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Exploring students' creative thinking in the use of representations in solving mathematical problems based on cognitive style

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ABSTRACT

Creative thinking is the cognitive activities that process the received information to produce new representations. Therefore, it is necessary to develop creative thinking and represent a problem. This study aims to investigate the students' creative thinking processes based on representation in solving mathematical problems reviewed from cognitive style. Qualitative research was used as a procedure of the study. The data was collected through MFFT questionnaires, mathematics problem tests, and interviews. This research involved 31 eighth-grade students at one of junior high school in Kendal regency, Central Java. Those two subjects represented the reflective and impulsive cognitive styles that have been selected based on their mathematical abilities. The data was analyzed through iterative method. The results of the study showed that both subjects demonstrated a different performance in solving problem. In term of fluency, both subjects used visual representations in interpreting information. On the originality, the reflective subject used symbolic representations. while the impulsive one used symbolic and verbal representations in constructing the mathematical expressions. However, both of them have not yet created new ideas in solving problems. Moreover, on the flexibility, these both subjects used visual and symbolic representations that could solve the problems by utilizing the environment objects towards the interpret problems into mathematical expressions. However, the reflective subject made a mistake in elaborating the formula as well as the impulsive subject can do it. These results indicated that both subjects have used the representation of each indicator of creative thinking in solving problems.

Introduction

Mathematical knowledge is the extensive knowledge that is considered difficult and challenging by most students who those understand it procedurally. The role of mathematics in social life is very important because it can help people to be able to think logically, objectively, analytically, critically, and creatively in overcoming a problem they face (Arshad et al., 2017). Therefore, it is necessary to train and develop thinking processes in learning especially for students. The thinking processes a mind activity that is used to formulate, understand and solve problems and make a decision (Ariefia et al., 2016). Students' thinking processes can run well if there is active teacher participation in learning.

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The thinking process is one of the abilities of creativity to understand and work by using abstract or concrete concepts in new or different ways. Creative thinking is the ability of the thinking process to identify and propose solutions to a problem and generate new ideas and combine new ideas with previous ideas (Jankowska et al., 2019). The development of the ability to think creatively is one focus on learning mathematics (Hendriana& Fadhillah, 2019). This is in line with one of the goals of mathematics learning listed in the 2013 curriculum to prepare Indonesian students to have the ability to live as individuals and creative citizens (Permendikbud, 2016). Creative thinking is also an important thing in the social field so that with the ability to think creatively humans can improve their quality of life (Robinson, 2006). Students are said to be smart not only from their ability to answer problems correctly but also find diverse and appropriate ways to solve mathematical problems. Gregory (2000) also suggests that intelligence is an ability or skill to solve a problem. Creative thinking is a reasoning process that is focusing on idea exploration and finding the correct answer (Nurdin, 2016). Some strategies have also been developed to foster creative thinking such as creating an open atmosphere in class and enriching math knowledge with ideas from other disciplines (Schoevers et al., 2019).

Creative thinking begins with generating ideas and associations followed by exploration through evaluation and testing (Wang et al., 2019). It is also a whole set of cognitive activities used by individuals according to a specific object, problem and condition, based on the capacity of the individuals (Birgili, 2015). Therefore, teachers should take the time to plant creative thinking on their students so they can learn through their guidance (Inuusah et al., 2019). Developing creative thinking in learning can be done by the teacher by giving questions to students to obtain several alternative solutions (Octaviani et al., 2019).

Problems in mathematics have several level of thinking that develops every student to get the stages LOTS or HOTS (Purwati & Nugroho, 2015). In fact, the students' problem-solving abilities need to be improved through integrating a variety of student experiences in learning particularly in solving mathematical problems (Utami, Nugroho, Dwijayanti, & Sukarno, 2018). Problem-solving is a mental process that requires a person to think critically and creatively to find alternative ideas and specific steps to overcome obstacles or deficiencies (Hasibuan et al., 2019). The students' higher-order thinking skill in Indonesia especially in mathematics is still relatively low. This can be seen in the Program for International Student Assessment (PISA) in reading, mathematics and science, and technology skills as a whole. Based on the results of the PISA evaluation in 2015, Indonesian students ranked 63 out of 69 countries with a score of 386 (OECD, 2016). One of the causes of a low level of thinking ability is low and lack of attention to creativity at school, especially in learning mathematics. The low ability of students in aspects of creative thinking is influenced by errors in the way students learn(Firdausi & Asikin, 2018). Creativity in solving the problem is important for a student because with creative thinking student can develop their potential talents and understand problems from different points of view (Fauziah et al., 2019). Therefore, the ability to think creatively into mathematics is one of the main priorities in learning mathematics from elementary to secondary levels. The process of students' creative thinking is a process that students actively go through to produce ideas in solving mathematical problems. The low ability of creative thinking must be an important concern for teachers, so they are required to design learning designs to produce students' potential in using their thinking skills in solving given problems (Coelho & Cabrita, 2015).

