Analyzing students’ representation ability: viewed from reflective-impulsive cognitive style

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Abstract. The main purpose of this research is to describe the ability of student representation viewed from reflective-impulsive cognitive style in resolving geometry problems. This research is a qualitative descriptive. The subject of this study consisted of 6 students of 8th grade Islamic Junior High School 2 Sragen which were taken through a purposive sampling technique. The data were collected through mathematical representation tests followed by interviews. The researchers employed the triangulation method to validate the data. Based on the results of the analysis, it could be concluded that the ability of students’ representation who have a reflective cognitive style was known: (1) Students are able to sketch problems in the form of geometric images to clarify problems and solve problems, (2) Students are able to make Mathematical expressions from other representations and solve problems using mathematical expressions. While the ability of representation of students who have impulsive cognitive style known to students is only able to sketch problems into the form of geometric images to clarify the problem and resolve the problem. This is because reflective students tend to be more in solving problems. Reflective students are able to divide and redraw plane shapes. In addition, reflective students are also looking for the area of the image correctly using mathematical symbols. While impulsive students are in a hurry in resolving the problem so that impulsive students are only able to divide and redraw plane shapes. Impulsive students cannot be looking for the area of the image correctly.

1. Introduction
Mathematics is considered as an important basic education. The purpose of mathematics education is to produce students who have skills in solving problems and cultivating high interest and motivation in learning Mathematics [1]. However, based on TIMMS year 2015 on mathematics, Indonesia is ranked 45 from 50 countries [2]. In addition, the average marks of national exam in Islamic Junior High School 2 Sragen on math subject is 42.45, it describes that their score still low from the KKM standard [3]. It indicates that there is a problem that occurs in mathematics learning. There are many students have difficulties in learning mathematics, while students consider that mathematics is something fear and boring [4]. The students struggle to understand mathematics because it is something abstract, while the students are accustomed to thinking concrete[5].

Representation is one of the mathematical skills that students must master in learning mathematics [6]. Representation is one of the standard mathematical processes to develop and optimize students’ thinking skills [7]. The roles of representation in mathematics learning are: 1) representations assist students in understanding the tasks and concepts of mathematics, 2) representations facilitate the learning process of students, 3) representations help students in managing their thinking, 4)
Representation helps students understand the concept of abstract mathematical, and 5) representations is used to assist students in analyzing the problem [8]. Mathematical representations are required in understanding the concept, solving mathematical problems and communicating mathematical ideas by students [9].

Representations are categorized into two types of internal and external representations. The internal representation is the process of thinking about the idea of math that allows someone to work on that idea, while an external representation is the ability to pour thoughts into the verbal, symbolic, visual form [10]. The representation can be expressed in visual, verbal, and symbolic form. Visual representation includes illustrating, displaying, or working with mathematical ideas using diagrams, drawings, or graphs [11]. The verbal representation uses language (words and phrases) to interpret, discuss, define or explain the idea of mathematical, while symbolic representation includes recording or working with mathematical ideas using numbers, variables, and other symbols [11].

The representation is used to describe how processes of cognitive in understanding the idea of mathematics [12]. The cognitive style will affect how students solve problems. Simult & Schuller state that cognitive style can be defined as how someone thinks, how they process and remember information or how they use the information in problem-solving [13]. There are several types of cognitive styles that are field-independent/field-dependent, reflective-impulsiven and verbalizer-visualizer [14].

A grouping of reflective-impulsive cognitive styles is based on the time that is taken students to solve problems in the accuracy of the answer [15]. Rozencwajg and Carroyer explain that there are four groups of cognitive styles: 1) individuals reflective, 2) individuals impulsive, 3) individuals of fast-accurate, 4) individuals who are slow and inaccurate [16].

