Analysis of mathematical creativity in the field of geometry in junior high school students

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Abstract. Nowadays, world civilization has entered the 21st century. One of the challenges of education in the 21st century is the development of human resources that have mathematical creativity. With mathematical creativity, students are trained to solve problems related to mathematics, students can facilitate their abilities, discuss various ways to find solutions, and make combinations of new knowledge or new problem solving techniques. This research has an aim to analyse mathematical creativity in the field of geometry in junior high school students in Surakarta. The research method used in this research is quantitative descriptive. The sample of this research is 56 students from 8th grade student of junior high school in Surakarta were taken by random sampling method that represent the population. The results of this research indicated that out of 56 students of junior high school in Surakarta have 2 students who are on level 3 of mathematical creativity, 17 students who are on level 2 of mathematical creativity, and 37 students who are on level 1 of mathematical creativity. These result can be used as preliminary data to determine the level of mathematical creativity students in Surakarta.

1. Introduction
Creative thinking ability is considered as one of the human abilities that is more qualified than other abilities, and is an important factor to support the progress of the country [1], as found in the challenges of the 21st century. Creativity is traditionally supposed to attribute to art and literature, but nowadays doing meaningful science has also been considered as a creative act. In areas of art and literature, it is generally enough to create an extraordinary and novel work, but a creative scientific idea needs not only to be novel but also useful [2]. Moreover, in a vastly changing world, in which technological and scientific advancements change social networks and individual lives, creativity is needed both for adapting to this changing world and for continuing these advancements [3]. Mathematical creativity is one specific type of creativity that is important.

Mathematical creativity comes from more than a strong knowledge base. To create something new and meaningful in mathematics, it is important to break away from established mindset, to see problems from outside and to apply mathematical knowledge to see the possibility of solving the problem [4-6]. There is no single definition of mathematical creativity that is generally accepted or used by many people [7,8]. Chamberlin and Moon stated that mathematical creativity is observed when someone produces a nonstandard solution to problem that may not be solved by using a standard method [9].

Furthermore, mathematical creativity plays a key role in the whole cycle of advanced mathematical thinking [10]. This research is in line with the research of Sriraman which states that mathematical
creativity ensures the development of mathematics as a whole. Instead of being a source of development, mathematical creativity as a field was not well explored in mathematics and mathematics education in the world [11]. In the other hand, Poincare described that the mathematical creativity referred to the ability to construct mathematical alternatives leading to success [12]. Additionally, mathematical creativity is the ability to process the result in unusual and insightful solution to a problem and to produce various kinds of products in the mathematical situations from new angle requiring imagination [5,7,13,14].

Hereafter, creative thinking ability defined as the ability reflecting aspects of fluency, flexibility, originality and elaboration [15,16]. It is including a) fluency which is related to the student's ability to produce many answers or ideas that are relevant from a given problem, b) flexibility which is associated with the ability of students to generate different ideas, able to change the system or approach, and be able to resolve the problem with the different direction of thinking from a problem, c) the authenticity or uniqueness (originality) which is the ability of students to try the approach in a way or method of an unusual or unique based on the ideas from the students themselves, d) elaboration which is the student’s ability to redefine a problem or situation and itemize in detail the steps of a problem given. The aspects uniqueness (originality) and of detail (elaboration) are encapsulated into aspects of novelty in creative thinking that demonstrates the ability of students to solve problems.

So, it can be concluded that mathematical creativity is the ability to think in solving problems by different, various, and new methods that defined as the ability reflecting aspects of fluency, flexibility, originality and elaboration. Thus, encouraging students' creativity needs to be given an open minded atmosphere and opportunities for students to express different opinions, to ask questions freely, and to give students the right to choose learning resources and methods freely [17].

Testing for creativity is considered an important part of education assessment [18], especially because creativity is highly valued in modern technology society and should be developed in as many individuals as possible. However, Nasution et al. conducted a study that found out that teacher did not have time to analyse mathematical creativity student, so they only gave the routine question during learning and evaluation [19]. In additionally, Sinaga also stated that most teacher used conventional learning model and are dominated by them, so the student cannot develop their knowledge [20]. Moreover, Yee stated that one of the ways of generating creative thinking is the presentation of problems with open answers, so there is more than one solution, and the student will have to make presuppositions before offering an answer [21].