Solso (2000) stated that thinking is the process to form a new mental representation. Meanwhile, the indicators of creative thinking are fluency, flexible, original, and elaboration

(Chiu et al., 2019). Therefore, this article defines the creative thinking is a process whereby a new mental representation is formed using fluency, flexible, original, and elaboration. Based on that definition, creative thinking is always related to representation. This statement is supported by Anwar and Rahmawati (2017)which state that through the symbolic representation of students it is helped to problem solve in non-routine ways. One of the factors that influence students' creative thinking processes in solving mathematical problems is the ability of student representation because the ability of mathematical representation expresses or represents mathematical ideas as a tool to find solutions to mathematical problems (Rahmadian et al., 2019).

The National Council of Teachers of Mathematics states that representation is the translation of a problem or idea in a new form, including a picture or physical model in the form of symbols, words or sentences (NCTM, 2000). The representation can be raised through mathematical ideas to find a solution to a problem (Kilpatrick, Swafford, & Findell, 2001). This is also seen as an important part of mathematical activity and a means of capturing mathematical concepts (Rahmad et al., 2016). This shows the mathematical representation that is raised by students is the expression of mathematical ideas or ideas that are displayed by students to understand a mathematical concept or to find solutions to the problems (Hutagaol, 2013). Representation is also seen as an important part of mathematical activity and a means of capturing mathematical concepts (Boonen et al., 2014). The ability to solve mathematical problems depends on one's ability to think of different representations during the problem-solving process. When solving a problem, an ability is needed, namely the student ability to consider the form of representation involved. This shows that a person's ability to change one representation to another will affect his ability to find solutions to solve a problem.

Based on the facts in the field shows that the ability of student representation, in general, is still low because most teachers have not seen the ability of mathematical representation as an important foundation in learning mathematics (Huda et al., 2019). The mathematical representation ability of each student is different, they should be able to develop ideas of a problem but some are unable to develop ideas from problems (Panduwinata et al., 2019). The limitations of teachers' knowledge and students' habits of learning in the classroom conventionally have not made it possible to grow or develop the power of representation so that the ability of mathematical representation that should develop in students becomes not optimally developed (Nugraha, 2017). Therefore, to overcome these problems, teacher's efforts are needed to create learning that can improve students' mathematical representation abilities in solving problems, especially in their creative thinking processes. Representations are also used to construct a concept of mathematical problems or configure a person's cognitive (Bartolini, 2014). The success of students in solving problems is also inseparable from the role of representation (Boonen et al., 2014).

Erdogan and Akkaya (2009)state that creative thinking is a thought process that allows individuals to produce new and authentic products, find new solutions and achieve a synthesis. In the process of thinking, students have a tendency which is called as cognitive style which is defined as a preferred way for students to organize and process the information obtained (Sagi, Arieli, Goldenberg, & Goldschmidt, 2010). The cognitive style has also been described as the preference for the manner in which a problem is perceived, managed, and resolved (Kirton, 2003). Cognitive styles are key candidates for understanding the impact of the cognitive diversity on its creative thinking because the cognitive style diversity is leading to a greater chance of divergent perspectives and skills (Aggarwal & Woolleyb, 2019). The solution of mathematical problem solving based on cognitive style also influences the creative thinking process through the processing information and thinking consistently (Setyana et al., 2019). In addition, cognitive styles also considered as a stable system of the ways of cognitive activity, which determines the ways of thinking, perception, and processing of information which manifest creative thinking in solving various problems (Masalimova et al., 2019).

