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Student's Critical Thinking in Solving Open-Ended Problems Based on Their Personality Type

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Abstract. Critical thinking plays an important role for students in solving open-ended problems. This research aims at describing student's critical thinking in solving open-ended problems based on Keirse's personality types, namely rational, idealist, guardian, and artisan. Four students, with the higher rank in the mathematics' test and representing each type of Keirse personality, were selected as the research subjects. The data were collected from the geometry problem and interviews. The student's critical thinking is described based on the FRISCO criteria. The result underlines that rational and idealist students fulfilled all FRISCO criteria, and but not for guardian and artisan students. Related to the inference criteria, guardian and artisan students could not make reasonable conclusions and connect the concepts. Related to the reason of criteria, rational student performed critical thinking by providing logical reason that supported his strategy to solve the problem. In contrast, the idealist student provided subjective reason. This results suggest that teachers should frequently train the students' logical thinking in every lesson and activity to develop student's critical thinking and take the student's personality character into account, especially for guardian and artisan students.

1. Introduction

It has been recognized that one of primary aims of education is to foster student's ability to think critically. Critical thinking is to think logically and accurately when evaluating reasons as the basis for action [3, 4, 8, 10]. Critical thinking involves challenges in problem-solving because it is stated as one factor that affects a person's ability to solve problems [2, 8]. Critical thinking relates to the judgments as the basis for decision making when solving the problem. A student who thinks critically tends to use his or her knowledge and intelligence effectively to achieve the correct and logical decisions. On the contrary, when a student does not think critically then he tend to make illogical and unjustified decisions, unless he is lucky or be able to make the right decisions with, perhaps, some wrong reasons. Ennis [6] states six critical thinking criterias which can be used as a mental checklist for critical thinking and guarantees in which the final decision are concluded as the most important things. These criterias include focus, reason, inference, situation, clarity, and overview which are shown on Table 1.

Table 1. FRISCO Criterias for Critical Thinking

Criteria	Indicators
Focus	Figuring out the problem.
Reason	- Looking for reasons for and against the decision in a certain way (pro and contra reasons). - Looking for evidence.



	- Identifying and judging the acceptability of the reasons.
Inference	Making a reasonable conclusion that suits the reason.
Situation	Identifying the thing which is relevant to the significance of the thinking activity and some of the rules that guide it.
Clarity	Clarifying the meaning of terms and the way that is used.
Overview	Checking what have decided and inferred.

Critical thinking needs to be integrated in the curriculum so that students can learn and can apply them to improve their performance and reasoning ability. Some schemes that can develop critical thinking involves more than one good answer or explanation, comparing various answers to a question and judgement which performs the best strategy or answer. In line with it [1], another kind of critical thinking activity is involving students' presentations with dilemmas or situations from which two solutions which are equally valid can be proposed.

An open-ended problem is a structured problem in which it has more than one correct solution or way to elicit the solution [11, 15]. Through the provision of open-ended problems, students are given the opportunity to view the problems from several perspectives and are expected to provide evidence or logical arguments which supports their judgement or choice [5, 10]. In this study, students are expected to demonstrate their critical thinking ability in choosing strategy by providing supportive reasons.

Every student tends to have differences in thinking and solving problems. This is reasonable because every student has a different personality. Based on the condition that each student is different from each other, employing the Keirsey's criterias can be used to classify students' personality into four types of personality types: rational, idealist, guardian, and artisan [9]. The classification can be observed through how students derive their energy (introvert versus extrovert), receive and process the information (sensing versus intuitive), make decisions (thinking versus feeling), and organize their lives (judging versus perceiving) [13]. All the rationals are intuitive and thinking, idealists are intuitive and feeling, guardians are sensing and judging, and artisans are sensing and perceiving.

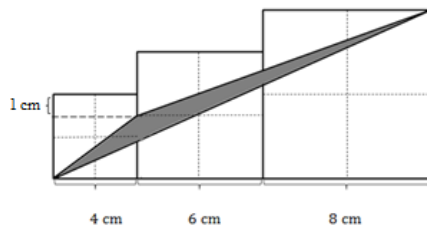
Moreover, the previous research showed that thinking has a significant correlation with the personality types [7]. However, this study tries to describe student's critical thinking in solving open-ended problems based on the Keirsey personality types. Students with different personality types may indicate differences in critical thinking when solving the given problem.