Hakim and Gazim point out the fact that the more unusual the question and then the more creative thinking required, the number of correct answers decreases and so does the ability to cope with the problems [22]. But the students who do succeed in solving the problem gain a high sense of competence, satisfaction, and motivation. Students with learning disabilities need this type of questions that raises their personal moral and strengthen their motivation to learn on. In other research, Sirait determined the level of mathematical creativity in junior high school student reviewed by learning style and found out that [23]. The level of mathematical creativity for learning styles of accommodation 2 students (moderate), and 5 students (low); the level of mathematical creativity for divergent learning styles 2 students (high), 4 students (moderate), and 7 students (low); the level of mathematical creativity for assimilation learning styles 3 students (moderate), and 7 students (low); the level of mathematical creativity for convergent learning styles 1 students (high), 2 students (moderate), and 2 students (low).

As it has been mention above, mathematical creativity has four indicators: fluency, flexibility, originality and elaboration. The four indicator review different things and stand alone, so students with different ability and background will have different abilities according to level of mathematical creativity. In this study, The Level of Mathematical Creativity (LMC) is the level of mathematical thinking that categorised based on the characteristics of one’s creative thinking and creativity products. According to Siswono [24], creativity is divided into 5 levels, namely, level 4 (very creative), level 3 (creative), level 2 (quite creative), level 1 (less creative), and level 0 (not creative). The gap is summarized at the level of creative thinking skills which can be seen in Table 1.
Table 1. Levels of creativity and characteristics.

| Level                        | Characteristics                                                                 |
|------------------------------|---------------------------------------------------------------------------------|
| level 4 (very creative)      | Students are able to show fluency, flexibility, and novelty or novelty and flexibility in solving problems |
| level 3 (creative)           | Students are able to show fluency and novelty or fluency and flexibility in solving problems |
| level 2 (quite creative)     | Students are able to show novelty or flexibility in solving problems             |
| level 1 (less creative) level 0 (not creative) | Students are able to show fluency in solving problems |

Based on several studies and explanations regarding mathematical creativity above, there is no research on junior high school students in the matter of circle. Therefore, researchers conducted a study to increase the mathematical creativity of junior high school students in the material of circle. This study aims to determine the level of mathematical creativity of junior high school students that can be use as preliminary data.

2. Method
In this study, the method used is descriptive quantitative method to analyse the level of mathematical creativity in the field of geometry in junior high school students in Surakarta. The population in this study were all 8th grade junior high school students in Surakarta. From the population, one school have been chosen to represent the population. The selection of samples to represent the school was done by random sampling and was selected in SMP Batik Surakarta that representing the population. The students who were sampled at SMP Batik Surakarta were 56 students. In collecting data, this study used an instrument in the form of a mathematical creativity test. The students were given 4 questions that were done within 60 minutes, each question presents 4 indicators of mathematical creativity which is fluency, flexibility, originality and elaboration. The topic in the question is circle. The data obtained will be used as the preliminary data of the research to be carried out next.

3. Result and discussion
Based on the result, from 4 questions given to 56 students in SMP Batik Surakarta, the average value of students is at level 2 (quite creative) with a value of 39.93. Meanwhile, for the results of each level obtained by each student will be explained in Table 2.

Table 2. Levels of mathematical creativity.

| Level                     | Students | %      |
|---------------------------|----------|--------|
| level 3 (creative)        | 2        | 3.57   |
| level 2 (quite creative)  | 17       | 30.36  |
| level 1 (less creative)   | 37       | 66.07  |

Table 2 show that from 5 levels of mathematical creativity, students in SMP Batik Surakarta get level 1 (less creative), level 2 (quite creative) and level 3 (creative). In addition, out of 56 students of SMP Batik Surakarta have 2 students who are on level 3 (creative) of mathematical creativity, 17 students who are on level 2 (quite creative) of mathematical creativity, and 37 students who are on level 1 (less creative) of mathematical creativity. This shows that in the school the level of students' mathematical creativity is still low, so effort is needed to improve that ability. One way that can be done is teaching-learning sessions to be student-centered, students have become more active throughout sessions. It was
consistent with findings by Heong that students who were trained to think critically often demonstrated a positive impact on the development of their education [25].