Several cognitive styles have been identified in any literatures, one of which is the dimension of cognitive style that receives the most attention in the assessment of children, namely impulsive and reflective (Putri et al., 2017). Impulsive and reflective cognitive styles were firstly put forward by Jerome Kagan in 1965. Kagan classifies children's cognitive styles into 2 groups, namely: children who have impulsive cognitive style (Children who have the characteristics of being quick in answering problems, but they are careful to answers to problems, it tends to be wrong) and children with reflective cognitive style (Children who have the characteristics of being slow in answering but they are careful, so that their answers tends to be correct) (Kagan, 1965). Reflective-impulsive cognitive style is a cognitive system that combines decision making and student performance in problem-solving situations (Rozencwajg& Corroyer, 2005). The novelty of this research is to investigate a creative thinking processes based on representations of students who have reflective and impulsive cognitive styles.

This study aims to find out students' creative thinking processes based on representation in solving mathematical problems with reflective cognitive styles and impulsive cognitive. So, it is expected to provide information about the analysis of students' creative thinking processes based on representation in solving mathematical problems in terms of cognitive style. Therefore, during the learning process in solving mathematical problems, an educator can pay more attention to students' creative thinking processes based on representation by looking at the cognitive style of their students. Based on the importance of creative thinking (Jankowska et al., 2019; Nurdin, 2016; Octaviani et al., 2019; Firdausi & Asikin, 2018; Fauziah et al., 2019; Coelho & Cabrita, 2015) and representations (Huda et al., 2019; Panduwinata et al., 2019; Boonen et al., 2014) viewed from cognitive styles (Erdogan & Akkaya, 2009; Sagi, Arieli, Goldenberg, & Goldschmidt, 2010) especially in solving problems, the researchers want to study more about students' creative thinking processes based on representation in solving mathematical problems in terms of cognitive style. In this case, discussing the description of students' creative thinking processes based on representation in solving mathematical problems can contribute to support the development of creative thinking and representation in mathematics education.

Research Methods

This research employed the qualitative approach that was conducted to describe information about an event by exploring and understanding data from several individuals focused on the study. The study was conducted at a junior high school in Central Java which has a heterogeneous cognitive style. Based on interviews with teachers, the researchers got the information that students' creative abilities and other mathematical abilities should be explored deeper to affect the creating thinking. This is considered important because students have high scores in routine problem solving, but it faced with non-routine problems students will experience difficulties. The subjects of this study were 31 students of grade 8 students in 2019/2020 academic year who had acquired the number pattern theory and selected using the MFFT instrument. Based on the MFFT test obtained 17 reflective students and 14 impulsive students. The criteria for reflective and impulsive cognitive style as in table 1 below.

Table 1
Reflective and impulsive cognitive style criteria

Cognitive style	Time (seconds)	Frequency
Reflective	t ≥ 17,808	f < 1,808
Impulsif	t < 17,808	f ≥ 1,808

The study explores more the students' creative thinking processes, for each subject chosen at least 1 subject from impulsive and reflective groups with equal problem-solving abilities. Selected subjects can be seen in Table 2.

Table 2
The subjects based on cognitive style

No	Subject	Cognitive Style	Average	
			Time (seconds)	Frequency
1.	IAK	Reflective	25,846	1,462
2.	WDAK	Impulsive	16,845	2,077

The instruments in this study were mathematics problem-solving tests about pattern of numbers, interviews and the Matching Familiar Figure Test (MFFT) made by Jerome Kagan (Warli, 2013). The validity of the instrument was carried out through expert validation tests related to the content/material, construction, and language used. Of the 2 questions made, all validators agreed that the instruments were appropriate for using with revised sentences that were still ambiguous. The questions used are shown in table 3 below.

Table 3
The instruments of mathematics problem-solving

No	Problem	Question
1.	Ayu plays with matchsticks then shapes them into squares, where each square requires 4 matchsticks. Ayu wants to arrange the squares in a brick arrangement. The first brick arrangement requires 12 matchsticks, the 2nd brick arrangement requires 20 matchsticks, and the 3rd brick arrangement requires 28 matchsticks.	a. What information do you know from the problem above? b. Arrange the bricks that are possible to be formed by Ayu! c. Determine the arrangement of bricks to-n! d. How many matchsticks are needed to form a brick arrangement to- 12?
2.	Rizki plays with matchsticks then shapes them into a square, where each square need 4 matchsticks. Rizki wants to arrange the squares in a gun arrangement. The arrangement of the 1st gun requires 16 matchsticks, the 2nd arrangement of the gun requires 24 matchsticks, and the arrangement of the 3rd gun requires 32 matchsticks.	a. What information do you know from the problem above? b. Arrange the arrangement of pistols that are possible to be formed by Rizki! c. Determine the arrangement of the gun to-n! d. How many matchsticks are needed to form the arrangement of the gun to- 10?

