathematical critical thinking ability problems. The study was conducted at one of the State Junior High Schools in Kroya District, Indramayu, West Java. As a result of the study, information was obtained about students who could not solve the problems presented in mathematical critical thinking ability problems, so they did not understand which strategies should be used to solve problems that could be solved.

Keywords: analysis of student difficulties, mathematical critical thinking ability

1. Introduction

Mathematics is the science of organized structures (Ruseffendi, [2006](#)). Mathematics is one of the basic sciences that has an essential role in developing science and technology. Mathematics is the science that emphasizes the formation of thinking ability. According to Samo et al ([2017](#)), the systematic characteristic in mathematics confirms a coherent mindset, practical and straightforward. Mathematics also asserts rational characteristics that mean everything used must be accounted for in rational, logical, or reasoned ways. This is because mathematics is a universal science that underlies the development of modern technology in various disciplines and advances human thinking (Sudirman et al., [2021](#)). In addition, mathematics is always used in all fields of life and supports other branches of knowledge.

Students need experience and practice in solving problems posed in solving problems, and they must understand various kinds of solving strategies and understand which strategies help solve these problems. When discussing a problem, students must formulate the problem, choose information relevant to the problem, and understand the ways and strategies that must be applied to overcome the problem (Son et al., [2020](#)).

According to Klein ([2016](#)), the criticism of reason and reflective thinking is directed to decide the things that are agreed to be done. Presseisen (1986) says critical learning that uses basic thinking processes to analyze arguments and bring opinions to each meaning and interpretation develops a cohesive and logical pattern of punishment, questions the underlying of each, and provides a reliable, concise, and convincing presentation model.

Students still have difficulty solving story questions on critical mathematical

ability (Gaol et al., 2019; Lorentzen, 2013; Palinussa, 2013; Su et al., 2016). Therefore, the researchers want to study the problem at what level the students are doing to solve mathematical critical thinking problems.

2. Method

The research method used is a qualitative method, with the implementation of analyzing the results of student answers when working on mathematical critical thinking skills questions. The analysis was carried out based on the point of view of researchers and some mathematic education experts at Wiralodra University, Indramayu.

The material for critical mathematical thinking used in this study is rectangles and triangles. This material was chosen because, at the time of going to research, the material that corresponds to his research time was rectangles and triangles. The difficulty of the questions is made accessible to avoid why students cannot work on the problem because of the high level of difficulty. According to McLean (2005); Syah et al (2019) and validated by several mathematicians from Wiralodra University.

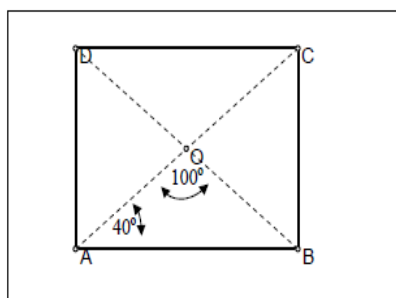
The study was conducted at one of the State Junior High Schools in Kroya District, Indramayu Regency. The selected school is a school that is far from the reach of tutoring institutions, so that it is expected to describe the primary mathematics education organized by the government.

3. Results and Discussion

The analysis of students' difficulties can be seen from the mistakes students make when answering critical thinking skills in this study. The following is an analysis of the difficulties of students' mistakes in answering the most common questions.

Figure 1

The Indonesian version of problem number 1

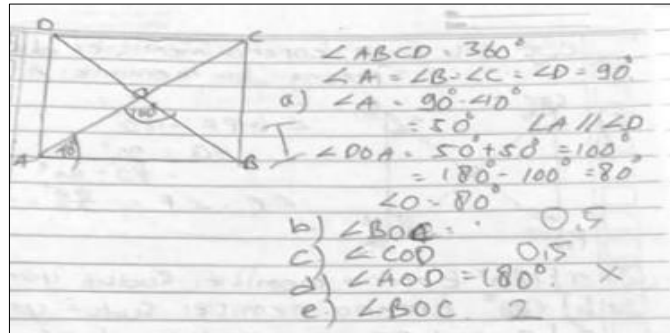


Consider the ABCD rectangle below

- Determine the size of the DAO angle and the ABO angle.
- Write another angle that has the same angle size as the DAO angle.
- Write another angle that has the same angle size as the ABO angle.
- Specify the AOD angle size.
- Write another angle that has the same angle size as the AOD angle.

