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Elementary teacher's perspective critical thinking process in analyzing mathematics problems: Right triangles

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Abstract: In the learning process that occurs, many students work quickly, but the results obtained are not accurate. This is because students do not carry out the evaluation process. This research aims to analyze students' critical thinking processes in solving mathematics problems. The questions discussed are for geometry material, especially right triangles. The research method used is descriptive qualitative. The subjects were 13 students Elementary School Teacher, Faculty Teacher Training and Education, University Muhammadiyah of Malang. Subjects were selected using the purposive sampling method. The questions were given to 50 potential respondents and only 13 students were able to analyze them correctly. This research has resulted in 13 subjects being able to write information using their language at the interpretation stage. In the analysis stage, this subject can find the latest information by connecting previous knowledge with information obtained while studying in class. Evaluation Stage, 13 subjects were able to carry out the evaluation process by linking the main information found. In the interpretation stage, all subjects can draw a conclusion accompanied by reasons to support the answers and conclusions obtained. Communication and regulation stage, 13 subjects were able to communicate and carry out the process well.

Keywords: critical thinking; elementary teacher; mathematics problem

1. Introduction


In the 21st century, the development of technology and information is growing very rapidly. This causes everyone to be able to access and obtain information via the Internet easily (Asari, 2014; Eviandri et al., 2022; Zetrisulita et al., 2018). However, not all information available via the internet is correct and trustworthy. This information is still very unstructured and cannot be categorized (Asari, 2014; Hujatussaini et al., 2022; Kalebogha & Gilbahar, 2013; Hakim & Windayana, 2016; Facione, 2015). Therefore, the ability to select and check the truth of the information obtained is needed. This ability is critical thinking. By thinking critically, someone will be able to analyze whether the information obtained is correct or not (Asari, 2014; Naidoo & Reddy, 2023).

Apart from being used to check the truth of information, critical thinking is also very necessary in the world of work. For example, when someone becomes a professional engineer, the main competency that must be possessed is critical thinking (Aizkoviish-Udi & Cheng, 2015; Brodin, 2016; Kriel, 2013; Wahyudi et al., 2021). Apart from that, in the world of medicine, critical thinking is also very necessary in providing care to According to Davis & Deming (2018); Yildirim & Ozkaraman (2011) in determining a patient's treatment plan, starting from diagnosing the disease to implementing the patient's treatment plan, critical thinking has a very important role. By thinking critically, a doctor can determine the type of disease that the patient is suffering from, and then determine the appropriate treatment plan for the patient's recovery.

Critical thinking is also very necessary when continuing education to a higher level (Asari, 2014; As'ari et al., 2019). This is intended so that when discussing or giving arguments, students do not give wrong and misleading opinions in a community. Therefore, by equipping students with critical thinking, students are expected to be able

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Abstract: In the learning process that occurs, many students work quickly, but the results obtained are not accurate. This is because students do not carry out the evaluation process. This research aims to analyze students' critical thinking processes in solving mathematics problems. The questions discussed are flat geometry material, especially right triangles. The research method used is descriptive qualitative. The subjects were 13 students Elementary School Teacher, Faculty Teacher Training and Education, University Muhammadiyah of Malang. Subjects were selected using the purposive sampling method. The questions were given to 50 potential respondents and only 13 students were able to analyze them correctly. This research has resulted in 13 subjects being able to write information using their language at the interpretation stage. In the analysis stage, this subject can find the latest information by connecting previous knowledge with information obtained while studying in class. Evaluation Stage, 13 subjects were able to carry out the evaluation process by linking the main information found. In the interpretation stage, all subjects can draw a conclusion accompanied by reasons to support the answers and conclusions obtained. Communication and regulation stage, 13 subjects were able to communicate and carry out the process well.

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1. Introduction

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Critical thinking is also very necessary when continuing education to a higher level (Asari, 2014; As'ari et al., 2019). This is intended so that when discussing or giving arguments, students do not give wrong and misleading opinions in a community. Therefore, by equipping students with critical thinking, students are expected to be able

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to develop themselves and adapt to the surrounding daily environment, both in the living environment and the workplace environment.