In this study the data were obtained through the results of tests of mathematical problem solving (time allocation of 30 minutes) and interview results. The results of the data are reduced and presented then test the validity of the data using time triangulation. Based on the results of the validity that the researchers obtained the data, there is a conclusion from the research conducted. The indicators in this study are combining the indicators of creative thinking and representation in solving mathematical problems as shown in Table 4.

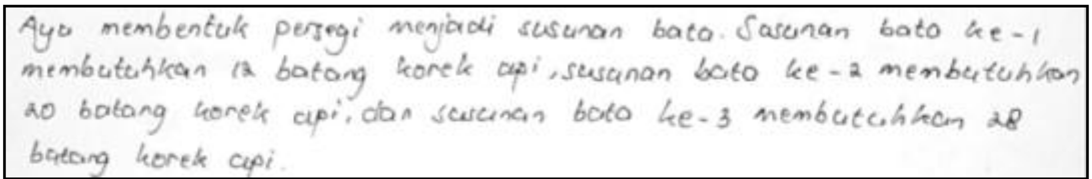
Table 4
Criteria and indicators of students creative thinking process based on representation

Representation / Think creatively	Visual Representation	Symbolic Representation	Verbal Representation
Fluency	Giving lots of ideas of a problem by drawing pictures, graphics, or tables.	Giving a lot of ideas of a problem by making an equation or mathematical model	Giving lots of ideas of a problem by making words.
Flexibility	Generating answers that vary from a problem and presenting it in the form of images, graphs, or tables.	Generating varied answers to a problem by creating an equation or mathematical model.	Generating answers that vary from a problem using words.
Originality	Choose different ways of thinking in the form of images, graphics or tables.	Choose a different way of thinking by making an equation or mathematical model.	Choose a different way of thinking by making words.
Elaboration	Resolve the problem by restoring the data in pictures, graphs, or tables using detailed steps.	Solve problems using detailed steps by creating equations or mathematical models.	Solve problems using detailed steps in words.

Results and Discussion

Case 1: The subject of reflective cognitive style

The fluency indicator on the subject with reflective cognitive style is shown when she was asked to solve a problem with the pattern of numbers. The subject could solve problems using visual representations in the stages of understanding the problem and planning strategies to find patterns. She could also represent the information into the picture and text as show in Figures 1a and 1b.


Ayu membentuk persegi menjadi susunan bata. Susunan bata ke-1 membutuhkan 12 batang korek api, susunan bata ke-2 membutuhkan 20 batang korek api, dan susunan bata ke-3 membutuhkan 28 batang korek api.

Translation:
Ayu formed a square into a brick arrangement. The first brick arrangement requires 12 matchsticks, the 2nd brick arrangement requires 20 matchsticks, and the 3rd brick arrangement requires 28 matchsticks.

Figure 1a. Text representation of the reflective subject

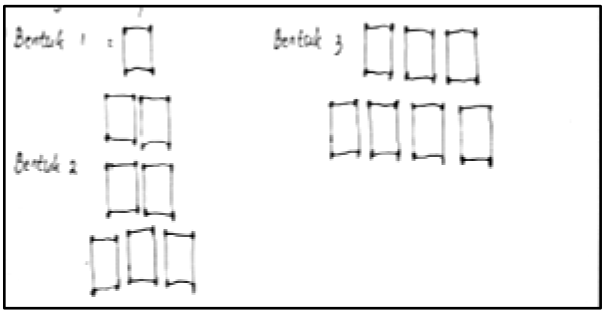


Figure 1b. Visual representation of the reflective subject

The following are excerpts of interviews that show the thinking fluency (*R*=researcher, S_1=Subject with reflective cognitive style).

R : Can you understand the problem by looking at pictures /objects around?
S_1 : Yes, it can
R : From all the data obtained, can you suppose with a variable?
S_1 : Yes. a, n dan b.

