Students’ critical-metacognition activity based on their personality type

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Abstract. Metacognition and critical thinking become a foundation key to solve any problem. Therefore, students with higher level of those aspects tend to demonstrate better skills in accomplishing problem solving tasks. This study aims to describe student’s critical-metacognition activity in solving geometry problem based on Keirsey personality types, namely rational, idealist, guardian, and artisan. The samples were 8th grade students of the Labschool Universitas Negeri Surabaya. Students were given mathematics test and the adapted Keirsey personality questionnaires. Four volunteer students, with higher rank of mathematics and represented each Keirsey personality types, were selected as the research subjects. Data were collected by giving geometry task and interviews. The collected data were analyzed by using critical-metacognition indicators. The result affirms that all students demonstrated critical-metacognition through planning, monitoring, and reflection activities although some parts were missed. For planning activity, rational and idealist students could explain their reason behind the strategy used. On the other hand, different condition was shown by guardian and artisan students who could not make conclusions correctly. For reflection activity, only guardian student who did not check his performance. This study suggests that teachers should facilitate students to practice critical thinking and metacognition activities in order to solve problems mathematically.

1. Introduction
Critical thinking and metacognition cannot be separated. Students with higher level of metacognition and critical thinking skills tend to perform better in problem solving tasks. Critical thinking can be shown by inquiring and testing hypothesis, accepting or rejecting arguments, and applying reasoning to make an appropriate decision. Meanwhile, metacognition is stated as an awareness of students’ thinking process and ability to control the process, or as thinking about thinking [2].

The relationship between critical thinking and metacognition has been investigated in some literatures. The results of [3, 4] showed that critical thinking and metacognition associated positively. In order to qualify metacognition as critical thinking, an important behavior is self-correcting [5]. There are six criteria of critical thinking skills [6], namely focus, reason, inference, situation, clarity, and overview. On the other hand, metacognition includes planning, monitoring, and reflection activities [7].

Taking into account these criteria and activities, the proposed indicators are used to investigate students’ behavior of critical-metacognition activities, as shown on Table 1.

Table 1. Behavior of critical-metacognition activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Indicators</th>
</tr>
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<tbody>
<tr>
<td>Planning</td>
<td>- Figuring out the problem.</td>
</tr>
<tr>
<td>(Focus, Reason)</td>
<td>- Choosing suitable mathematical tools.</td>
</tr>
<tr>
<td></td>
<td>- Contructing reasons.</td>
</tr>
<tr>
<td>Monitoring</td>
<td>- Controlling application of the tools, including its relevance to the target</td>
</tr>
<tr>
<td>(Inference, Situation)</td>
<td>in mind.</td>
</tr>
<tr>
<td>Reflection</td>
<td>- Understanding the problem and reflecting on the relevance of the results</td>
</tr>
<tr>
<td>(Clarity, Overview)</td>
<td>- Clarifying the meaning of terms and the way used.</td>
</tr>
<tr>
<td></td>
<td>- Checking the accuracy of what have decided and inferred.</td>
</tr>
</tbody>
</table>

When solving a problem, each student has different ways of thinking and personality [1]. Moreover, Keirsey and Bates had classified students’ personality into four types: rational, idealist, guardian, and artisan [8]. This classification can be observed through how students acquire their energy (introvert or extrovert), receive and process information (by sense or intuition), make decisions (by thinking or feeling), and manage their lives (judging or perceiving).

Previous researches addressed a positive correlation between thinking skills and personality [9], and the result of [1] emphasized a different condition between rational and idealist students. Relating to the previous research, this study is to assess students’ critical-metacognition activities based on Keirsey personality type in solving an open-ended problem.

2. Experimental Method
A qualitative approach is applied on this research to investigate students’ critical-metacognition activities when solving the given problem. 8th grade students of Labschool Universitas Negeri Surabaya (Unesa) were purposively selected. There were 20 students (14 boys and 6 girls) who were given the personality questionnaire, mathematical test, and the open-ended geometry problem. The test instruments were validated by 2 senior lecturers of Mathematics Department of Unesa and 1 senior mathematics teacher. The test result showed, 5 boys got score more than 80, another 5 boys got score in the range of 70–80, and the other 4 boys got score less than 70. Meanwhile, 4 girls got score in the range of 70–80 and the other 2 girls got score less than 70. In addition, the questionnaire result categorized that 1 boy is a rational, 1 boy is an idealist, 6 boys and 4 girls are guardians, 4 boys and 1 girl are artisans, and 3 students tend to none of personality types. Four volunteer boys who got highest score tests and represented each personality types, were selected as the research subjects. All subjects were chosen to reveal critical-metacognition activity in more detail and were individually interviewed based on their answer sheets. The obtained data was qualitatively analyzed through three steps: condensation, presentation, and interpretation.