According to [As'ari, A. R. et al., \(2021\)](#); [Sánchez-Barbero et al., \(2020\)](#) critical thinking is a person's ability to make decisions that will be trusted or carried out logically and reflectively. Meanwhile, according to [\(Lestari et al., 2023\)](#); Critical thinking is a skill in evaluating and analyzing information. [Facione \(2015\)](#) suggests there are 6 elements of critical thinking abilities, namely interpretation, analysis, evaluation, inference, explanation, and self-regulation. If students master these six core points of critical thinking, students can be said to be able to think critically. In this research, researchers define critical thinking as an ability that is carried out logically and reflectively with six core components.

One of the subjects that can improve students' critical thinking skills is mathematics. There has been a lot of research conducted related to critical thinking in mathematics learning. According to research by [Kriel \(2013\)](#), critical thinking can be learned and trained through mathematics with a problem-solving approach. [Peters \(2012\)](#) in his research stated that in teaching critical thinking through mathematics teachers must consider students as users of information, not as recipients of information. Apart from that, according to research by [Chukwuyenum \(2013\)](#), the results showed that students' mathematical abilities increased thanks to critical thinking. Furthermore, [Wang et al.\(2022\)](#), stated that students can improve their critical thinking thanks to mathematical problems applied in everyday life. Some of the results of this research illustrate that the thinking process of critical thinking and mathematics have a very close relationship. From the research above, it can be concluded that both of them are very closely related. Through learning mathematics, students can improve their critical thinking. Apart from that, by thinking critically, students can improve their mathematical abilities.

2. Materials and Methods

This research seeks to reveal students' critical thinking processes in analyzing mathematics problems. Research data is presented by the reality that occurred during the research (natural setting). Researchers act as the main instrument, because researchers plan, design, implement, collect data, analyze data, draw conclusions, and make reports. Apart from that, this research places more emphasis on the analysis and evaluation process of students in solving problems rather than the results. Based on this description, this research is qualitative descriptive. This type of research is descriptive research because the data collected is verbal data.

There are two stages of data analysis, namely analysis of data from validation results and analysis of research data. For data analysis of validation results, the average value of the indicators is determined from the data resulting from the assessment of the validity of each validator's instrument. Based on the average indicator value, the average value for each aspect is determined. The average value for each aspect is totaled to obtain the total average value of the aspect. This research uses the following data analysis stage, namely: (1) Transcript of data from the collected data; (2) reviewing data from interviews and observations; (3) data reduction and abstraction; (4) compiling data coding; (5) analysis of processes; and (6) concluding.

Prospective subjects for this research are those who have studied triangles, the Pythagorean Theorem, and the comparison of the lengths of the sides of special triangles. The selection of these three subjects used the purposive sampling method. Researchers gave research questions to 50 potential subjects. Of the 50 prospective subjects, 13 prospective subjects were able to analyze the questions correctly. Based on these results, the researcher selected 13 potential subjects to become research subjects. The instruments used are 1) researchers. The main instrument in qualitative research is the researchers themselves or other people who help with the research. 2) Mathematics questions. Mathematics questions are given to selected subjects. The questions given are questions

related to the circumference of triangles and trigonometry concepts in right triangles. Students are given 15 minutes to analyze. 3) Interview Guidelines, Interview guidelines are used to measure obtaining information that cannot be obtained only by analyzing student work results. 4) Validation sheet. The validation sheet in this research is used to determine the validity of the instruments used in the research before being tested on students. The instruments to be validated are mathematics questions and interview guidelines.

3. Results

Exposure to the subject's critical thinking process data in analyzing question number

1.

3.1 Interpret

The interpreting stage is the stage of the critical thinking process where someone rewrites the information obtained using their language. Based on the results of subject work in analyzing geometry problems, it was found that subject had carried out the interpreting stage.

