Mathematics creativity skill of student in junior high school based on students thinking style

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Abstract. Mathematical creativity is the ability needed to solve various problems in mathematics. Each student has different creativity, one of which, influenced by thinking styles that have an impact on the quality of perception and ability to order. Students' thinking styles are divided into four types, namely Concrete Sequential (CS), Abstract Sequential (AS), Concrete Random (CR), and Abstract Random (AR). This research is descriptive qualitative research. The research data were obtained from 25 junior high school students in the Kediri Regency with different student abilities and instruments used in the form of written tests and questionnaires and interviews. The results show that CS students can achieve creativity at the flexibility stage, AS students can achieve creativity at the fluency stage, CR students can reach creativity at the flexibility stage, and AR students can reach creativity at the novelty stage. In order to improve mathematical creativity, students should be given unlimited problem-solving in one way, and the teacher is expected to know students' thinking styles to be able to determine the appropriate learning methods and techniques.

1. Introduction
Mathematics is one of the sciences that has an essential role in the development of science and technology. Mathematics is involved in most fields of scientific research and plays a crucial role in various fields of contemporary discovery [1]. The critical role of these creative mathematicians who have been able to create new mathematical insights and ideas is so much apparent that there is no need to be emphasized [2]. Not only in the field of art and literature that requires creativity to get novelty works, but creativity in other fields is also essential to be able to create new ideas. Creative thinking is critical in this era of global competition because the level of complex problems is higher in all aspects of modern life [3]. At the individual level, creativity can lead to new ways related to work or daily life and solve problems in non-traditional ways, and at the community level, creativity can lead to new scientific findings, discoveries, new procedures, and reforms social [4]. In the education level, creativity plays an important role in the cycle of mathematical thinking advanced [5].

For this reason, creativity, especially in the field of mathematics, needs attention. Creativity in mathematics differs from creativity in other fields; creativity in mathematics can be defined as the ability to see or choose a solution in mathematics [6]. Besides, mathematical creativity can also be defined as the ability to produce new solutions to problems and apply mathematical principles in various ways to produce correct mathematical solutions [7]. Mathematical creativity is observed when someone produces a non-standard solution to a problem that might not be solved using standard methods [8]. Fluency, flexibility, and novelty are three important aspects of creativity [9,6,10].
Fluency is the ability to solve problems by giving various answers, flexibility is the ability to solve problems not only in one way but can provide other ways, and novelty is the ability to solve problems with answers that are not normally done by other students [11].

Based on the results of the mathematics teacher interview at Al-Fath Islamic Middle School on May 21, 2019, learning at Al-Fath is still focused on convergent thinking which requires students to memorize existing mathematical rules and apply them to specific problems to find answers, however, it does not lead students to use a variety of different ways, resulting in low mathematical creativity. In other studies, data were also found that showed students with high creative thinking abilities were only 20%, moderate categories were 33.33%, and low categories were 46.67% of the total number of students [12]. Because of the importance of the ability of mathematical creativity, an educator must understand what factors can influence the low mathematical ability of students' creativity. These factors include internal factors (within students) and external factors (outside students) [13]. Internal factors include talent, interest, motivation in students, learning styles, thinking styles, and many other internal factors. In contrast, external factors include facilities needed to support learning, learning less attractive processes, the accuracy of the teacher in choosing the shortcomings and learning models, the environment, close family and many other factors that exist outside of students [13].

Style of thinking is one of the internal factors that affect students' mathematical creativity. The thinking style of each student is different from each other [14]. The difference in thinking style is influenced by the perspective of students in dealing with problems and the preparation of the information that has been received. Therefore this perspective is based on the perception of each individual [15]. Children who have concrete perceptions, they will solve problems according to what is there. In contrast, children who have abstract perceptions, they will solve problems using their logic. Antony Gregorc in [16] concluded that there are two perceptions that each individual has, namely concrete and abstract perceptions, and the way information is organized can be grouped into two, namely sequential and random. This can be combined into four groups of behavioral combinations called thinking styles [13]. This can be combined into four groups of behaviors called thinking styles [13]. Gregorc calls these four styles of concrete sequential, abstract sequential, concrete random, and abstract random.

To maximize the potential and modalities of learning, students must know each other's thinking styles to develop the potential that exists in themselves because thinking styles also greatly affect success in achieving learning goals. On the other hand, the teacher must also know the student's thinking style to maximize learning. It is hoped that educators can determine the right method and model for overcoming various problems in the learning process and will ultimately have an impact on improvement in learning outcomes [17].

2. Method
The method used in this research is the descriptive qualitative method. This method is used to analyze mathematical creativity based on students' thinking styles namely CS, AS, CR, and AR. To determine the subject, researchers used students' thinking style questionnaires to get students with CS, AS, CR, and AR thinking styles. Then the researchers gave a written mathematical test in the form of essays with a duration of 20 minutes and continued with the interview process to get the data needed from the student answer sheet. The study was conducted at Al-Fath Islamic Middle School with the ability of heterogeneous students. The subjects of this study were four students drawn from 8th grade with purposive sampling. To check the credibility of the data, researchers used the time triangulation method. Then the data that has been obtained is analyzed descriptively. The analysis techniques used in this study include reducing data, presenting data, and conclusions.

