Mathematical creative thinking ability in middle school students

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Abstract. The mathematical creative thinking ability in this study is the ability to think which involves elements of fluency, flexibility, originality, or elaboration, in the process of solving mathematical problems. This study aims at determining the mathematical creative thinking ability of junior high school students in solving the problem of the plane figure. To do so, first, 28 students in the 7th grade (12-13-years-old) from a junior high school in Indonesia were given four plane figure problems. The problems were developed based on indicators of creative thinking ability. Then, three of the students were selected based on the prior mathematical ability to represent the creative thinking ability of all students. The interviews were conducted to confirm the students' answers. Finally, the results of student answers were analyzed based on indicators of creative thinking ability. The results of the study show that overall students were able to make new problems from the information presented, although the solution they wrote has not been systematically structured. In this case, the most visible students' creative thinking element is flexibility.

1. Introduction
In the 21st century, several abilities such as 4C skills (critical thinking, communication, collaboration, & creativity) are needed [1]. In this study, one of the skills elements examined was creativity, especially the creative thinking ability. One study in mathematics education which is an interesting topic to learn is about the relationship between creativity and high thinking ability [2]. Creativity is a product of one's creative thinking and an essential part of human culture [3,4]. A creative thinking will produce creativity. The creativity can be defined as the ability to create new, different products and unique ideas [5,6]. Creativity plays an important role in mathematics learning [7]. According to Pamilu, “Children shouldn’t be educated to be intelligent children, but must be educated to be creative children” [8]. For example, in solving mathematical problems, students are required to be able to see from a diverse perspective to solve problems in new ways. For this reason, creativity in mathematics ensures overall mathematical growth, because creative thinking means seeing things from different perspectives [5,9]. However, one of the challenges in examining mathematical creativity is the lack of a clear definition about the terms of mathematical creativity and creativity itself [10,11]. So, creativity needs to be explored more seriously to uncover the challenge. This is reinforced by the existence of clear boundaries about the indicators of creative thinking which have been developed by previous researchers.

One of the mathematics topics that can be used to measure mathematical creative thinking ability is geometry. In general, the topic of geometry is divided into two, plane figure and solid figure [12]. Geometry needs to be studied because it can train the ability to think logically, systematically, and turn
on creativity [13]. Why is creative thinking needed in geometry learning? Because increasing creative abilities contribute positively to children’s achievement [14]. Educating children to be creative will make learning more meaningful. This is supported by [3,15-17], that creative thinking is a mental activity related to the sensitivity to problems the discovery of new ideas for problem-solving through how to build, to synthesize and to apply new ideas. It is not surprising when Sriraman states that creative thinking is often associated with high-level thinking skills [2].

However, nowadays, more students are only able to solve simple problems, not used to solving non-routine problems or high order thinking skills problems (HOTS), such as creative thinking ability [18]. According to Siswono students in general are still having trouble to find a variety of ways to solve non-routine problems [19]. Most students solve the problem in the same way and tend to follow the example procedure [20]. This issue shows that geometry achievement at the student level in public secondary schools is still low [20]. As explained previously, creative thinking is the ability of humans to make things different, investigate, explore new things, and make things original [21]. For this reason, researchers analyzed students’ answers to measure their mathematical creative thinking ability in solving triangles and quadrilaterals. Because according to Nadjafikhah, through creative thinking in mathematics it will help to make reasonable guesses in developing mathematical theory [22]. The indicators to measure the mathematical creative thinking ability of students in this study are: fluency, flexibility, originality, and elaboration [22-27]. Based on the presentation, the importance of creative thinking ability in solving mathematical problems can be seen, especially in non-routine problems. This study focused on analyzing the students’ creative thinking ability at middle school level in Indonesia.

2. Method
This study analyzed students' mathematical creative thinking ability in the topic of triangles and quadrilaterals. This study is a part of descriptive study. The participants of this study were three junior high school students who have been obtained learning mathematics related to triangle and quadrilateral topics. Then, the prior students’ mathematical abilities in this study were grouped into the low, the medium and the high one. In order to do so, first, 28 students in the 7th grade (12-13- years-old) from a junior high school in Indonesia were given four geometry problems (see Table 1).

| Indicators | No. | The items of tests |
|------------|-----|-------------------|
| Fluency: trigger many ways of solving problems | 1 | A rectangle has length is \(2y + 6\) cm and the width are \((y - 1)\) cm. The area of the rectangle is equal to the area of a rectangle whose length is \(y + 3\) cm. In the various ways, find the rectangle size possibility! |
| Flexibility: generates problems were varied. | 2 | A room has a rectangular floor with a size of \(9 \times 5\) m. The floor will be installed with each tile size \(30 \times 30\) cm. The price of one ceramic is IDR 48,000,00 (with 11 pieces). Based on the data, create some questions related to the problem and then solve it! |
| Originality: make a combination of problems independently | 3 | Given the surface of an equilateral triangle-shaped park, with each side length of \(25\) m. create problems from the data, and solve the problem in your own way! |
| Elaboration: Make details of the problem in the form of problems | 4 | Given ABCD rectangle with the size are \(6x\) cm for the length and \((4x + 2)\) cm for the width, and the circumference is \(84\) cm. The midpoint of each rectangular side forms an EFGH rhombus. If the T point is the diagonal intersection point of the EFGH rhombus, then, create some questions related to the problem and then solve it! |

(Modified from Sahliawati [28])

3. Results and discussion
Research participants in this study were divided into 3 criteria based on prior students' mathematical abilities, which consisted of high (S-1), moderate (S-2), and low (S-3). Based on the results of data
analysis, we found students' creative thinking ability category, for S-1 and S-2 were in the low category, while S-3 was in the very low category. If the average value of the three scores is taken, the ability of the three students is in the very low category. However, if analyzed in more detail, it was found that students with moderate ability (S-2) showed higher creative thinking ability compared to students with high ability (S-1).

