Analysis of mathematical creative thinking level based on logical mathematical intelligence

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Abstract. Creativity is an ability that must be developed from an early age. The ability to think creatively is also one of the higher-order thinking skills needed in the 21st century. This study aimed to analyze the level of mathematical creative thinking skills of students’ mathematical logical intelligence. Indicators on the ability to think creatively include fluency, flexibility, and novelty. The method used in this research was descriptive qualitative. Data filling methods were tests, interviews, and documentation. The results of this study revealed the profile of students’ level of mathematical critical thinking and logical mathematical intelligence, and showed that students who have high mathematical logical intelligence are at level 3 creative thinking (creative). Students who have mathematical moderate logical intelligence are at level 2 creative thinking (creative enough) and students who have low mathematical logical intelligence are at creative thinking level 0 (not creative). Therefore, based on the results of this study, we know that students who have high, medium, and low mathematical logical intelligence can solve math problems based on their creative thinking abilities.

Keywords: Creative thinking, Mathematical logical intelligence, Mathematics

1. Introduction
Mathematics can be interpreted as the study of patterns and relationships, language, art, and tools which are one of the subjects that play a role in advancing the civilization of a nation. Therefore, mathematics is not a separate knowledge but its existence is also to help humans understand and master various other problems [1]. Also, mathematics is the basis of other sciences and is important to learn. We know that mathematics is often associated with calculations and numbers and is involved in everyday life so that one of the main objectives in learning mathematics is to be able to develop skills in creative thinking [2]. This agrees with [3] that creative thinking is an ability that must be developed from an early age. This ability can be obtained from the social environment such as teachers and other students who are sources of information in their learning environment [4]. The creativity that students have is also an important component of advanced mathematical thinking [5]. But at this time, mathematics is a subject that is considered by students as a difficult and boring subject. This will affect a student’s low learning achievement because students find it difficult to understand and apply mathematical problem-solving. Furthermore, based on the absorption of students in Madiun Regency on geometry and measurements for the Regency level got 45.02%, the provincial level got 44.50% and the national got 41.09% [6].

In geometry material, it is necessary to have a good understanding of how to build an idea in solving the problem. Therefore, the concepts in geometry need to be emphasized because students do not have the experience to know the geometric concepts used and to combine various concepts in solving
problems using their abilities. An idea to get a good concept requires different thinking and creativity of students who have in solving problems [7]. However, students tend to practice routine questions only, only following step-by-step instructions so that there is no way for creativity to emerge in students [8].

Creative thinking is a mental process that produces new and unique solutions to the problems given [9]. Creative thinking is also one of the higher-order thinking used to face the industrial revolution 4.0. One of the skills in creative thinking to solve problems proposed by NCTM is to apply a variety of strategies to solve problems [10].

Creative thinking is useful for exploring, understanding how to think, and for developing their thinking concepts [11]. There are three components to discovering students’ creative thinking skills in solving math problems assessed using the Torrance Test of Creative Thinking (TTCT), namely fluency which includes producing varied answers smoothly and correctly, flexibility that refers to the number of giving many different ways, and novelty which includes being able to solve problems in their way before being given knowledge [12]. In each component, if the command response is indicated to be appropriate, appropriate, or useful with the desired command, the indicators of creative thinking have been fulfilled.

The ability to think creatively has four levels [13], namely the fourth level is categorized as very creative. At this level, students provide answers smoothly and correctly (fluency), provide different settlement methods (flexibility), and provide new solutions (novelty). The third level includes the creative category, in which students provide different solutions (flexibility) and can make new answers (novelty) even though they are not fluent (fluency). The second level is categorized as quite creative, where students can give new answers even without flexibility or fluency, or students can provide different solutions but the answers are not new. The first level is in the less creative category, where students only give one correct answer (fluency). The zero levels are included in the uncreative category, where students cannot meet the fluency, flexibility, and novelty indicators.

How to develop creative thinking skills can be by providing problems or questions that have many solutions, namely using an open-ended approach [14]. This open-ended approach can be applied by teachers effectively when providing exercises during learning, starting with students being given open-ended problems with many correct answers for students [15]. At the time of solving these problems, students are given the freedom to cooperate with their friends so that it will bring up various kinds of solutions, thus providing many opportunities to explore the competencies that students have [16]. Creative thinking also focuses on the ability of students to produce various solutions that are new to open math problems. That is, through the ability to think creatively students can observe problems first and solve these problems through their various points of view and then relate them to the knowledge that students have so that students can express new ideas in solving math problems [17]. This will provide opportunities to improve student’s creative thinking skills.