2. Method

This study used qualitative approach to investigate student's critical thinking in solving the given problems which formed two geometry questions. A purposive sampling technique were applied to select the 8th grade students from the Unesa's Labschool of Surabaya. Twenty students in the chosen class were given the Keirsey personality and mathematical tests. Based on the test results, four students with the highest rank who represent each type of Keirsey personality were selected as the research subject. Then, the problems were given to the students in order to promote as much student's critical thinking as possible. All subjects were given the first problem and were individually interviewed based on their answers. The second one was conducted two weeks later to ensure the validity of the data. The obtained data was qualitatively analyzed based on the FRISCO criterias through three steps including data condensation, data presentation, and data interpretation.

3. Results And Discussion

The given open-ended problems are described as follows.



- Determine the shaded area!
- If the length sides of each square is a half of the original, is the shaded area changed to be a half of the original area?
- If the length sides of each square is k times of the original length, $k \neq 1$, is the shaded area also changed to be k times of the original area?

3.1 Critical Thinking of Rational Student

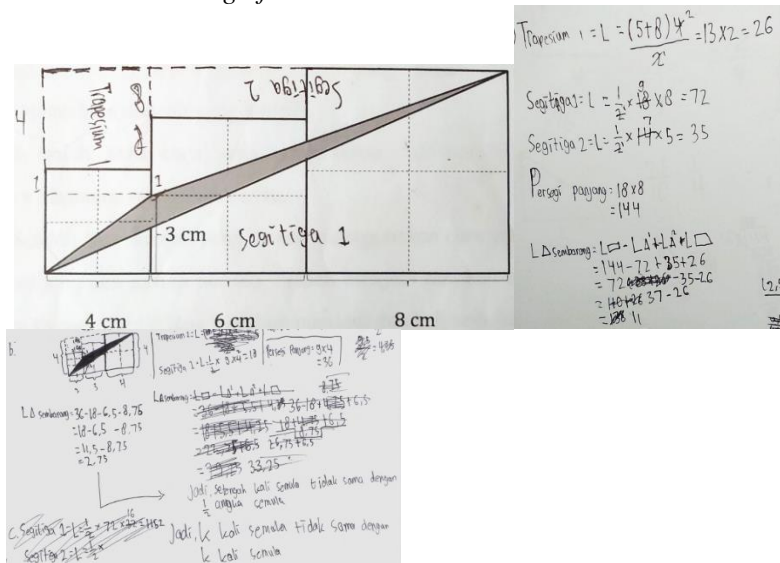


Figure 1. Rational Student's Answer

Focusing on the criteria, the rational student didn't fully write about what is known and what is asked from the problem. He simply stated there are three squares that has one side of 4 cm, 6 cm, and 8 cm. In the interview, he is, however, able to explain what is being asked and what is known. He mentioned the information which is implicitly deduced from the problem, namely the length sides of the square that can be directly identified. He associated the known information with the square properties, that has four equally length sides. According to [16, 17], an intuitive student prefers to focus on the connections and relationships among the facts, informations or concepts. He is also able to find two strategies which are used to determine the shaded area. The first one is to draw auxiliary lines so that a rectangle can be obtained. In addition, the subtracting the area of the rectangle with the first triangle area, second triangle area, and the trapezoid area can also be obtained. The second one is done by using the Heron's formula, i.e. $L = \sqrt{S(S-a)(S-b)(S-c)}$, S which involves the half of the triangle perimeter; and a, b, c as length sides of the triangle.

Relating to reason criteria, the rational student chose the first strategy because it is simpler than the second one. In the interview, he could explain the supporting reasons for the selection of his strategy. The rectangle can be composed by triangles 1, triangle 2, trapezoid, and shaded area. Hence, the shaded area can be determined by his chosen strategy. On the other hand, he did not use the small planes to determine the shaded area. It is because he did not know the length sides of the triangle and it will be difficult in the calculation. It concludes that he can show the pro and contra reasons in choosing a certain strategy. According to [12], an intuitive student solved the given problems according to "right versus wrong" principle.

Based on the calculation, the rational student can fulfill the inference criteria by making a correct conclusion, namely the shaded area which is 11 cm^2 . If the length sides of the squares are changed to be a half, then the shaded area is 2.75 cm^2 , which is not a half but a quarter of the original area. If the

length sides of the square are changed to be k ($k > 1$) times of the original, the shaded area will not be k times but k^2 times of the original area. Moreover, he underlined that the argument is similar to a square and a right triangle in which the length sides are converted to k times of the original, then the area becomes k^2 times of the original. The conclusion is taken by associating with the ratio concept and the concept of a plane area. According to [17], an intuition student tends to be careful in observing the patterns and in continually looking for new possibilities.