![Figure 1. Students’ cognitive styling](image-url)

According to Egeland and Weinberg, the student who takes a longer time to respond and makes a slight error is interpreted as "reflective", whereas the student who responds faster and less accurate is interpreted as "impulsive" [17]. In addition, the subject may also be classified as "fast and accurate" and "slow and inaccurate" [17]. Kagan and Kogan explained that the reflective-impulsive describe student tendency showing sooner or later in answering the questions [18]. The variables that had to attend in the test are the time (t) that is used when answering the question and the frequency (f) answer until correct [18].

A reflective-Impulsive cognitive style is a cognitive style that shows tempo or speed in thinking [19]. The students impulsive are students who tend to make a quick guess and the students reflective tend to make decisions slower and more accounted for [20]. Impulsive shows spontaneous tempo in making a decision, so that they can make quick hypotheses and they can make many mistakes in
delivering solutions, while reflective it needs to take longer tempo in taking a decision, the students tend to check the solution systematically [21]. The study focuses on students with impulsive reflective cognitive style, expressed by Joreme Kagan (1965). Therefore, the purpose of this research is to describe the ability of a student's representation is viewed from a reflective-impulsive cognitive style in Islamic Junior High School 2 Sragen.

2. Method
This was qualitative descriptive research. This research was conducted in Islamic Junior High School 2 Sragen with the purposive sampling technique to select the subject. The subjects of this research were 6 students (3 reflective students and 3 impulsive students) which was selected based on the MFFT test. The test was employed to measure reflective cognitive-impulsive style using a modified MFFT test by Warli (2010) which has been proven validity and reliability and it could be used in junior high school students. The MFFT instrument had the following provisions: 1) the number of questions was 13 problems with 2 problems example, 2) it consisted of one original image (default) and 8 images variance, 3) on the variances image, there was only one image that was the same as the original image (standard), 4) There was no difference between the original image (default) and the variation image [22]. While the representation ability test consisted of three geometric questions in the form of a description. The indicators that were used as references could be seen in the table below:

| Table 1. Representation Indicators |
|-----------------------------------|
| Representation Aspects            | Indicators                                                                 |
| Visual representation             | • Create geometric images to clarify problems and resolve problems          |
| Symbolic representation           | • Create mathematical expressions from other representations and solve problems using mathematical expressions |
| Verbal representation             | • Answering questions and writing problem-solving steps with words or written text |

Data collection techniques in this study used tests and interviews. The Data obtained will be validated using the triangulation method. The following criteria for grouping the ability of representation can be seen in the table below:

| Table 2. Criteria for grouping the ability of representation |
|-------------------------------------------------------------|
| Level of Representation Ability | Visual Representation | Symbolic Representation | Verbal Representation |
| Very low             | Students cannot make geometry drawings to solve problems | Students cannot make equations and solve problems using mathematical symbols | Students cannot write problem-solving steps with words |
| Quite Low            | Students can only make geometry drawings without writing the length and width of the sides | Students make equations using mathematical symbols but are still wrong in solving problems | Students can write problem-solving steps in words but it is concise |
| Quite High           | Students can make geometry drawings to clarify the problem but there are still errors in | Students can make equations and solve problems using mathematical symbols but | Students can write the steps of problem-solving with words but it is incomplete |
Level of Representation Ability | Visual Representation | Symbolic Representation | Verbal Representation
--- | --- | --- | ---
Very High | writing the length and width of the sides | students forget to write units of area, side length, and side width | Students can write the steps of problem-solving with words in a complete and systematic way
| Students can make geometry drawings and write the length of the sides and width of the sides correctly | Students can present equations into mathematical symbols and solve problems correctly using mathematical symbols |

3. **Result and Discussion**
The Data obtained in this study are the classification of cognitive styling of students, the ability to test representations and interviews.