Students are instructed to check the size of the angle and write down other angles based on the information provided. Students' answers will vary, but students who have good critical thinking skills will only use relevant information (suitable for measuring indicators determining relevant and irrelevant information) and sufficient (suitable for measuring indicators determining information provided) to indicate the magnitude of angles and determine other angles. If the information taken is excessive, students are less critical.

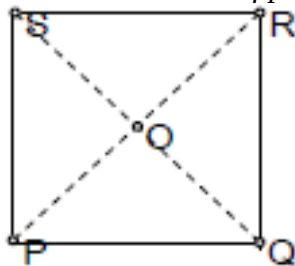
Figure 2
 Indonesian version of Wrong Answer to Problem Number 1



Examples of incorrect answers that often arise from question number 1 can be seen in Figure 2. Figure 2 shows that the angle and other angular names are still incorrect and incomplete, such as part a) 400, written 500. Part b) the answer is still lacking complete, written only the BOC angle, while other angles such as the ADO angle and the DCO angle whose angular size is the same as the DAO angle. This can be interpreted that students are still not able to determine relevant information.

Figure 2 also shows that students have not only been able to determine relevant information but have also not determined the information needed. They were seen still unable to determine the magnitude of the angle in question and the names of other angles whose angles correspond. Answering question number 2, is still simple. By determining the size of ABO and AOD, students can determine the size of the other angles and the names of the other angles.

Figure 3
 Indonesian version of problem



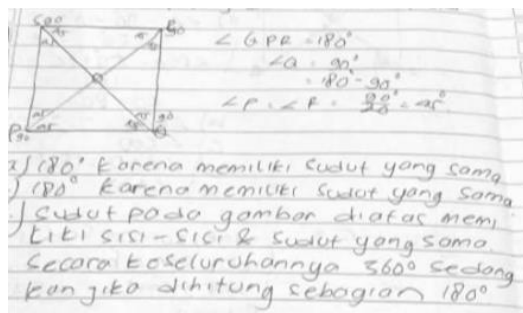
Consider the PQRS square below

- What is the size of the QPR angle and QRP angle? Explain your answer.
- What is the size of the SQP angle and PSQ angle? Explain your answer.
- What can you conclude about the size of the four corners of a square?

Students are asked to pay attention to the patterns given to determine the angle. These patterns are used as a reference to solve the real problem, which is to determine the angle based on the diagonal diagnoses in a square. If the student is critical, the student will determine patterns in answering the magnitude of the angle and determine the number of angles based on the known diagonal. This problem is suitable for measuring the ability to think critically about determining and inferring sub-goals that lead to goals.

Figure 4

Indonesian version of Wrong Answer to Problem Number 2



- 180^0 because it has the same angle.
- 180^0 because it has the same angle.
- The corners in the image above have the same sides and angles. Overall 360^0 whereas if calculated in part 180^0

For an example of wrong answer number 2, it appears that students can determine the number of angles in a square but have not been able to determine the size of the angles in a square PQRS drawing. They are seen in Figure 6. The angles are not correct, so that the other angles are also wrong.

Figure 5

Indonesian version of Problem Number 3

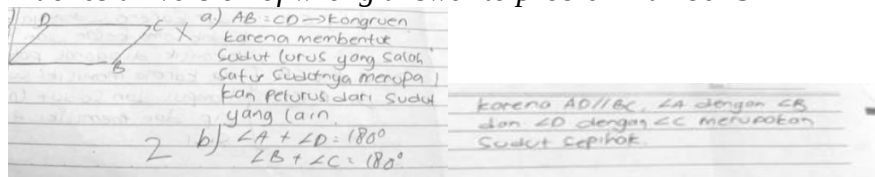
- Mungkinkah dua sudut yang berhadapan dalam jajargenjang saling berpelurus? Jelaskan jawabanmu! (Skor: 5)
- Dua sudut yang berdekatan dalam jajargenjang jumlahnya sama dengan 180^0 . Benarkah pernyataan tersebut? Jelaskan jawabanmu! (Skor: 5)

- Is it possible that the two opposing angles in the parallelogram are aligned? Explain your answer. 180^0 because it has the same angle.
- Two adjacent angles in the range of parallelogram are equal to 180^0 . Is that statement correct? Explain your answer.