Furthermore, the rational student maintained the context of the problem by observing the length sides of the changing square to answer the problem. He was also able to identify an appropriate formula which supports his chosen strategy. To apply his strategy, he used formula of rectangle, triangle, and trapezoid area. It shows that the rational student can identify such situations which relevant to his thinking process skills. In addition, he explained that the shaded area is the area that is coloured differently. It shows that the rational student fulfills the clarity criteria because he understood the terms “shaded area”. After finding the answer, the rational student demonstrates the overview criteria by checking the truth of his decision, conclusion, and all of his answer.

3.2 Critical Thinking of Idealist Student

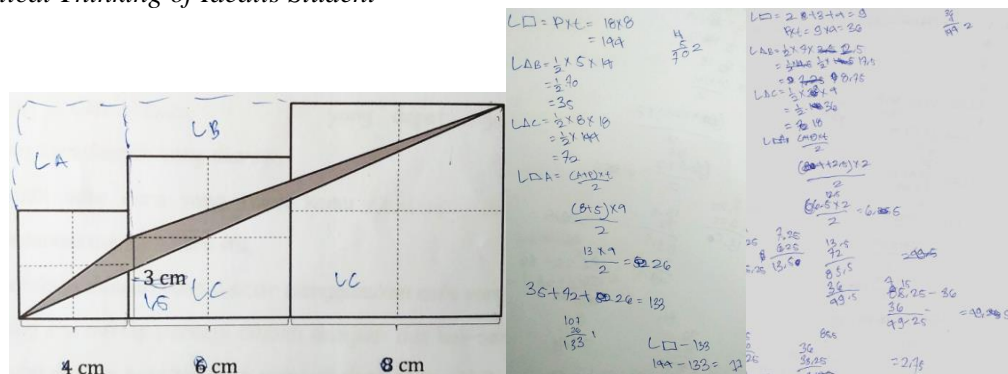


Figure 2. Idealist Student's Answer

Focusing on the criteria, the idealist students did not write about what is known and what is asked from the question. In the interview, he can fully explain what is being asked and what is known. He employ only one strategy that can be used to determine the shaded area. His strategy is by drawing an auxiliary line so that a rectangle can be formed as well as the subtracting the area of the rectangle with the trapezoid area (L_A), first triangle area (L_B), and the second triangle area (L_C). He said that his strategy is easy to implement. The condition shows that the idealist student gave a good reason about his selection strategy subjectively. According to [16], one of the terms that can be used to describe feelings is subjective. Besides, a feeling student frequently takes criticism very personally [12].

In terms of reason criteria, the idealist student explained the same reason about his proposed strategy as well as the rational student. As well as the rational student, for the inference criteria, the idealist student concluded correctly that the shaded area is 11 cm^2 . When the length sides of the squares are changed to be a half of the original lengths, the shaded area is 2.75 cm^2 , which is not a half but a quarter of the original area. However, if the length sides of the squares become k times of the original, the shaded area will not be k times of the original area. The idealist student insists that it is because the k is substituted by $\frac{1}{2}$ then the shaded area is not a half of the original one. It shows such intuitive natures of the rational type. This condition supports the statement of [14] that someone with intuitive nature has a tendency to see patterns and connect some known information when taking and processing information. Relating to the clarity and overview criteria, the idealist student showed all these criteria as well as the rational student. However, he defined that the shaded area is the area that is black coloured.

3.3 Critical Thinking of Guardian Student

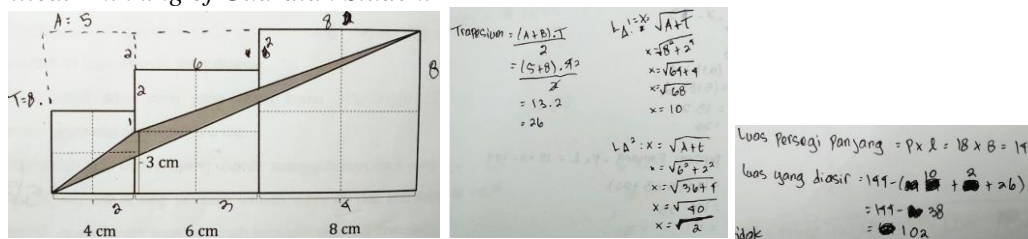


Figure 3. Guardian Student's Answer

Focusing on the criteria, the guardian student did not write about what is known and what is asked by the question on his answer sheets. In the interview, he was not fully understood the problem. He found only one strategy to determine the shaded area, which is similar to the strategy used by rational and idealist students. In solving the problem, he was consistently used his strategy. It is because a judging student likes everything which is established from the beginning [9].