3.1 **Student Cognitive styling**
The cognitive-style instruments in this study used the modified MFFT Test Warli (2010). The MFFT instrument consists of 13 items and 2 sample items. The image consists of 1 raw image and 8 of the variance images. Students are required to complete the test one by one in front of the researcher. Then the researcher noted the first time when the student answered and wrote the frequency of the answer (the number of students answers options until correct) each item is solved. The student's cognitive style determination is based on the median time (t) and median frequency (f) based on all data obtained. Median time (t) and median frequency (f) as a determining limit for students who have a characteristic:(1) reflective individual, 2) individual impulsivity, 3) a fast-accurate, 4) individual who is slow and inaccurate. If students resolve the time above the median and frequency (answering questions correctly) under the median, so the students are on the reflective student group. Whereas if the students resolve the problem with the time above the median and frequency (answer the question correctly) above the median then students are on the group of impulsive students. The following are selected subjects for identification of the representation ability can be seen in the table below:

| Table 3. Reflective Students. |
| --- | --- | --- |
| Subject | Time (seconds) | Frequency |
| R1 | 47.85 | 2.08 |
| R2 | 48.77 | 2.62 |
| R3 | 42.70 | 2.70 |

| Table 4. Impulsive Students |
| --- | --- | --- |
| Subject | Time (seconds) | Frequency |
| I1 | 9.85 | 4.85 |
| I2 | 17.23 | 3.77 |
| I3 | 5.62 | 4.08 |

3.2 **Analysis of student representation skills**
The question given is a plane shape. These are the questions of representation ability given to students.
In question 1a, students are required to write down the steps to look for the area of the image. In question 1b, students were asked to divide the picture into several plane shapes and redraw them again. In the matter of 1c, students are required to find the area of the image. Based on the result of the data analysis results, the analysis of student representations are presented in the table below:

**Table 5. Reflective student representation capability**

| Cognitive style | Achievement indicators | 1a            | 1b            | 1c            |
|-----------------|------------------------|---------------|---------------|---------------|
| R1              | Quite High             | Very High     | Very High     |               |
| R2              | Quite Low              | Very High     | Very High     |               |
| R3              | Quite Low              | Very High     | Quite High    |               |

**Table 6. Impulsive student representation capability**

| Cognitive style | Achievement indicators | 1a            | 1b            | 1c            |
|-----------------|------------------------|---------------|---------------|---------------|
| I1              | Quite Low              | Quite High    | Quite Low     |               |
| I2              | Quite High             | Quite High    | Quite Low     |               |
| I3              | Quite Low              | Very High     | Quite High    |               |

Based on the results of the analysis, it is shown that reflective students have quite low verbal representation ability. Reflective students still have trouble answering questions by writing down the completion steps. Reflective students have a very high visual representation and symbolic representation ability. Reflective students are able to sketch problems into the shape of geometry images properly and correctly. Reflective students are also able to create equations and solve the problems using mathematical symbols properly and correctly.

Meanwhile, the impulsive student has a quite low verbal representation ability such as reflective students. Impulsive students still have trouble answering the question by writing down the completion steps. The students' reflective visual representation ability is quite high, although there are still mistakes the students are able to sketch the problems in the form of geometric images. As for the ability of symbolic representation is quite low, students are still wrong in creating equations (expressing other forms into mathematical symbols) so that impulsive students do not resolve the problem correctly. Based on the results of the student representation above, the students will be shown reflective and impulsive answers based on test results and interviews.
3.2.1 Reflective student representation capability (R1 and R2)

Reflective students tend to solve the representation that given more thoroughly. The reflective students are able to complete all the three questions well enough. In question 1a, reflective students are able to solve the problem even though they are not perfect yet. There is a little error in writing the steps of looking for the area of the image. In question 1b, reflective students are able to solve questions well. Reflective students are able to redraw and write down the length and width of the sides correctly. Similarly to the 1c problem, reflective students are able to do well and properly. In addition, reflective students tend to be more correct and write the unit area, length, and width of the side. Here are some reflective students’ answers.