Problem number 3a. Contains instructions to students to look for large angles in the alignment of the ranks. In order to answer these questions, students are required to detail problems and develop their ideas. In detailing problems and developing ideas, students must recall other problems that have been done before (suitable for measuring critical thinking skills with indicators determining the similarities and differences between given problems and other problems). After that, students must determine how to solve the problem (suitable for measuring critical thinking skills with indicators to choose and justify strategies for solving problems). Students are said to have good critical thinking skills if students can develop the concept of the ladder to a rectangular concept. Students' critical ability is terrible if students look for large angles facing each other by adding all the angles. Problem number 3b. have many ways to solve it; students are asked to determine the number of adjacent angles in equations equal to 1800. This problem is suitable for measuring indicators to make valuable considerations for solving problems in critical thinking and indicators compiling explanations based on relevant and irrelevant data on the problem given and other problems, which are essentially contained in each question.

Figure 6

Indonesian version of wrong answer to problem number 3



- a. $AB = CD \rightarrow$ congruent because it forms the wrong angle, one corner is the straightener from another angle.
- b. $\angle A + \angle D = 180^0$
 $\angle B + \angle C = 180^0$

Because $AD \parallel BC$, $\angle A$ with angle $\angle B$ and $\angle D$ with $\angle C$ are unilateral angles.

In Figure 6, students also make mistakes. Determine parallel lines, even though the solution sought is two angles facing each other in a parallel alignment. The concept of large corners on a square is not used at all.

Figure 7

Indonesian version of Problem Number 4

Jika diketahui: $T = \{\text{trapesium}\}$, $B = \{\text{belah ketupat}\}$, $J = \{\text{jajargenjang}\}$, dan $L = \{\text{layang-layang}\}$

- a. Apakah $T \subset J$? Jelaskan jawabanmu! (Skor : 2)
- b. Apakah $J \subset T$? Jelaskan jawabanmu! (Skor : 2)
- c. Apakah $T \subset B$? Jelaskan jawabanmu! (Skor : 2)
- d. Apakah $B \subset T$? Jelaskan jawabanmu! (Skor : 2)
- e. Apakah $J \subset L$? Jelaskan jawabanmu! (Skor : 2)

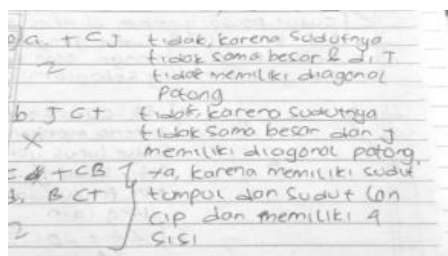
If known $T = \{\text{trapezoid}\}$, $B = \{\text{Rhombus}\}$, $J = \{\text{parallelogram}\}$, and $L = \{\text{kite}\}$

- a. Is $T \subset J$? Explain your answer!
- b. Is $J \subset T$? Explain your answer!
- c. Is $T \subset B$? Explain your answer!
- d. Is $B \subset T$? Explain your answer!
- e. Is $J \subset L$? Explain your answer!

In problem number 4, students are instructed to determine the characteristics of the ladder, rhombus, trapezoid, and kite so that students can make connections that may differ from one another. Suitable for measuring critical thinking skills. Based on problem number 4, students already know the desired quadrilateral properties of the problem. Students are asked to make connections on quadrilateral where in question number 4 are parallelogram, rhombus, trapezoid, and kite, with more specific criteria. Suitable for measuring critical thinking skills.

Figure 8

Wrong Answer to Problem Number 4



- 1) $T \subset J$ no, because the angles are not equal B at T doesn't have a diagonal cut.
- 2) $J \subset T$ no, because the angles are not equal and J doesn't have a diagonal cut.
- 3) $T \subset B$ $B \subset T$ $J \subset L$ yes, because it has a obtuse angle and a sharp angle and has 4 sides

In Figure 8, students can understand the properties of quadrilateral, especially parallelogram, rhombus, trapezoid, and kite. However, students can still not interpret the diagonals that can direct them to answer the angles of a rectangle. Students still cannot understand the meaning of the problem. The four questions

above are mathematical critical thinking problems, but the solution will never be separated from the stages of how to solve the problem.

Polya (1957) mentions how to solve problems divided into four phases. The first phase is understanding the problem. The second phase is planning the complete plan. The third phase is implementing the plan. Furthermore, the fourth phase checks the results of the work. If we look at the results of students' answers on each item, the underlying problem occurs in the first and second phases.