3. Result and Discussion
The open-ended problem is as follows. Look at the following geometry shape.

![Geometry Shape](image)

a. If point A is coincided with point C and point B is coincided with point D, is there a formed-plane between Figure 1 and 2?

b. If there is a formed-plane, determine its area!

c. If the side length of the squares is changed to a half of the original length, is the area of formed-plane also changed to half of the original? Write up your reasons!

d. If the side length of the squares is changed to \(k\) times \((k \neq 1)\) of the original length, is the area of the formed-plane also changed to \(k\) times of the original? Write up your reasons!

3.1. Rational Student (RTS)

![Rational Student](image)

**Figure 1. Performance of RTS**

Figure 1 shows that RTS demonstrated performance according to the question. Planning activity started by focusing on the given problem. He identified three squares from which the length of respective sides had been known. He associated his existing knowledge that a square has four equal sides-length. Referring to [10, 11], RTS understood the problem very well and applied a unique strategy for convincing the formed-plane. He carefully combined a part of the the full geometry shape, so that the
points A and C were coincided exactly, as well as the points B and D. He showed the formed-plane was constructed well and indicated the new formed-plane was a triangle. Here is an interview excerpt with RTS.

**Table 2. Interview Excerpt with RTS**

<table>
<thead>
<tr>
<th>R</th>
<th>How did you know that there is a new formed-plane?</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTS</td>
<td>I took a picture of one part of the pictures using <em>my phone</em>, then I combined the picture on <em>my phone</em> and the picture on the problem sheet. The points A and C were crushed, and also the points B and D. Apparently, there was a triangle formed.</td>
</tr>
</tbody>
</table>

To determine the area of the formed-plane, he employed a suitable mathematical strategy. Firstly, he changed the picture on his problem sheet into a rectangular form. Then, he subtracted the rectangular area by the area of two triangles and a trapezoid around the formed-plane. Supporting to [7], RTS used correctly the formula to determine the area of rectangle, trapezoid, and triangle. He also constructed and thought of acceptability of his reason. He knew already the sides-length of each shape which the area were determined, so that he could easily compute the area of the formed-plane. He claimed that his used strategy was an easier strategy to apply than any other strategy.

RTS performed monitoring activity by controlling application of his strategy which was correct one. He concluded the area of the formed-plane was not the same with the change of square side-length. He stated that if the length sides of the squares are changed to be a half, then the area of the formed-plane will not be a half but a quarter of the original area. If the length sides of the square are \( k \) \((k \neq 1)\) times of the original, its square area will be \( k^2 \) times of the original. Similarly, if the length sides are \( k \) times of the original, then its area becomes \( k^2 \) times of the original. Referring to [11], RTS tends to be careful in observing patterns and looking for new possibilities. For overview step, RTS conducted reflection activity by re-examining the correctness of the used procedures in solving the problem, and had thought other alternative strategy. However, he believed the chosen strategy was an effective and efficient to find the answer.

**Table 3. Interview Excerpt with RTS**

<table>
<thead>
<tr>
<th>R</th>
<th>To determine the formed-plane area, do you think of other alternative strategies?</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTS</td>
<td>Yes, I found two strategies. Firstly, I subtracted rectangular area by the area of two triangles and trapezoid. Secondly, I can use Pythagorean theorem and the area of triangle, i.e. ( \sqrt{S(S-a)(S-b)(S-c)} ), ( S ) is the half of the triangle perimeter; and ( a, b, c ) is sides length of the triangle). However, I used the first strategy because the steps are simpler and easier to implement. In addition, all of the sides are known.</td>
</tr>
</tbody>
</table>

After finding the final result and referring to [12], RTS also carefully rechecked and ensured the correctness of understanding of existing terms and then checked all of things that had been concluded.

### 3.2. Idealist Student (IDS)

![Figure 2. Performance of IDS](image)

Figure 2 shows that IDS implemented his steps and revealed all informations provided about the sides length of the square. He explained that one was whether there is a formed-plane or not. Then IDS exactly used a ruler and folded his problem sheet.