Here’s an answer to R1

| 1. I divide the image into three rectangle | 2. I look for a rectangular formula | 3. I calculate the area of of the each rectangle | 4. I add up the area of the three rectangle |
|------------------------------------------|---------------------------------|---------------------------------------------|---------------------------------|
| ![Image](a) | ![Image](b) | ![Image](c) | ![Image](d) |

### Figure 3. Answers of R1

Table 7. The results of the written answers and interviews

| No  | Representation ability | R1’s Description |
|-----|------------------------|------------------|
| 1a  | Verbal representation  | In question 1a, R1 wrote 4 steps. But in 2nd step, R1 wrote a less precise step. R1 has been able to write and explain the steps using words well in the first, third and fourth steps. |
| 1b  | Visual representation  | Dialog* P : Why do you divide the image (plane shape) into 3 parts and do not redraw it separately? R1 : Because I think the answer is correct. I redraw by dividing the image into the three rectangles and each one named (plane shape I, plane shape II, plane shape III). Then I wrote the length and width on the rectangle side. R1 divides the image (plane shape) into the three rectangles by giving a mark on each rectangle (plane shape I, plane shape II, plane shape III). However, R1 does not redraw separately. R1 also writes the length and width of each side of the rectangle correctly. |
| 1c  | Symbolic representation | Dialog* P : Can you redescribe your answer? |
R1: Already. I am looking for the breadth of each rectangle (plane shape I, plane shape II, plane shape III). Then I add up the three areas of the rectangle.

R1 searches the area of each rectangle (plane shape I, plane shape II, plane shape III). Each rectangle, R1 writes the length ($p$) and the width ($l$) and searches extensively using the formula "$P = p \times l\)". After that, R1 adds up the three areas of the rectangle. So, the area of the image is $565\text{cm}^2$.

Based on the results of the written answers and interviews. In question 1a, R1 is still less precise writing the 2nd step. However, R1 is already able to explain the steps of using words well but not perfectly. While in question 1b, R1 redraw but not separately. R1 also writes the length and width of the rectangle correctly. For the problem 1c, R1 is able to solve problems correctly. In addition, R1 also writes the unit area, length, and width of the side correctly.

Here's an answer to R2

1. I divide the image into 3 parts
2. I count the area of the image
3. I add up the three plane shape areas

![Diagram](a) ![Diagram](b)

| Plane Shape | Length | Width | Area |
|-------------|--------|-------|------|
| PS I        | 25 cm  |       |      |
| PS II       | 17 cm  | 4 cm  | 68 cm$^2$ |
| PS III      | 6 cm   | 12 cm | 72 cm$^2$ |

$L_{Total} = PS I + PS II + PS III$

$= 425 + 68 + 72$

$= 565 cm^2$

Figure 4. Answers of R2

Table 8. The results of written answers and interviews

| No | Representation ability | R2’s Description |
|----|------------------------|------------------|
| 1a | Verbal representation | Dialog* |

P : Can you re-explain your answer?
R2: In the first step, I divide the image (plane shape) into 3 parts. After that I count the area of the plane shape, then I add up three plane shape areas.
R2 wrote 3 steps briefly. So the result of written answers R3 less complete. R2 is less capable of writing it using words.
**No.**  
**Representation ability.**  
**R2’s Description.**

1b  
**Visual representation**  
Dialog*  
**P:** What do you do to solve the problem?  
**R2:** I divide the image (plane shapes) into 3 parts. Then I draw back into three rectangles. Next, I write the length and width of each of the rectangles.

R2 is able to depict back to 3 rectangles correctly. R2 redraw and writes the length and width of the rectangle correctly.

1c  
**Symbolic representation**  
Dialog*  
**P:** How do you look for the area of the image (plane shape)?  
**R2:** I wrote the length and width of each of those rectangles. Next, I calculate the area of each rectangle with the formula “\( P = p \times l \)”. Then I add up the area of the three rectangles.