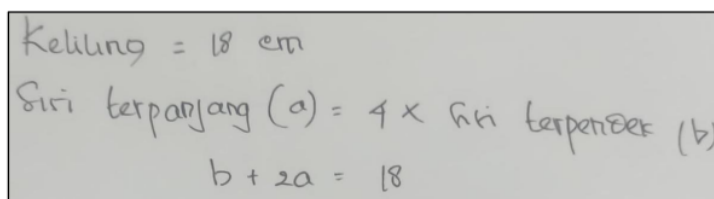


Figure 1. Students write information on the question

Based on the written evidence in Figure 1, subject has completely written down the information given in the question. The first step that subject took was to rewrite all the information contained in the question. First, subject writes that the perimeter of the triangle is 14 cm. Then subject assumes the longest side is a and the shortest side is b . After that, subject wrote in equation form that $a = 4b$ and $b + 2a = 18$. Regarding writing this information, the researcher (P) interviewed with subject.

Q: Why did you write down this information?

S: Because that's all I know, sir. I think it's better to write it like this (pointing to his work).

Q: Why isn't the information in picture form?

S: It's not known which type of triangle it is, sir. It's not right-angled, it's not isosceles, it's not on the same side. Because there is no information, I'm confused about how to make a triangle image. Haha

P: OK, in your work, for example, the sides that you know are a and b . What is your reason for making this example?

S: In the question, three equations are given. Because it involves equations, it is better to take the lengths of the sides so that it will be easier to write them in equation form.

Q: What about the third side? Didn't you write the example for the third side here?

S: For example, my third side is c Sir. Indeed, I didn't write it at the beginning because the initial information didn't concern the third side at all.

Q: For information about the perimeter of a triangle, why don't you explain it?

S: Because from the perimeter of a triangle, it is clear that the perimeter is the sum of the lengths of the three sides of the triangle

Based on the interview, subject explained that subject wrote information in the form of mathematical sentences. subject explained that it was difficult to create a pictorial representation of the information provided. According to subject, this is because it is not known which type of triangle the triangle referred to in the problem is. Apart from that,

Subject makes an example of two sides of a triangle that are related to each other, namely the longest side of the triangle is let as a and the shortest side of the triangle is let as b . Then subject assumes the third side is c but it is not written in the representation stage.

3.2 Analyze

The analyzing stage is a stage of critical thinking in which a person finds new information from the relationship between the information provided or the relationship between the information provided and previously possessed knowledge. In the previous stage, subject had written down the information given in the questions using his language. After going through the interpreting stage, subject tries to find new information by connecting the information obtained from the questions. The following is written evidence of subject conducting the analysis.

$$\begin{array}{r}
 a - 4b = 0 \quad | \times 2 \quad | \quad 2a - 8b = 0 \\
 2a + b = 18 \quad | \times 0 \quad | \quad 2a + b = 18 \\
 \hline
 - 9b = -18 \\
 b = 2 \\
 a = 2 - 4 = 8
 \end{array}$$

Figure 2. Evidence of subjects carrying out the analysis process

In Figure 2, the first step that subject takes in analyzing is to rewrite the known information in mathematical equations. subject wrote down the information "the length of the longest side is 4 times the length of the shortest side" into the equation form $a - 4b = 0$. Then subject wrote down the information "twice the length of the longest side added to the shortest side is 18 cm" into the equation form $2a + b = 18$. Based on these two equations, subject uses the elimination method to find the length of b . After going through the calculation process, the value $b = 2$ is obtained. After obtaining the value b , subject substitutes this value into the equation $a - 4b = 0$. After going through the calculation process, the value $a = 8$ is obtained. After obtaining the values a and b , S writes down the information as in Figure 3.

$$\begin{array}{l}
 a = 8 \\
 b = 2 \\
 c = 4
 \end{array}$$

Figure 3. Evidence of subjects conducting analysis

In Figure 3, subject wrote $a = 8$, $b = 2$, and $c = 4$. In determining the value of $c = 4$, subject did not write the steps. Therefore, researchers conducted interviews to obtain clearer information regarding the information written by subject. The following is a transcript of the interview between Researcher (P) and subject.

Q: In the work you wrote, suddenly the value $c = 4$ appears. Where did you get this answer?

S: I use the information that the perimeter of a triangle is 14 cm as already known in the problem.

Q: Please explain in more detail how you use information about the perimeter of a triangle to determine the value of c ?