3. Results
From the results of questionnaires 25 students found that there were six students (24%) who had CS thinking styles, four students (16%) had AS thinking styles, ten students (40%) had AR thinking styles, and five students (20%) had CR thinking styles. Based on the results of an analysis of 25
students, the researcher chose one of each thinking style as the research subject. The results in this study show scores and percentages of indicators of mathematical creativity ability based on each student's thinking style as in Table 1.

### Table 1. Percentage mathematics creativity skill.

| Mathematics creativity skill indicators                                      | CS   | %   | AS   | %   | AR   | %   | CR   | %   |
|-----------------------------------------------------------------------------|------|-----|------|-----|------|-----|------|-----|
| Solve problems with many answers viewed from one perspective                | 43   | 71.7% | 35   | 87.5% | 78   | 78%  | 32   | 64% |
| Solve problems with various answers viewed from different points of view   | 28   | 46.7% | 11   | 27.5% | 41   | 41%  | 29   | 58% |
| Solve problems in an unusual way for the level of student knowledge in general | 0    | 0%   | 0    | 0%   | 32   | 32%  | 2    | 4%  |

Table 1 shows that the highest fluency indicator is achieved by AS students, the highest flexibility indicator is achieved by CR students, and the highest novelty indicators are achieved by AR students. Some student answers are accompanied by interviews to find out the subject's ability to solve mathematical creativity abilities can be analyzed as follows:

#### 3.1 Analysis of mathematics creativity skill of concrete sequential

Students with concrete sequential thinking styles answer the information needed in more than one correct way. Students can solve these problems smoothly and use two different points of view, namely by using a picture that is accompanied by a percentage of the cake given to two younger siblings of different sizes and using a division operation on fractions. CS students in the process have not been able to bring up the settlement in an unusual way. This is in accordance with the statement of students: "The first way, I draw a circle cake, with a percentage of 1 circle is 100%, then divide the tart into 3 parts. The first part for neighbors is 50%, the rest of the first sister gets 10% = 1/10, and the second sister gets 40% = 2/5. The second way, I cut the cake into 10 equal portions. The neighbor gets 5 pieces of cake, while the first sister has 2 parts of the cake, and the second sister gets 3 parts of the cake." In the process, students do not show a new way to complete the fractional operation, as shown in Figure 1.
1 piece of tart
½ piece distributed by neighbors
½ piece divided by his two younger siblings
How many cakes did the younger sibling share?
Answer:

a) Neighbors = 50% = ½
Younger brother = 10% = 1/10
Brother = 40% = 2/5

b) Neighbors = 5 parts
Younger brother = 2 parts
Brother = 3 parts

Figure 1. Concrete sequential student answers.

3.2 Analysis of mathematics creativity skill of abstract sequential
Students with the abstract sequential thinking style can answer the information needed in more than one way, but in the process, students are only able to answer one answer correctly. The first way, AS students, use pictures to solve fractions, but the answer is not right. This is because when AS students divide ½ of the remainder of the tart into 5 parts, assuming the first sister gets the 2/5 portion and the second sister gets the 3/5 portion of the tart, without considering the cake being cut is ½ the portion of the whole cake. Whereas the second way AS students assume that 1 tart is 100%. If ½ of 100% is 50% given to neighbors, 20% is given to the first sister, then the second sister will get 30%. Based on the work done, AS students cannot use two different points of view and still use the method often used in fractional operations, as shown in Figure 2.

1 cake \( \rightarrow \) ½ neighbors \( \rightarrow \) ½ (two 2 younger siblings)
what is the part each sister gets if each sister gets a different part?
Answer:

1) One cake = 100% so ½ cake = 50%
50% \( \rightarrow \) first sister = 20%
second sister = 30%

2) ½ cake = 2/5

Figure 2. Abstract sequential student answers.

3.3 Analysis of mathematics creativity skill of abstract random
Students with abstract random thinking styles answer questions using 3 different ways. The first way, AR students use division fraction 1 : 2 : 2 = 1/4, then AR students multiply by 2. Actually, AR students don't need to multiply ¼ by 2, but only need to find the fraction that is equal to ¼, for example, 2 / 8, therefore 1 cake is 8/8. If the neighbor gets a 4/8 portion, then the rest of the cake is 4/8. Likewise, if the first sister gets 1/8, then the second sister gets 3/8. The second way, AR students use decimal fraction operations, if the neighbor gets \( \frac{1}{2} \) cake = 0.5, then the remaining cake is 0.5. For example, the
first sister gets 0.1, then the second sister gets 0.4 from the cake. The third way AR students use images to solve problems. This is what the students said: "I made a circular tart, and cut it into 2. ½ the portion was given to the neighbor, and the remaining ½ cake was cut into 3 equal parts. If the first sister gets 1/3, then the second sister gets 2/3 part of ½ tart. "AR students use different points of view in solving mathematical problems. Besides, AR students can solve problems in their way as seen in the first and third ways in Figure 3.