R2 writes the length and width of each rectangle with a mathematical symbol. Then R2 calculates the third area of the rectangle using the formula “\( P = p \times l \)”. Next in the last step R2 add up the areas of the three rectangles. So, the area of the image is 565\( \text{cm}^2 \).

Based on the results of written answers and interviews, R2 was unable to solve the 1a problem well. R2 is not able to write the completion steps clearly. R2 writes his answer briefly. Although R2 is able to understand the steps, R2 is difficult to write down these steps using words. In question 1b, R2 was able to divide and redraw into the three rectangular well and correctly. R2 redraw the three rectangles and writes the length and width of the side. In the matter of 1c, R2 is able to solve the problem well and correctly. R2 uses mathematical symbols in symbolizing the area (\( L \)), length (\( p \)), and width (\( l \)). In addition, R2 also writes the unit area, length or width correctly.

### 3.2.2 Impulsive student representation capability (I1 and I2)

Impulsive students are not able to solve the problem quite well. Based on the results of written answers and interviews, impulsive students are having more mistakes. In the question 1a, the impulsive student did not write down the completion steps using words with sequential and easy to understand. In question 1b, impulsive students are able to redraw but they did not finish perfectly. There is still an error in the writing of the length and width.

**Here’s an answer to I1**

#### Figure 5. Answers of I1.

While in the problem of 1c, many impulsive students encountered an error writes the length and width of the side. So their answers tend to be wrong. While the impulsive students forgot to complete the last step. In addition, the impulsive students forgot to write a unit of area, length or width of the side. Here are some answers to Impulsive students.
Table 9. The results of written answers and interviews.

| No | Representation ability | I1’s Description |
|----|------------------------|------------------|
| 1a | Verbal representation  | I1 writes what he thinks without thinking thoughtfully. It is seen in the answers I1 short and not precise. |
| 1b | Visual representation  | Dialog* P : What do you do to solve the problem? I1 : I divide the image into the three plane shapes (the two rectangles and the one square). I1 is able to divide and redraw into the two rectangles and the one square. But I1 is wrong in writing the length and width of its side. |
| 1c | Symbolic representation| Dialog* P : How do you looking for the area of the image? I1 : I wrote the length and width of each of those rectangles. Next, I calculate the area of each rectangle with the formula "L = p x l". Then I add up the areas of the three rectangles. I1 incorrectly writes the length and width of the sides’ plane shape. In addition, I1 does not take the last step is to add up the area completely. Even I1 is also wrong in giving broad units. |

Based on the results of written answers and interviews, I1 is not able to solve the problem well. In the 1a question, I1 did not write down the resolving steps using the words correctly and systematically. In the matter of 1b, I1 was able to share and redraw plane shapes. However, I1 incorrectly writes the length and width of the side. In the 1c question, I1 did not solve the problem correctly. I1 does not take the last step is to add up the area completely. Even I1 is also wrong to write a unit of area, length or width of the sides.

Here’s an answer to I2

1. I divide the image
2. I look for a rectangular formula
3. I calculate the area of of the each rectangle
4. I add up the area of the three rectangle

\[
\begin{align*}
D I & : \\
p & = 25 \text{ cm} \\
l & = 14 \text{ cm} \\
L & = \ldots ? \\
L & = p \times l \\
= 25 \times l & = 25 \times 4 = 100 \\
= 300 & = 56 \\
\end{align*}
\]

\[
\begin{align*}
D II & : \\
p & = 14 \text{ cm} \\
l & = 4 \text{ cm} \\
L & = \ldots ? \\
L & = p \times l \\
= 14 \times l & = 14 \times 4 = 56 \\
= 56 & = 56 \\
\end{align*}
\]

\[
\begin{align*}
D III & : \\
p & = 12 \text{ cm} \\
l & = 6 \text{ cm} \\
L & = \ldots ? \\
L & = p \times l \\
= 12 \times l & = 12 \times 6 = 72 \\
= 72 & = 72 \\
\end{align*}
\]