S: At the beginning, it was known that the perimeter of a triangle is 14. It is known that the perimeter of a triangle is the total length of all the sides of the triangle. This means that we can make the equation $14 = a + b + c$. Right from the second elimination

From the equation, we get $a = 8$ and $b = 2$. This means that I put these two values into the circumference equation, sir. Later we get $14 = 10 + c$. So clearly the value of c is 4.

Q: Why don't you write down how to get a C grade on your work?

S: Because I think it's clear, Sir, so I immediately wrote down the value of c .

Based on the interview, subject explained that in determining the value of c , subject used the information that the perimeter of the triangle was known. Initially, subject explained that the perimeter of a triangle is the sum of the lengths of all the sides of the triangle so that the known perimeter of the triangle can be written as $14 = a + b + c$. Then subject uses the information that has been obtained, namely $a = 8$ and $b = 2$. By substituting these two values into the circumference equation, subject obtains the value $c = 4$. However, subject does not write this method in his work. subject considers that it is clear that if the perimeter of a triangle and the lengths of the other two sides of the triangle are known then the length of the third side of the triangle is the result of subtracting the perimeter from the sum of the two known sides of the triangle. Because subject thought it was a certain thing, subject did not write down the calculation process in the work he wrote.

3.3 Evaluate

The evaluating stage is a stage of the critical thinking process in which a person assesses the credibility of a statement or information obtained from conclusions on previously obtained information. At this stage, subject has carried out the evaluation stage well. subject can determine the credibility of the information that has been obtained. The following are the results of work from subject at the evaluation stage (Figure 4).

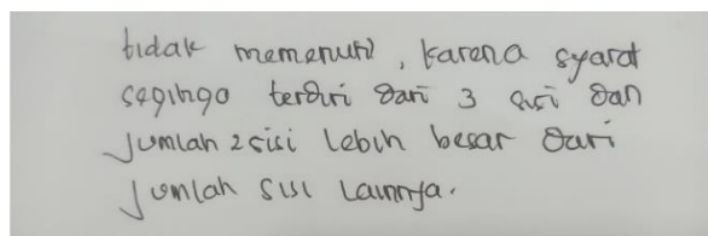


Figure 4. Evidence of subjects evaluating their work

Regarding the answers from subject, researchers conducted interviews to explore the meaning of the answers written. The following is a transcript of the interview conducted by Researcher (P) with subject.

P: In your answer, you wrote "does not meet". What does non-compliance mean?

S: If the side lengths are like that, if you draw it it won't form a triangle

Q: How are you sure that if you draw it it won't form a triangle?

S: When I was in junior high school, I was taught that the condition for forming a triangle is that it must have three sides. Then, if the lengths of the two sides are added together, they will be longer than the third side. If in this third problem, we add b and c , the length is shorter than a . That means it doesn't fulfill you, sir.

Q: Do you know the name of the condition "if the sum of the lengths of the two sides of a triangle must be greater than the third side"?

S: As far as I remember, it's called triangle inequality, sir.

Q: Why is it called inequality?

S: Because it uses a bigger sign.

Based on the interview, subject explained that the lengths of the sides of the triangle found would not form a triangle. subject shows that the three sides of the triangle that are not found do not satisfy the triangle inequality. In triangle inequality, subject explains that the sum of the two sides of the triangle must be longer than the third side. In the problem, subject finds that the first side is 8 cm, the second side is 4 cm, and the third side is 2 cm. Using the triangle inequality, subject finds that $2 + 4 = 6 < 8$.

3.4 Conclude

The concluding stage is a stage in the critical thinking process where someone writes down the conclusions they have reached by including logical reasons. Based on Figure 4, subject concludes that the triangle given in the problem does not satisfy the inequality. This is proven by showing that $2 + 4 = 6 < 8$, where 2 and 4 are the lengths of the two sides of the triangle and 8 is the length of the third side of the triangle.

3.5 Communicate

The communicating stage is a person's ability to express ideas or ideas related to the results of the analysis in a coherent manner accompanied by logical reasons to strengthen the arguments presented. Based on the results of observation and interviews conducted with s, the researcher concluded that subject had carried out the communication process well. In the first step, subject writes down all the known information in the form of mathematical equations. To make it easier to find new information, subject made an example. Then from the two equations found, subject uses the elimination method to find the unknown lengths of the two sides of the triangle. After that, subject determines the length of the third side by substituting it into the triangle perimeter equation. After finding the lengths of the three sides of the triangle, subject evaluates the information found and concludes that the triangle given in the problem does not satisfy the triangle inequality. So it is concluded that the triangle does not exist.