3.1. Students’ answer on item 1

From Figure 1(a) show that S-1 did not structured in working on the problem. So, the students were given a score of 1. After an interview, S-1 did not really understand how to solve this problem and looked doubt. In this case, S-1 are not yet eligible fluency. According to Yahya “there were other psychological factors noted as we such as carelessness and participants’ lack of confidence in answering the questions” [29].

In Figure 1(b), it can be seen that S-2’s answer was more structured than S-1. S-2 almost shows the fluency aspect of creative thinking ability. But there are errors when applying broad concepts and algebraic calculations. Even though the S-2 did not show the correct answer, he tried to the problem in his own way [20]. So, S-2 is given a score of 2. Based on the interview, S-2 forgot how to operate algebra.

Figure 1(c) shows that S-3 answer was not clear. When interviewed, S-3 did not understand the problem. So, S-3 was given a score of 1. Actually, in item 1, students were expected to be able to identify the broad formula of a rectangle for finding the circumference of a rectangle. However, they still had difficulties in algebraic operations. Hence, based on students’ answers and the results of interviews, they had not been able to demonstrate the fluency aspects of mathematical creative thinking as a whole.

3.2. Students answer on item 2

Figure 2(a) shows that S-1 can explain the answer. Based on the interview, S-1 understood what he had to do and what he wanted, but was confused in writing down the answer. In item 2, he could already show the flexibility aspect. So, S-1 is given a score of 3. The figure 2(b) shows that the answer of S-2 was more structured than S-1’s answer. It means that the S-2 had been able to demonstrate the flexibility aspect. Based on the interview, the S-2 was able and confident to make problems. But he was hesitant to write correct and systematic answers [30]. So, the S-2 was given a score of 4.

Figure 2(c) shows that the S-3’s answers were not structured and were still unclear. When
interviewed, the S-3 did not understand what to do with the item 2. So, the S-3 was given a score of 1. In item 2, the students were expected to produce varied problems. Based on students’ answers, the S-1 and S-2 were able to make diverse problems from the information obtained in the questions, so that the flexibility aspect arose from the work of item 2.

3.3. Students’ answer on item 3

The student’s answers on problem 3, can be seen in Figure 3. Figure 3(a) shows that the S-1 was able to make a combination of problems, but the process was still not structured. Based on the interview, when asked why she answered the area of a triangle that way, the S-1 said that the side was 25 cm. When asked for the triangle area formula, the S-1 said that he forgot to find the medium height known in the problem was the side. In this case, the S-1 was able to show aspects of originality in working on the problem. The score given to S-1 in this item was 1 because the S-1 was still trying to answer the question even though she had not produced the correct answer, this is according to Guzel [20].

Figure 3. Students’ answer on item 3.

From Figure 3(b), it was shown that that the S-2 was able to make problems from the information. Based on interview, the S-2 claimed that he had forgotten the triangle formula. In addition, he realized that he was mistaken in finding the area of a triangle using the square area formula. In this item, the S-2 was able to show aspects of originality but was still mistaken in giving answers. So, the S-2 was given a score of 1.

Based on Figure 3(c), it was shown that the S-3 was able to solve problem. When confirmed, the S-3 said that he would look for an area from the park. Then "when asked broadly, how to do it?" he said that he was mistaken about the size of the park by counting around the park. Based on interviews, the S-3 was actually able to provide originality arguments from the answer to question item 3. So, the S-3 was given a score of 1. According to Guzel [20], students have attempted to solve problems in the same ways or they tried to adapt the same incorrect solving method to the problems. In item 3, the students were expected to be able to make a combination of problems independently. Their mistake was calculating the area of a triangle using a square formula. It caused concept errors, i.e. the students did not master the concept of area, circumference, and numbers [30].

3.4. Students’ answer on item 4

Figure 4(a) shows that the S-1’s answer had not been structured and was wrong in the algebraic calculation process. Based on the interviews, the S-1 forgot writing information from the question and the S-1 was not able to show solving details it asked. So, the score of S-1 in this question was 1. Figure 4(b) and 4(c) show that the S-2 and the S-3 had the same answers in solving item 4. They did not show
details in their answers. Based on the interview, the S-2 panicked when he answered the question. Meanwhile, it was found that the S-3 admitted that he cheated, because he saw the S-2’s answer. Thus, the aspect of elaboration from their answers was still not visible. So, the score given for their answers was 1.

In item 4, the students were expected to be more detailed in giving answers. Overall, it was found that the problem was too difficult to solve by the students. The students’ difficulties in solving problems may be due to the type of question given which was the type of non-routine problems. This finding, according to [19] is that one of problems in junior high school mathematics learning is the ability of students to solve problem in the form of story problems, especially non-routine or open-ended problems.

4. Conclusion
Based on the results of the study, we have made two conclusions. The first, we found that the students of the mathematical creative thinking ability in solved the non-routine problems on the topics of triangular and quadrilateral were still low. The last, the element of creative thinking that is most visible from students in this study is flexibility. The lowly mathematical creative thinking ability of the students who are shown in this study requires further research to find the factor of the cause. However, the results of this study can be used as basic information to facilitate teachers in applying learning methods and developing problems that can build and enhance students' creative mathematical thinking ability.

Acknowledgement
We thank all students and schools who involved to be volunteers in this study. Then, Mr. Achmad Salido and Ms. Neni Maulidah for helping in writing this paper. Especially Mr. Sahli has provided funding for this research.

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