Base on the results of interviews and figures above, it indicates that the subject have the ability to use its environment to represent problems into mathematical expressions (in this case patterned images) smoothly. In addition to patterned images, subject can also describe in written form as in Figure 1a. This shows that in non-routine problems, subject showed fluency in represent information to solve the problem. This is in line with the statement that fluency is the ability to produce many ideas (Chiu et al., 2019). In addition, reflective subject show an understanding of related variables. This supports the theory that the reflective students have the same mathematical representation ability and they can draw pictures to clarify problems and make equations or mathematical models of other given representations and solve problems involving mathematical expressions (Warli, 2013). In this case, the subject shows the ability to describe problems into mathematical expressions using the experience he has called the assimilation process. Then the subject tries to compile new knowledge by going through the process of equilibration or adapting information that has different schemes to the schemes of knowledge possessed (Dwijayanti et al., 2019). Reflective subject perform equilibration processes well as shown in the ability to identify the variables that exist in the problem. It definitely supports the theory that reflective students think of various considerations before giving a response so that reflective subject has a high likelihood of answering correctly (Firestone, 1997).

The *Originality* indicator on the subject with reflective cognitive style is showed in the process of implementing strategies for solving problems. The subject could solve non-routine problems appropriately and use symbolic representations in making mathematical equations or expressions as shown in Figures 2.

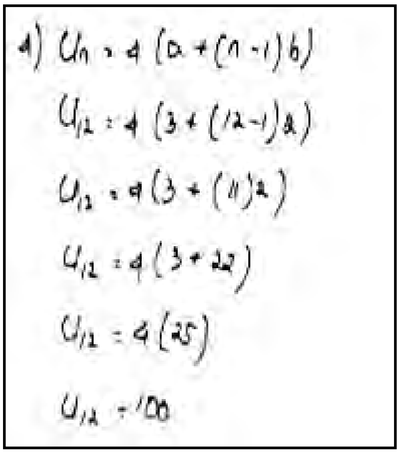


Figure 2. Symbolic representation of the reflective subject

The following are excerpts of interviews that show the thinking Originality.

R : Do you draw patterns on an object in solving problems?
S_1 : Yes, making a square arrangement into known bricks, from that arrangement can be obtained u_1=3 ,u_2= 5, u_3=7 after getting the nth term formula. After obtaining the nth term formula, only then can find the number of matchsticks needed to form the 12th arrangement. And the number of matchsticks needed for the 12th arrangement is 100

Base on the results of interviews and figure, it is shown that the subject has not responded to the idea of modification/non-procedure. The subject has not yet come up with new ideas, but it can solve non-routine problems through the patterns she formulates. Besides, she does the way solving problems do not write conclusions but in the interviews she is sure with the answers. This figure shows that subject has less originality in solving problems but she can solve these problems by using the experience she has (Gube & Lajoie, 2020). This is in line with the statement that originality is the ability to produce an idea or new ideas (Chiu et al., 2019). This is consistent with Damayanti's research which states that originality is shown by the ability of students to create problems that are rarely found by other students (Damayanti & Sumardi, 2018).

Figure 2 also shows the *flexibility* indicator of the subject. Subject with reflective cognitive style is shown in the process of implementing the strategy in solving problems, subjects solve non-routine problems appropriately and use visual and symbolic representations in determining U_{12}.

The following are excerpts of interviews that show thinking *flexibility*.

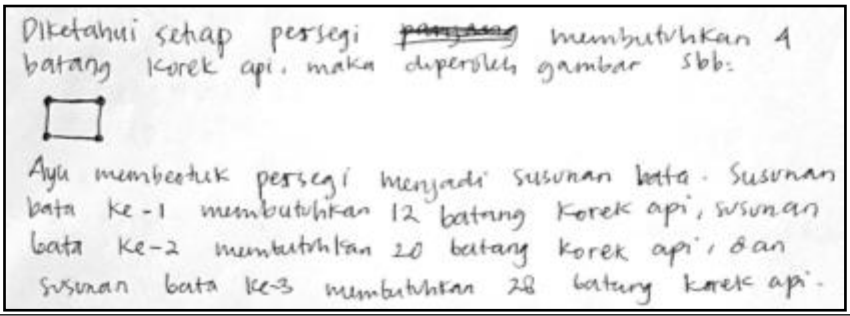
R : How do you change this problem into a number pattern?
S_1 : When I look at the arrangement of bricks, I am reminded of a number pattern. So I did it using a number pattern