In answer to question number one, it appears that students are still not quite right in determining the angle size and are incomplete in determining the names of other angles. Students cannot understand the problem in problem number one, so the solution is not directed. In answer to question number two, students have determined the number of angles in a square, but students have not determined the size of the angles in a PQRS square. Students are not able to use concepts correctly. That means students have problems in phase two in dealing with problems, according to Polya. Answers to questions number three and four appear to be students not answering questions according to the question. So, the completion steps taken by students are not clear in their direction.

First Experts

Analyze of Answer to the Question Number 1

Problem number 1 answered by students is still not quite right because the student's perception is still wrong about the problem and students' perceptions of the problem, so the answers they present are still wrong. When applying the number of angles and estimating the size of the angles in a square, there is no explanation of the reasons for the answers.

Analyze of Answer to the Question Number 2

Students' answers to question number 2 are not correct because students misunderstand the magnitude of each corner in the PQRS square that is known in the problem, and students do not give the number of angles in the picture in the question, so students only calculate the magnitude of the straight angle.

Analyze of Answer to the Question Number 3

Students' answers to problem number 3 are incorrect because students only focus on parallel lines known to the problem and do not understand the question. Students' answers should pay attention to the different ways to calculate the magnitude of the opposing angles in the parallelogram parallel to each other, but the student answers two parallel lines, not the intended angle. This shows that students do not understand the questions given.

Analyze of Answer to the Question Number 4

Students' answers to problem number 4 show a picture of the properties of the quadrilateral (trapezoid, rhombus, parallelogram, and kite), which are still not the correct answer.

Second Expert

Analyze of Answer to the Question Number 1

Students are still wrong in determining its size; from the problem, it is clear that the right angle is prominent on the square, so it is clear the angle is large and can determine the names of other angles that correspond. However, students do not understand the purpose of the problem.

Analyze of Answer to the Question Number 2

Students do not seem to understand square material. The basic concept of quadrilateral and large angle is still problematic.

Analyze of Answer to the Question Number 3

Students do not understand what is wanted by the problem. Besides that, students also do not understand the differences in straight angles, facing angles, and parallel lines.

Analyze of Answer to the Question Number 4

Visible students already understand the properties of quadrilateral, but to think about the properties of each quadrilateral. The four analysis of answers to the questions of critical thinking skills solved by students shows that most problems cannot analyze the problem. Of course, if the student cannot analyze the problem, let alone face critical thinking, even facing common problems is still tricky. This is in line with Barwell (2011), who said students need to learn how to read such problems. Simply decoding words or extracting arithmetic operations is not enough; students must learn to read between the lines and understand what they are expected to do mathematically. Katsikopoulos (2011) reveals that an essential part of planning a lesson is engaging in solving the lesson problem in various ways. This enables teachers to anticipate students' thinking and the multiple ways they will devise to solve the problem. This also enables the teachers to anticipate and plan the possible questions they may ask to stimulate their understanding.

The eight tips for asking practical questions from Katsikopoulos (2011) are: (1) anticipate the students' thinking, (2) link the learning goals, pose open question, (3) post question that needs to be answered, (4) incorporate verbs that elicit higher levels of bloom's taxonomy, (5) post question that opens up the conversation to include others, (6) keep the question neutral, and (7) provide wait time. Asking analytical and critical questions presents a question stratified according to blooms' taxonomy level, which the estuary is at the higher-order thinking level. This is in line (Kojo et al, 2018) to understand the importance of asking good questions in the problem-solving mathematics classroom to promote deep discussion about the relative efficiency of the solution.

Other than that, Steele et al. (2015) explains why we need them for asking activity: (1) to encourage students to participate; (2) to show we value their thinking; (3) to inform our teaching decisions; (4) to help students articulate their thinking; (5) to encourage students' metacognition; 6) to deepen students' ability to use the mathematical practices, (7) to help students develop a repertoire of questions to ask themselves.

Therefore, Critical thinking skills should be part of student's learning, and schools should be responsible for developing and evaluating critical thinking skills through the teaching and learning process (Lorentzen, 2013). Mathematics learning can develop critical thinking skills in mathematics that require complex mathematical tasks that can encourage higher-order thinking skills (Henningsen & Stein, 1997). As for high-level mathematics problems, according to Krulik (Lorentzen, 2013), that involves thinking, analysis, synthesis can stimulate students' critical thinking skills.