\[ 1: 2: 2 = (1/1 : 2/1): 2/1 = \frac{1}{3} : \frac{2}{1} = \frac{1}{4} \times 2 = \frac{2}{4} \]

\[ 2/4 = 4/8 = 1/8 + 3/8 \text{ therefore first sister } = 1/8 \text{ and second sister } = 3/8 \]

\[ 1-0.5= 0.5 = 0.1 + 0.4 \text{ therefore first sister } = 0.1 \text{ and second sister } = 0.4 \]

![Figure 3. Abstract random student answers.](image)

3.4 Analysis of mathematics creativity skill of concrete random

Students with concrete random thinking styles can answer the information needed in more than one way. The first way students use pictures to be able to solve problems. Students describe ½ cake divided into 2 so that ¼ is obtained. Students do not explain that cakes can be divided into 4, students only take pictures of 4 pieces of cake, and write 1/8 fractions. Students do not write the intent of the statement, students only write down the results of the operation ¼ divided by 2 which is 1/8. This is by students' statements: "I mean, the cake that is left after being given to neighbors is ½ cake. ½ my cake was divided into 2, therefore I got ¼, meaning I could make 4 of those cakes. I was confused about writing the part of the cake that was received by the first sister, therefore I made a picture of 4 pieces of cake. If ½ cake can be cut into 4, then 1 cake can be cut into 8 pieces I mean like that. And from the results of the operation ¼: 2 obtained 1/8 results, but I was confused to write my two statements therefore the first answer I made in the form of pieces of cake, while the results of the second operation I wrote down beside it. If the first younger sibling gets 1/8, then the second younger sibling gets 3/8. " As for the second way the students solve the problem in a less obvious way, students only draw a half circle with writing inside 50%, meaning that students assume 1 whole cake is 100%, so if half or 50% is given to neighbors, then the remaining cake is half a cake or 50%. Then 50% divided by four students to get their parts one by one so that the results obtained by the equation is 12.5%. If the first sister gets 12.5%, then the second sister gets 37.5%. This is by the statement of students: "Because 50% is given to neighbors, therefore for the remaining 50% younger siblings. If I cut the cake into 4, then 50% is divided into 4, therefore getting one result is 12.5%. If one younger sibling gets 12.5%, then the other younger sibling gets 37.5%, this result is obtained from 50% reduced by 12.5%, thus getting 37.5% results. Of the two methods used, concrete random student can use different points of view in solving problems, but with the writing of calculations that are less clear, as shown in Figure 4.
First step:
\[
\frac{1}{2} \text{ cake} : 2 = \frac{1}{4} \text{ cake} : 2 = \frac{1}{8} \text{ cake}
\]

One sister gets 3/8 and the other gets 1/8 cake.

Second step:
\[
50 : 4 = 12.5\% \text{ so one sister gets 37.5\% and the other gets 12.5\% cake}
\]

Figure 4. Concrete random student answers.

4. Discussion
Based on the results of the analysis note that concrete sequential students can write information that is in the problem. This is consistent with Djadir's research [18] that CS students tend to organize facts obtained systematically, by writing down the elements present in the questions. CS students can also explain the steps written on the answer sheet clearly and precisely, this study is also in line with Kholiqowati [19] that CS students have excellent visual, mathematical representation. In the process, students can answer using two different viewpoints of the resolution, but students have difficulty when faced with open-ended problems. Students tend to like solving problems using existing formulas. This is by the opinion of Deporter [16] that CS students easily remember the reality, facts, information, and existing rules. In work on the problems that have been done, students can answer these problems using two different points of view but have the same results, so that in this case, students with CS thinking style can achieve creativity at the flexibility stage. Not much different from CS students, students with AS thinking style can answer questions systematically, using two different points of view, but in the process, one of the methods used by students is not appropriate in using procedures. This is by Zakir's research [20] that abstract sequential students are less able to solve problems by planned procedures, so AS students can be said to achieve creativity at the smooth stage.

Students with abstract random thinking styles tend to solve problems in an unsystematic way. Students can answer questions by using several different points of view with different answers. How to answer students who are not structured, make others who see the answer will state that it is wrong, but when students explain the purpose of the answer clearly, then clearly know the purpose of student answers. In this case, students can achieve creativity at the novelty stage. Because students can solve problems by answering unusual ways, using unstructured ways. Not much different from students with AR thinking styles, CR students answer questions in an unstructured way and use their methods, but still follow the rules that apply to completion. CR students can solve problems using two different points of view. Therefore, in this case, students with CR thinking styles have creativity at the flexibility stage.

5. Conclusion
The results of the above analysis illustrate that students' mathematical creativity is different. Students with CS and CR thinking styles have mathematical creativity at the flexibility stage. Whereas, students with AS thinking style do not have perspective and do not find new ways, therefore in this case, AS students can only solve problems at the fluency stage. Mathematical creativity of students with AR thinking style results that students with this thinking style can solve problems with different perspectives and provide novelty ways to solve these problems, but with unstructured solutions, therefore, that in this case, AR students can achieve creativity in the novelty stage.
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