In addition to the learning process, there are still many things that can affect success in learning with mathematics, one of which is mathematical logical intelligence. This intelligence has a greater contribution to the success of a student in improving learning outcomes [18]. This intelligence also refers to the ability to analyze problems logically, solve mathematical calculations, and deductive reasoning [19]. Students who have high mathematical logical intelligence can apply and reason when faced with mathematical problems [20]. Students who have high mathematical logical intelligence are very happy to count, ask questions, and do experiments [21]. Therefore, when a student is faced with open-ended questions, these students will build their creative ideas by conducting experiments and making proofs based on the formulas they know, so their creative thinking skills lead to skills in providing many solutions. The results of previous research conducted by Utami only discussed the level of students’ creative thinking abilities on geometry without involving any of the students’ multiple intelligences [22]. The results of other studies indicate that the level of students’ creative thinking abilities is influenced by interpersonal intelligence at level 0, level 2, and level 3. Then suggest doing other research that can be influenced by one kind of multiple intelligence [23]. Based on previous research, researchers carried out research updates related to the level of students’ creative thinking abilities based on one type of multiple intelligence, namely mathematical logical intelligence. Therefore, in this study, the researcher will analyze the level of creative thinking ability of mathematics based on students’ mathematical logical intelligence.
2. Method
This research used descriptive qualitative research which was conducted in the even semester at a state junior high school in Madiun Regency. The population of this study was all students of class VIII SMP Negeri 01 Geger. In this study the subjects were selected using purposive sampling technique, this technique was used to select students based on the mathematical logical intelligence category in VIII F with a total of 32 students. Furthermore, three students who have different mathematical logical intelligence levels will be selected, namely one student with high mathematical logical intelligence, one student for moderate mathematical logical intelligence, and one student for low mathematical logical intelligence. The instrument used was a mathematical creative thinking test consisting of 2 description questions on the teaching material that students had studied and a mathematical logical intelligence test. The validation of this instrument was carried out by three lecturers from the University of March 11 and validation of the logical intelligence test by three lecturers from the Muhammadiyah University of Surakarta. Students’ creative thinking abilities are assessed based on indicators of mathematical creative thinking abilities. This scoring criterion refers to the rubric score developed by [13]. The test results on mathematical logical intelligence showed that students’ thinking levels were high, medium, and low. Then, an interview was conducted to obtain more detailed information. Figure 1 shows a design of the research steps.

3. Results and Discussion
Mathematical logical intelligence is assigned to classes and obtained at different levels. Each level is taken by one student to analyze the answer based on creative thinking skills. The following is the percentage of students’ mathematical logical intelligence which is presented in table 1.

Table 1. Percentage of mathematical logical intelligence
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| Mathematical logical intelligence | Total Students | Percentage |
|----------------------------------|---------------|------------|
| High                             | 10            | 31%        |
| Moderate                         | 12            | 38%        |
| Low                              | 10            | 31%        |

There are five categories in the ability to think creatively, namely level 0 (not creative), level 1 (less creative), level 2 (quite creative), level 3 (creative), and level 4 (very creative). Data were collected through tests and followed by interviews to confirm students’ written answers so that researchers could obtain more in-depth information. The creative thinking test questions can be presented in Table 2.

**Table 2. Creative thinking test**

| Indicator | Question |
|-----------|----------|
| Fluency   | a) Write down the various possible ways to calculate the area of the lateral shape! |
| Flexibility | 1  
|           | b) Make at least 2 different problems about the shape above and give a solution to the problem that you have made! |
| Novelty   | 2  
|           | Based on the shapes on the side, make a variety of possible ways to calculate the total area of the shaded shape! |

The following are the results of students’ answers in creative thinking based on mathematical logical intelligence on geometry material.

3.1. Analysis of the answers of subjects who have high mathematical logical intelligence (S1)

The results of the S1 are seen in Figure 2 and Figure 3.