3.6 Regulate yourself

The self-regulation stage is a stage of the critical thinking process where a person monitors themselves and correct mistakes they have made. Based on the results of previous work, it can be seen that subject has carried out a self-regulation process. From the start of work, subject always checks the steps he has taken before proceeding to the next step. Based on the data obtained from subject, a critical thinking process chart for subject can be created. The critical thinking process that occurs in subject is shown in Figure 5.

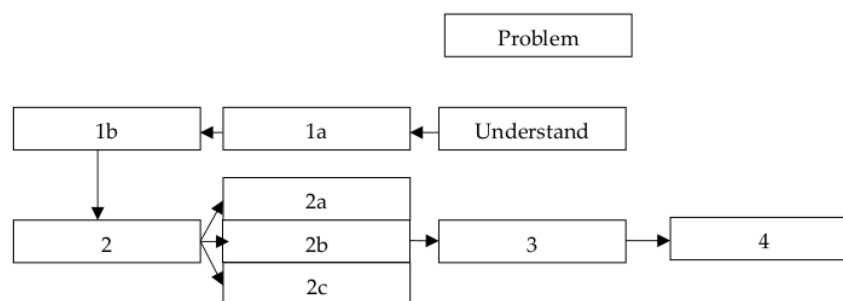


Figure 5. Subject critical thinking process chart for question number 1

Based on the detailed explanation of each subject in analyzing each question, the researcher summarized the thinking process of each subject in Table 1.

Table 1. Students thinking processes

Code	Information
1a	Make an Example
1b	Write information in the form of mathematical equations
12	Collect information using the elimination method
2a	Find the value of a
2b	Find the value of b
2c	Find the value of c
3	Communicate
4	Regulate yourself

4. Discussion

Based on results research obtained here is a number of matter interesting that becomes focus discussion in chapter This. First, on the thought process critical third mercy subject during analyze question number one, there is similarity flow of thought processes that occur. Third mercy subject choose For for example information received, then, make equality based on information provided by the questions and examples that have been given made. After make example, third mercy subject determine long third mercy side triangle use method elimination and substitution in finish system triple linear equation variables that have made. After find long third mercy side triangle, third mercy subject No direct conclude that long third mercy side triangle has found, but third mercy subject evaluate is long third mercy side triangle the has fulfil inequality triangle. After evaluated third mercy subject conclude that long third mercy side triangle No fulfil inequality triangle, so based on interview third mercy subject conclude that triangle in the problem is wrong or No There is triangle as intende.

Based on exposure related with thought processes critical subject study in analyze question number one and results interview, yes concluded that third twelve subject capable understand draft system triple linear equation variables and concepts inequality triangle. Based on results interview, third twelve subject disclose that teachers often give exercise varied questions related draft system triple linear equation variables and concepts inequality triangle when classroom learning. That conclusion in accordance with theory expressed by (Jacobs et al., 2008). According to Jacobs et al. (2008), 50% to 70% ability student remember and understand material in class is results from activity learning carried out with the teacher in class. Therefore that, the teacher has quite a role big in understand something draft to student. Next, on to the question number two, subject does analysis with Good. Thought process critical that occurs in subject shows that subject has ability think critical level tall. At stage interpret, based on results interview, subject read question number two over and over again for can understand all sentence in the question so that can write information with precise and detailed. This matter show that subject is trying for read question with thorough so that no there is missed information. These results are also consistent with results study from Ngilawajan (2013) that read with thorough show exists attention to information provided. Additionally, results study Amamah et al., (2016) also shows that read question show there is an acceptance process information. With read question in a way thorough so information received will become more complete compared to with read question in a way no thorough. Subject shows that accuracy read question is very necessary in obtain all information provided in a way complete without there is one missed information.