Figure 6. Answers of I2
Table 10. The results of written answers and interviews.

| No | Representation ability   | I2’s Description                                                                                                                                 |
|----|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| 1a | Verbal representation    | I2 is able to write steps using words quite well. From all 4 steps, the second step still has errors.                                               |
| 1b | Visual representation    | I2 is able to divide and redraw into the three plane shapes. But, I2 incorrectly writes the width of the side (plane shape I). Meanwhile, I2 incorrectly writes the length of the side (plane shape II). |
| 1c | Symbolic representation  | I2 does not solve the 1c problem correctly. I2 incorrectly writes the width of the side (plane shape I) and incorrectly writes the length of the side on (plane shape I) and incorrectly writes the length of the side on (plane shape II). So that the area of the plane shape I and the plane shape II are wrong. In addition, I2 does not take the last step is to sum the third area (plane shape I, plane shape II, plane shape III). Even I1 is also wrong in giving unit area. |

Based on the results of written answers and interviews, I2 was able to resolve the 1a problem quite well. From all 4 steps, the 2nd step is still an error. But overall I2 is able to write down the steps of wording clearly and systematically. In the question of 1b, I2 has not been able to solve the problem perfectly. There is still little error in the writing of the width of the side (plane shape I) and the length of the side (plane shape II). In the question of 1c, I2 was not able to solve the problem well. There are still mistakes in writing the length and width of the side. Additionally, I2 does not perform the final completion. I2 also does not write area unit.

Based on the results of the analysis shows that reflective students are able to solve problems 1b and 1c well. Reflective students are able to sketch problems in the form of geometric shapes to clarify problems and solve problems. Besides, that reflective students are also able to make equations in mathematical symbols and solve problems using correct mathematical expressions. While impulsive students can only solve problem 1b. Impulsive students are only able to sketch problems in the form of geometric shapes to clarify problems and solve problems. This shows that reflective students have the ability of visual representation and the ability of symbolic representation is very high. Whereas impulsive students have high enough visual representation abilities. But both reflective and impulsive students both have quite low verbal representation abilities. Students are not able to write steps for completion using words completely and systematically.

The results of this study are relevant to the results of Bal's study which states that mathematics students have difficulty expressing graph problems in the form of words [23]. In addition, the results of this study are also relevant to the results of Utami's study which states that students find it difficult to solve problems, especially in the form of words [4]. Therefore the ability of representation must be mastered by students in learning mathematics, the ability of representation is closely related to communication and problem-solving skills [6]. So it is suggested to all levels of school to use representation in learning to help students organize, record, and communicate mathematical ideas in solving problems [24].

4. Conclusion
Based on the results of the analysis showed that the ability of representation of students who have a reflective cognitive style is known: (1) Students are able to sketch problems in the form of geometric images to clarify problems and solve problems. (2) Students are able to make Mathematical expressions from other representations and solve problems using mathematical expressions. While the ability of representation of students who have impulsive cognitive style known to students is only able to sketch problems into the form of geometric images to clarify the problem and resolve the problem. This is because reflective students tend to be thorough in solving problems. Reflective students are able to divide and redraw plane shapes. In addition, reflective students are also looking for the area of
the image correctly using mathematical symbols. Reflective students also write the unit area, length and width of the sides correctly. While impulsive students are a hurry in resolving the problem so that impulsive students are only able to divide and redraw plane shapes. Impulsive students cannot be looking for the area of the image correctly. Impulsive students also forgot to write the unit area, length, and width of the sides. However, both reflective and impulsive students are equally incapable of writing completion measures with complete and systematic words.

Acknowledgments
The researchers would like to express gratitude to the Islamic Junior High School 2 Sragen for the help and cooperation until the researchers are able to complete the data related to the students’ representation ability viewed from reflective-impulsive cognitive style.

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