Base on the results of interviews and figures, it shows that the subject can use her environment to represent problems into mathematical expressions (in this case patterned images). This shows that in non-routine problems, subject showed flexibility in solving problems using their experiences (Gube & Lajoie, 2020). This is in line with the statement that flexibility is the ability to produce ideas for several concepts of the category (Chiu et al., 2019). This study shows that the reflective subject shows the ability to apply the Un formula that has been formulated to find U_{12} with the less precise calculation, see Figure 2. Subject shows the ability to represent problems into mathematical expressions using the experience they have called the assimilation process (Dwijayanti et al., 2019), after that the subject tries to arrange new knowledge by going through the process of equilibration or adaptation of information that has a different scheme from the knowledge scheme that is owned. Reflective subject did not get through the equilibration process well as shown in the ability to apply the Un formula that has been formulated to find U_{12} not true. These findings support the theory that reflective students less various consideration possibilities answer so that it has a likelihood of answering less correctly (Firestone, 1997).

The elaboration indicator on the subject with reflective cognitive style is showed that elaboration skills are shown in Figure 2 for reflective subject, as well as the result of interviews. It can be seen that reflective subject use visual and symbolic representations in determining the results of U_{12}, but made mistakes in elaborating the Un formula that has been formulated in finding U_{12}, namely in the calculation. This shows that reflective subject has poor elaboration skills. Disequilibrium experienced by reflective subject was seen when she succeeded in formulating U_1, U_2, and U_3 but failed to find the value of U_{12}. Its fails to adapt new information that has a different scheme from the knowledge possessed (Dwijayanti et al., 2019). These findings support the theory that reflective students less various consideration possibilities answer so that it has a likelihood of answering less correctly (Firestone, 1997).

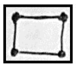
Case 2.The subject of impulsive cognitive style

The fluency indicator on the subject with impulsive cognitive style is showed when she is asked to solve a problem with the pattern of numbers. The subject could solve problems using visual representations in the stages of understanding the problem and planning strategies to find patterns. She could also interpret the information into the picture and text as showin Figures 3a and 3b.


Diketahui setiap persegi ~~panjang~~ membutuhkan 4 batang korek api. maka diperoleh gambar sbb:

Ayu membentuk persegi menjadi susunan bata. Susunan bata ke-1 membutuhkan 12 batang korek api, susunan bata ke-2 membutuhkan 20 batang korek api, dan susunan bata ke-3 membutuhkan 28 batang korek api.

Translation:
It is known that each square requires 4 matches, then the following picture is obtained:



Ayu formed a square into a brick arrangement. The first brick arrangement requires 12 matchsticks, the second brick arrangement requires 20 matchsticks, and the 3rd brick arrangement requires 28 matchsticks.

Figure 3a. Text representation of the impulsive subject

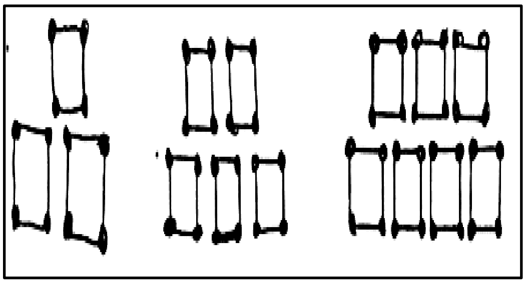


Figure 3b. Visual representation of the impulsive subject

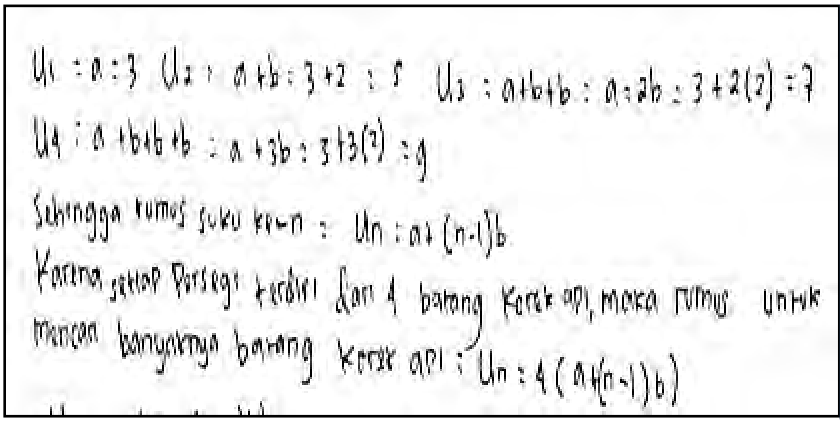
The following are excerpts of interviews that show thinking fluency.