4. Conclusion

Study results show that one of the problems experienced by students in dealing with mathematical critical thinking problems is the weakness of students in understanding problems. This problem is undoubtedly a fundamental obstacle because the inability to understand problems in dealing with problems can make students unable to design appropriate problem-solving strategies and solve problems that are in the problem. For questions that require high-level thinking, even ordinary story questions will be difficult for students to deal with.

5. References

- Barwell, R. (2011). Word problems: Connecting language, mathematics and life what works. *Research into Practice: Research Monograph*, 34.
- Gaol, M. L., Prabawanto, S., & Usdiyana, D. (2019, February). Students' mathematical critical thinking ability on cube and cuboid problems. In *Journal of Physics: Conference Series* (Vol. 1157, No. 4, p. 042055). IOP Publishing. <https://doi.org/10.1088/1742-6596/1157/4/042055>
- Henningsen, M., & Stein, M. K. (1997). Mathematical tasks and student cognition: Classroom-based factors that support and inhibit high-level mathematical thinking and reasoning. *Journal for research in mathematics education*, 28(5), 524-549.
- Katsikopoulos, K. V. (2011). Psychological heuristics for making inferences: Definition, performance, and the emerging theory and practice. *Decision analysis*, 8(1), 10-29.
- Klein, E. (2016). Developing Minds. *Developing Minds*. <https://doi.org/10.4324/9781315623511>.
- Kojo, A., Laine, A., & Näveri, L. (2018). How did you solve it?—Teachers' approaches to guiding mathematics problem solving. *LUMAT: International Journal on Math, Science and Technology Education*, 6(1), 22-40.
- Lorentzen, L. (2013). Limiting behavior of random continued fractions. *Constructive Approximation*, 38, 171-191.
- McLean, C. L. (2005). Evaluating critical thinking skills: Two conceptualizations. *International Journal of E-Learning & Distance Education/Revue internationale du e-learning et la formation à distance*, 20(2), 1-20. <https://www.ijede.ca/index.php/jde/article/view/84>
- Palinussa, A. L. (2013). Students' critical mathematical thinking skills and character: Experiments for junior high school students through realistic mathematics education culture-based. *Journal on Mathematics Education*, 4(1), 75-94.
- Ruseffendi, E. T. (2006). Pengantar kepada membantu guru mengembangkan kompetensinya dalam pengajaran matematika untuk meningkatkan CBSA. *Bandung: Tarsito*.
- Samo, D. D., & Kartasmita, B. (2017). Developing Contextual Mathematical Thinking Learning Model to Enhance Higher-Order Thinking Ability for Middle School Students. *International Education Studies*, 10(12), 17-29. <https://doi.org/10.5539/ies.v10n12p17>
- Son, A. L., Sudirman, S., & Widodo, S. A. (2020). Asosiasi Kemampuan Koneksi Dan Pemecahan Masalah Matematika: Cross-Sectional di Timor Barat. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, 9(2), 326-337. <http://dx.doi.org/10.24127/ajpm.v9i2.2742>

- Su, H. F. H., Ricci, F. A., & Mnatsakanian, M. (2016). Mathematical teaching strategies: Pathways to critical thinking and metacognition. *International Journal of Research in Education and Science*, 2(1), 190-200.
- Sudirman, Mellawaty, Yaniawati, P., & Indrawan, R. (2021, February). Augmented reality application: What are the constraints and perceptions of the students during the covid 19 pandemic's 3D geometry learning process?. In *Journal of Physics: Conference Series* (Vol. 1783, No. 1, p. 012007). IOP Publishing.
- Steele, M. D., Johnson, K. R., Otten, S., Herbel-Eisenmann, B. A., & Carver, C. L. (2015). Improving instructional leadership through the development of leadership content knowledge: The case of principal learning in algebra. *Journal of Research on Leadership Education*, 10(2), 127-150. <https://dx.doi.org/10.1177/1942775115569353>
- Syah, I. M., Suyahmo, S., & Utomo, C. B. (2019). An Analysis of Critical Thinking Ability of Elementary School Students Through Model Contextual Teaching and Learning on Social Learning. *Journal of Primary Education*, 8(7), 24-31.