Relating to the reason criteria, the guardian student could not explain the reasons beyond his chosen strategy as well as rational and idealist students. The guardian student cannot fulfill the inference criteria. It is because he concluded the shaded area incorrectly. He explained that the shaded area will be a half of the original when the length sides of squares are a half of the original. He incorrectly connected the related information or concepts. According to [17], a sensing student prefers to think about thing that is presented clearly.

After choosing the strategy, the guardian student could not identify the formula that appropriates his strategy. To find the area of the right triangle, he used the Pythagoras formula so that he can determine the hypotenuse of the triangle, which is not the triangle area (Figure 3). It shows that the guardian student does not fulfill the situation criteria. The guardian student explained his understanding about the term "shaded area". As well as the rational student, the guardian student underlined that the shaded area is the area that is coloured differently. After determining the answer, he said that he did not check the truth of his answer or his conclusion consistently. It underlines that the guardian student does not fulfill the overview criteria.

3.4 Critical Thinking of Artisan Student

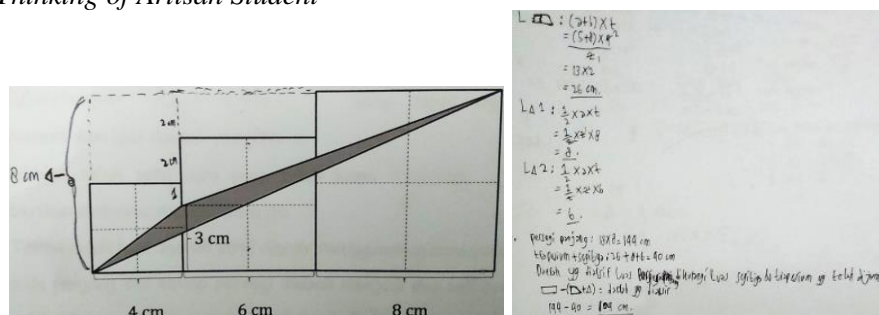


Figure 4. Artisan Student's Answer

On the answer sheet, the artisan students also did not write about what is known and what is asked from the question. However, in the interview, he showed that he can fulfill the focused criteria by explaining what is being asked and what is known from the problem. His explanation is based on the information that there are three squares with one side of 4 cm, 6 cm, and 8 cm, respectively. According to [16], a sensing student prefers to see things by relying on their senses. He found only one strategy to determine the shaded area, which is similar to the strategy used by rational, idealist, and guardian students.

Related to the reason criteria, the artisan student explained the similar reasons about his proposed strategy as well as rational and idealist students. He underlined that the rectangle can be constructed by

the triangle 1, triangle 2, trapezoid, and shaded area. Hence, the shaded area can be determined by subtracting the area of rectangle with the triangle 1, triangle 2, and trapezoid areas.

Although his idea is correct, the artisan student concluded the shaded area incorrectly. He explained, as the guardian student, that the shaded area will be a half of the original area when the length sides of the square are changed to be a half of the original. He also could not understand the notation “k” because k performs an unusual number of his knowledge. It is because sensing student who prefers something that is presented clearly [17].

The artisan student was able to identify the formula that is appropriate to his strategy. It shows that the artisan student fulfills the situation criteria. However, he determined the length side of the triangle incorrectly. In addition, the artisan student fulfills the clarity criteria by explaining the terms “shaded area” correctly. He underlined that the shaded area is the area that is coloured black. He similarly defined the shaded area as the idealist student did. After finding his answer, he said that he didn’t checked his answer and conclusion consistently.

4. Conclusion

Rational and idealist students could fulfill all FRISCO criterias which were not fulfilled by guardian and artisan students. In solving the given problem, all subjects were able to focus in explaining the what is known and what is asked although the guardian student was not considered well enough. On the reason criteria, only rational, idealist, and artisan students could clarify their reasons and can make a reasonable conclusion. On inference criteria, only rational and idealist students could make conclusion correctly. On situation and clarity criterias, all students had demonstrated their ability to solve the problem by involving all situations which are presented on their question sheets, and understand all terms. However, guardian student could not choose the appropriate formula. On the overview criteria, the guardian and artisan students unchecked the answer consistently. In this study, not all students could think critically based on FRISCO criterias. Therefore, the teachers should frequently train students on how to develop critical thinking skills, especially for guardian and artisan students.

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