At stage analyzing and evaluating, subject chooses use information related cosine for evaluate information given start question. Election information This based on subject understanding of draft cosine. Due to the second ADC right triangle his side known and big all the corner is known then subject uses information mark cosine corner C for evaluate information provided by the question. Subject compare between mark cosine angle C is found through comparison long sides triangle with mark cosine that has studied previously. Subject found that there is difference mark cosine whereas big the corner the

same. This matter show that subject has understanding and mastery good material to material trigonometry specifically material cosine so the thought process S's critical work is very efficient. Subject understands that in one corner only there is one mark cosine. This matter support results research conducted by [Umraatin \(2012\)](#) that understanding and mastery something material by students influence the thought process carried out. The more good understanding material owned by a person then the thought process is carried out will the more efficient and minimized mistakes made. Different with subject, in carry out the analysis and evaluation process of S4 and S7 initially experience error. Subject 4 and subject 7 processing in a way direct information given start question. At stage analyzing, subject 4 and subject 7 obtain information new related the required length of each side for find around triangle ABC. Second subject capable obtain information the from results read question then hook with knowledge previously. This matter strengthen results study previously that with read question then ideas can be generated ([Talun, 2015](#); [Dan Su, et al; 2022](#)) and linking information new with information previously capable come up with new ideas ([Jesica, 2016](#)). Additionally, results study ([Dayang et al., 2013](#); [Khanlar, 2022](#)) that ideas can generated with read questions and linking with knowledge previously also strengthened results research that has been found. However, ideas or information the new found subject 4 and subject 7 do not everything is valid and acceptable information accountable the truth because not yet through an evaluation process

5. Conclusions

Several interesting things are the focus of discussion in this chapter, it can be concluded that the three research subjects have fulfilled the critical thinking stage. There were two questions analyzed by the three research subjects. The first question is a question about right triangles which are related to the circumference and inequality of triangles. The second question is a question about right triangles which is related to trigonometry concepts, especially the concept of cosines. In the first stage, the three subjects re-wrote the information provided using their language. For question number one, the three subjects wrote down the information obtained in the form of a three-variable linear equation. Meanwhile, in question number two, the three subjects wrote down the information obtained in the form of a triangular image.

In the second stage, the three subjects discovered new information by connecting the information they had obtained with previous knowledge. In problem number one, the three subjects used the elimination and substitution method to find the lengths of the three sides of the triangle. Meanwhile, in question number 2, the three subjects used different knowledge to find the required information. Subject uses the cosine concept to find the required information. Subject 2 uses the concept of cosine and comparison of the sides of a triangle to find the necessary information. Subject 3 uses trigonometry concepts, namely sine and cosine, to find the necessary information.

In the third stage, all subjects evaluate the information that has been obtained using the basic information found. In problem number one, the three subjects used triangle inequality to evaluate the validity of the lengths of all the sides of the triangle found. In question number two, all subjects used the cosine value of angle C to evaluate the initial information given in the question. For question number two, initially, subject 2 and subject 3 failed to carry out evaluations. However, both subjects succeeded in evaluating and carrying out the self-regulation process. In the fourth stage, the three subjects wrote precise conclusions accompanied by reasons to strengthen the conclusions obtained. In question number one, the three subjects concluded that the given triangle was wrong because the lengths of the sides did not satisfy the triangle inequality. In question number two, the three subjects concluded that the given triangle was wrong because there were two different cosine values at one angle. In the fifth and sixth stages, the three subjects carried out the process well.

In the fifth and sixth stages, the three subjects wrote down all the information completely and coherently. Then, in writing down the results of the work, the three subjects did it coherently and clearly. In the sixth stage, the three subjects carried out the process well. This is demonstrated by the accuracy of the conclusions obtained by the three subjects. Even though initially Subject 2 and Subject 3 wrote inaccurate conclusions, through the process of self-regulation the two subjects were able to improve the conclusions they had obtained.

Based on the conclusions outlined in the previous sub-chapter, it can be seen that students' critical thinking processes are influenced by the learning process carried out. Therefore, to increase the effectiveness of the learning process carried out by students, researchers recommend conducting learning that can increase the effectiveness of the learning process carried out by students. One learning method that can improve this is problem-solving-based learning. With this learning method, students are indirectly required to improve their thinking skills, resulting in the critical thinking process becoming more effective

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