**Table 4. Interviews Excerpt with IDS**
IDS stated when points A, C and B, D are coincided, two pictures would perform a rectangle. There was a new formed-triangle which was in the middle of the rectangle. Since the formed-triangle was flanked by two triangles and trapezoid, then to find its area he subtracted the area of the rectangle by the area of two triangles and the trapezoid area. Thus, IDS had constructed the reason for using his chosen strategy. He described the reason by looking for and identifying the acceptability of the reason [6]. He applied his chosen strategy because it was easy to implement and without comparing to other strategies. He utilized the appropriate formulas of the area of triangle and trapezoid correctly.

In monitoring, IDS had controlled the relevance between application of the tools and target. He concluded correctly about the formed-plane area and its change. From his identification, he concluded the area of the formed-triangle would not change to a half of the original whenever the side length of squares was changed to half of the original. If the side length of the square becomes \( k \) times, then the area of the formed-triangle also will not directly change into \( k \) times. However, he did not reveal in detail about the area of the formed-triangle. For the reflection activity, IDS reflected on the result obtained and clarified the only one strategy used.

**Table 5. Interview Excerpt with IDS**

<table>
<thead>
<tr>
<th>R</th>
<th>To solve this problem, do you think about and find other alternative strategies?</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDS</td>
<td>I only found one strategy. The area of the rectangle is reduced by the area of two triangles and trapezoid.</td>
</tr>
</tbody>
</table>

In obtaining the final answer, IDS checked the validity of his answer and fulfilled overview criteria on critical thinking skills [6]. In the final activity of metacognition, IDS demonstrated by evaluating the decision made and outcome of the executed plan [14].

### 3.3. Guardian Student (GDS)

In Figure 3, GDS performed appropriately steps for his planning activity and only revealed there was a triangle although he knew that the side-length of three squares had been known. Pointing to [10], GDS had to focus on what can be seen clearly. For identification, GDS was able to find a new formed-plane. To determine its area, he subtracted the area of the rectangle by the area of triangle and the trapezoidal area. Nevertheless, he could explain about the acceptability reason of his strategy. He insisted his strategy was an easy one to apply. He also implemented the mathematics formula of rectangular, triangle, and trapezoid area correctly.

For monitoring activity, GDS did not control the relevance between application of the formula and the target. Thus, he concluded incorrectly about the new plane area and its vary change. From his identification, he concluded that the area of the formed-triangle would change to a half of the original if the side length of the square was changed to half time the original. Furthermore, if the side length of the square is \( k \) times initially, then the area of the formed-triangle also changes into \( k \) times. He could not provide an evidence which supported his conclusion.
For the last activity, he explained that he did not reflect on the result obtained because he was still confused by the given problem. He also did not check about terms, strategy used, and the accuracy of his final result.

3.4. Artisan Student (ATS)

ATS demonstrated his planning activity his identification were not different from both RTS and IDS. Based on Figure 4, he tried to sketch the combining pictures and found a new plane-formed. To determine the area of the new formed-plane, he subtracted the rectangular area by the area of two triangles and trapezoid around the formed-plane. He chose a suitable strategy by using the existing formula, referring to [7], to compute the area of rectangle, trapezoid, and triangle correctly. In addition, he also provided the reason in his implementation, since he knew the length of the sides of each shape.

In addition, he stated that his used strategy was an easier strategy without comparing other strategies. This condition shows that he made his decision subjectively.

ATS performed monitoring activity by controlling application of his strategy. But, he did not construct reasonable and correctly conclusion about the change of the formed-plane area. He concluded that the area of the formed-plane would change based on the change of side length. He could not provide the evidence of his conclusion. Supported by [11], he also explained that he could not understand about the notation “\(k\)” because \(k\) denotes an unusual number of his knowledge.

For reflection activity, ATS re-examined the correctness of the implemented procedures in solving the given problem, clarified the meaning of terms and the way used, also checked all of things which have decided and inferred. He also thought about any alternative strategy, but he found only one correct strategy.

4. Conclusion

Based on the result, all students demonstrated behavior of critical-metacognition through planning, monitoring, dan reflection activities. However, some significant differences were found in each activity. For planning activity, the rational and idealist students could explain well about the reason behind their strategy used. The rational student chose his strategy based on objective reason, while other students selected their strategy using their subjective reasons. In monitoring activities, only rational and idealist students who could make conclusions correctly. The rational student provided strongly evidences while the idealist student did not provide any detailed. For the reflection activity, the only guardian student did not checked his performance. The rational student demonstrated the reflection activity by providing more than one strategy correctly, however idealist and artisan students found only one correct strategy. Finally, the only guardian student proposed one strategy which was incorrect. Moreover, rational, idealist, and artisan students were able to re-examine overall validities of their performances. Our study recommends to extend the result for involving more students with vary mathematics ability.

5. References

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