Mathematical creativity has 4 indicators, namely fluency, flexibility, originality and elaboration. Based on the results of mathematical creativity, on question that represent fluency indicators, 69% of students are able to answer, even though the answers given are not perfect. This shows that students are not too difficult to answer the question. On question that represent flexibility indicators, only 36% of students are able to answer as well as on question that represent originality indicator only 24% and elaboration indicator only 31%. This shows that students has difficulty in solving problems in that questions. This is because some students were still having difficulties to decide the core of the problem and the way to solve it. It was similar to findings by Nguyen [26] that stated that students could almost draw out no conclusions and many of them were quite confused when the teacher asked them to specify their description. In the other hand, perfectly possibly were caused by the differences in the methods of answering the question. Sometimes the different methods led students out of track or unable to find the correct answer. However, it was understandable. Students were still in middle school which was the initial stage of high intelligence thinking. Each individual had different ways of finding and solving problems. It corresponds to statement according to Zhang dan Ching that identifying such relationships can provide instructors and authorities with useful information so that they can apply appropriate methods, based on student's individual differences, in order for them to be able to develop critical thinking in students [27,28].

Based on that discussion, now we will discuss the different answers from students of level 1, level 2 and level 3 on each indicators. We should emphasize that the perfect answers also had many alternative answers. Student answers will be shown below.

3.1. Fluency

\[
\text{Student's level 3.}
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Fluency is related to the diversity of student answers that can be produced. The following will be presented by students' answers that fulfill the fluency indicator. Figure 1 and 3 shows that students determine the extent of juring first, then determine the area of tembereng. On the other hand, figure 2 shows that's student determine the area of a quarter circle, then the area of the triangle. The answers from these students were correct.

3.2. **Flexibility**

**Figure 2.** Student’s level 2.

**Figure 3.** Student’s level 1.

**Figure 4.** Student’s level 3.

**Figure 5.** Student’s level 2.

**Figure 6.** Student’s level 1.
Flexibility is associated with the ability of students to generate different ideas, able to change the system or approach, and be able to resolve the problem with the different direction of thinking from a problem. Figure 4 shows that students determine the circumference the tree first, then manipulate the formula of circumference. It is seen that students have no difficulty in solving problems. In the other hand, Figure 5 shows that students understand the completion steps to be taken, but student were still difficult in the division operation. Different from Figure 6 that shows that student who did not understand what the command was.

### 3.3. Originality

![Figure 7. Student’s level 3.](image)

![Figure 8. Student’s level 2.](image)

No answer

![Figure 9. Student’s level 1.](image)

Originality is the ability of students to try the approach in a way or method of an unusual or unique based on the ideas from the students themselves. Figure 7 shows that student do not have difficulty in solving problems, students understand what steps to do. Student take the initiative to consider the length of the rectangle so that it is easier to calculate which shading area is wider. Figure 8 shows that students only guess without a clear basis. Different from Figure 9 that shows that student who did not understand what the command was.
3.4. Elaboration

Elaboration which is the student's ability to redefine a problem or situation and itemize in detail the steps of a problem given. Figure 10 shows that student do not have difficulty in solving problems, students understand what steps to do and solve the problem well. On the other hand, Figure 11 show that student make mistakes in understanding the purpose of the question so the student answer is wrong, but at least students have thought about the solution that will be done. Different from Figure 12 that shows that student who did not understand what the command was.

4. Conclusion

The importance of building creativity in thinking mathematics is a very important thing that must be done by adults to children, creative thinking skills are one of the skills that can support students' lives not only in school but also to support their thinking in facing the real world. In this study, SMP Batik students are divided into 3 levels of creativity. Students at level 3 are quite good in 4 indicators of mathematical creativity but have not reached the desired target, students have been able to analyse well what is meant by the problem, students have been able to read the flow of questions. Students at level 2 have been able to determine the core of the problem but have not been able to solve the questions correctly, students are only able to meet the indicators of fluency and flexibility. While students at level 1 are only able to meet the fluency indicator, for other indicators they cannot understand the purpose of the question. These result can be used as preliminary data to determine the level of mathematical creativity students in Surakarta. The suggestion for further research from the follow-up of this research is to use more questions and use more samples. Use the sample not only at one junior high school level, but three junior high school level. Using samples with different characters, will enrich the results of the study.
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