P1 : Can you understand the problem by looking at pictures /objects around?
I1 : I got it, I thought of the shape of the box.
P2 : From all the data obtained, can you suppose with a variable?
I2 : No.

Base on the results of interviews and figures above, it indicates that the subject has the ability to use her environment to interpret problems into mathematical expressions (in this case patterned images) smoothly. In addition to patterned images, subject can also represent in written form as in Figure 3a. This shows that in non-routine problems, she showed fluency in elaborating information to solve the problem. This is in line with the statement that fluency is the ability to produce many ideas (Chiu et al., 2019). Besides, the impulsive subject shows that she did not understood the related variables. This idea supports the theory that impulsive students can make drawings to clarify the problem.

However, they cannot give reasons that their drawings are following the provisions contained in the problems. They also can solve problems using mathematical expressions but they tend not to write equations or formulas that are must be used to complete (Azhil, 2017). In this case, the subject explains that the ability to explain problems into mathematical expressions using the experience was called the assimilation process. Then the subject tries to compile new knowledge by going through the process of equilibration or adapting information which has different schemes to the schemes of knowledge possessed (Dwijayanti et al., 2019). The impulsive subject did not make it through the equilibration process well.

The *Originality* indicator on the subjects with impulsive cognitive style is showed in the process of implementing strategies for solving problems. She could solve non-routine problems appropriately and use symbolic representations in making mathematical expressions. Besides, Impulsive subject also show verbal representation as shown in Figure 4.



Translation:

So the n term formula = Un = a + (n-1) b
Since each square consists of 4 matchsticks, the formula for finding the number of matchsticks = Un = 4 (a + (n-1) b)

Figure 4. Verbal representation of the impulsive subject

The following are excerpts of interviews that show thinking Originality (S_2=subject with impulsive cognitive style)

R : Do you draw patterns on an object in solving problems?
S_2 : Form a square of 4 match sticks. Then form a square into a brick arrangement that is known from the problem.

Base on the results of interviews and figure, it is shown that the subject has not responded with the idea of modification/non-procedure. The subject has not yet come up with new ideas, but she can solve non-routine problems through the patterns she formulates. Besides, the subject in solving problems does not write conclusions but in the interviews, she is sure of the answers. This shows that subject has less originality in solving problems but they can solve these problems by using the experience they have (Gube & Lajoie, 2020). This is in line with the statement that originality is the ability to produce an idea or new ideas (Chiu et al., 2019). This is consistent with the research results by Damayanti and Sumardi which states that originality is shown by the ability of students to create problems that are rarely found by other students (Damayanti & Sumardi, 2018).

The *flexibility* indicator on the subjects with reflective cognitive style is showed in the process of implementing the strategy in solving problems, they solve non-routine problems appropriately and use visual and symbolic representations in determining U_{12} results as show in Figures 5.

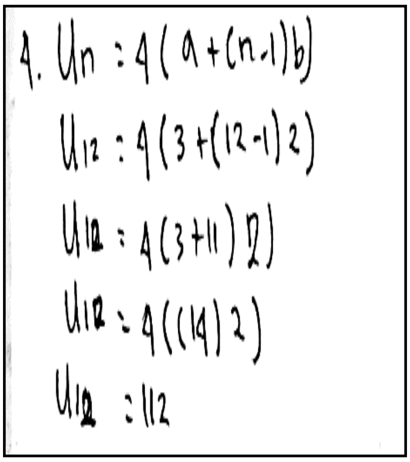


Figure 5. Symbolic representation of the impulsive subject

The following are excerpts of interviews that show thinking *flexibility*.

R	*P1*	:	How do you change this problem into a number pattern?
S_2	*I1*	:	When I look at the arrangement of bricks, I am reminded of a number pattern. So I did it using a number pattern.

The results of interviews and figures, its show that subject can use her environment to explain problems into mathematical expressions (in this case patterned images). This results show that in non-routine problems, subject showed flexibility in solving problems using their experiences (Gube & Lajoie, 2020). This finding is in line with the statement that flexibility is the ability to produce ideas for several concepts of the category (Chiu et al., 2019). The study shows that the impulsive subject shows the ability to apply the Un formula that has been formulated to find U_{12} with the appropriate calculation (see Figure 2). The subject shows the ability to describe problems into mathematical expressions using the experience, called as the assimilation process (Dwijayanti et al., 2019). Furthermore, the subject tries to arrange new knowledge by going through the process of equilibration or adaptation of information that has a different scheme from the knowledge scheme. The impulsive subject performs the equilibration process well shown in the ability to apply the Un formula that has been formulated to find U_{12} correctly. The findings support the theory that impulsive students think of various considerations before giving a response so that they have a high likelihood of answering correctly (Firestone, 1997).

The elaboration indicator of the subject with impulsive cognitive style is showed in Figures 4 and 5 as well as the result of interviews. The researchers can conclude that the impulsive subject use visual and symbolic representations in determining the results of U_{12}. The impulsive subject can elaborate the Un formula and obtains the correct problem-solving solution in its calculations. The findings support the theory that impulsive students think of various considerations before giving a response so that it has a high likelihood of answering correctly (Firestone, 1997).

Creative thinking based on representation

On the fluency indicators, both subjects in interpreting information to solve problems using visual representations are that in stages of understanding problems and planning strategies to find patterns. On the originality indicators, both subjects have not answered with the idea of modification/non-procedure and have not yet created a new idea.

However, they can solve non-routine problems through patterns that they formulate in making mathematical equations and expressions.

On the flexibility indicators, both subjects can use objects around them to represent the problem into mathematical expressions (in this case patterned images). They were using visual and symbolic representations in determining the solution. On the elaboration indicators, the reflective subject made a mistake in elaborating the formula U_n that has been formulated in its calculations. In contrast, the impulsive subject can elaborate the formula U_n in obtaining the correct problem-solving solutions in its calculations. Both subjects used visual and symbolic representations to solve the problem. Hence, the researchers identified the difference in creative thinking based on the representation from reflective and impulsive subjects as shown in table 5.

Table 5

Comparison of creative thinking based on representation in term of cognitive styles

indicators	Reflective Subject	Impulsive Subject
Fluency	a. Visual representation b. Understand the variables used	a. Visual representation b. Don't understand the variable used
Flexibility	a. Visual and symbolic representation b. In doing the calculation is not right	a. Visual and symbolic representation b. In doing the calculation correctly
Originality	a. Symbolic Representation b. Not yet to create new ideas but have the ability to solve problems through patterns that have been formulated	a. Symbolic and verbal representations b. Not yet to create new ideas but have the ability to solve problems through patterns that have been formulated
Elaboration	a. Visual and symbolic representation	a. Visual and symbolic representation

The findings provide challenge for educators to consider the creative thinking process, representations, and characteristics of the students in developing mathematics learning strategies. These abilities are important to help students in solving mathematical problems. Moreover, in constructing new knowledge, those abilities are necessary to adapt the information that has different schemes to the knowledge that students have. Therefore, the successful of students' in constructing knowledge will help them to solve the problem correctly.

Conclusion

The researchers can conclude that reflective subject meet the indicators of creative thinking in solving mathematical problems using visual and symbolic representations. However, the subject made a mistake in elaborating the formula U_n and error in the calculation of U_{12}. Furthermore, the impulsive subject met the indicators of creative thinking in solving mathematical problems using visual, verbal, and symbolic representations. However, the subject lack of understanding related to the variables used. Both subjects have not yet created new ideas or responded with the idea of modification/non-procedure in solving problems.

The findings show that the failure of the reflective subject on the elaboration indicator is due to its unsuccessful in carrying out the equilibration process. In addition, related to the originality aspect, reflective and impulsive subjects cannot answer with the new ideas. Based on these findings, educators need to consider the students' developing learning strategies and adapting new knowledge through the process of equilibration or adapting information that has different schemes that are owned. Therefore, students can answer correctly in solving problems. Moreover, students need to have its knowledge that is close to everyday life and related to mathematical models.

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