**Picture 2.** The results of the S1 answer to question number 1 with fluency and flexibility indicators.

**Picture 3.** The results of the S1 answer to question number 2 with novelty indicators.

Figure 2 shows that S1 in question number 1a has provided two different methods of solving (flexibility) and the calculation is correct, namely the first way by adding the areas of the two triangles...
and the second being formed into a large triangle and producing the correct answer, while for number 1b students are not yet fluent in giving answers, this lies in the second calculation of the area of the triangle that S1 is still wrong in doing calculations resulting in wrong answers. Furthermore, in Figure 3, it can be seen that S1 has shown a novelty in working on this problem, namely S1 can provide a different solution from other students by forming two rectangular shapes and a rectangle and a rhombus.

Based on the S1 interview, it was found that S1 could understand the problem, then plan some solutions. Furthermore, S1 has another way of thinking, namely by providing a different solution from the material provided by the teacher. S1 also said that he likes to try to think of solutions that are different from what the teacher has taught. But S1 does not meet the fluency indicator because S1 has not correctly calculated the area of the triangle. However, S1 can understand the problem first, formulate creative ideas, evaluate the ideas, choose and determine which one is the best. Based on the above description, it was found that S1 was included in the creative category (level 3). This is by the opinion [24] that the ability to think creatively can be seen from the various ways they do in analyzing a problem, generating ideas, and deciding which method is appropriate to solve new mathematical situations.

By the opinion [13] that if students provide different solutions (flexibility) and can make new answers (novelty) even though not fluently (fluency). Therefore, according to the results of the answers and interviews that S1 is at a creative level. Thinking at a creative level always shows flexibility.

3.2. Analysis of the answers of subjects who have moderate mathematical logical intelligence (S2)

The result of S2 answer is seen in Figure 4 and Figure 5.

Figure 4 shows that S2 has not been able to provide two solving methods in number 1a (flexibility), namely S2 only calculates one area of the triangle without paying attention to the other triangles, while in 1b has not provided an answer by the command, which is only writing questions without looking for the answer (fluency). In this job, it requires creativity in providing various answers and correct solutions. Furthermore, Figure 5 shows that S2 has provided the answer for the first method which is not correct because there is a miscalculation, but the second method S2 is correct by combining the triangle into a square and producing the correct answer.

According to the results of the interview that had been conducted, S2 did not understand the problem, namely related to the flexibility indicator, S2 experienced confusion in combining the two shapes into several other shapes. Furthermore, S2 has not been able to solve problems related to fluency indicators, namely students have not been able to understand the purpose of the problem and only answer without looking back at the problem. However, S2 was able to think of new things that were different from other students, namely being able to provide spatial shapes that were rarely known to other students, being able to manage numbers and carry out systematic calculations correctly. Tatag’s opinion that this S2 is at a fairly creative level, namely students do not meet the flexibility or fluency aspects but have provided a new solution [13]. So, it can be said that S2 is at level 2 (quite creative).

3.3. Analysis of the answers of subjects who have low mathematical logical intelligence (S3)
The result of S3 answer is seen in Figure 6 and Figure 7.

Figure 6 shows that S3 in number 1a only provides one solution and it is not correct because it should count two triangles but S3 only counts one triangle and produces the wrong answer, while for number 1b that S1 also has not been able to provide alternative answers that vary correctly just write down the question without finding a solution (fluency). Furthermore, for number 2 (figure 7), S3 is only able to show one way of solving it with work that has not been completed and has not shown novelty in answering it.

After conducting interviews, it was found that S3 has not been able to understand the problem and plan several other alternative solutions. S3 has not been able to understand the problem related to the flexibility indicator, which is still having difficulty finding several alternative solutions to answer questions ranging from combining several shapes into one new shape to performing calculations correctly. S3 has not been able to solve problems related to fluency, it only provides makeshift answers without thinking of solutions. Also, it is related to the novelty indicator that S3 is still doing what the teacher has taught and has not been able to think of new things that are different from other students. The results of tests and interviews that have been carried out, then S3 does not meet the aspects of fluency, flexibility, and novelty so this subject gets to level 0 (not creative). This result is by the statement [13] which states that students who have an uncreative level to give new answers (novelty) with different solutions (flexibility) and are not fluent in giving varied answers (fluency).

The characteristics of the level of creative thinking skills as shown in Table 3 contain different criteria for each level. The difference lies in the creative thinking aspect which consists of fluency, flexibility, and novelty in solving problems.

| Subject | Creative Thinking Indicators | Creative Thinking Level |
|---------|-------------------------------|-------------------------|
|         | Fluency                       | Flexibility             | Novelty                  |
| S1      | Students are not able to provide answers smoothly and correctly | Students can provide more than two different solutions | Students can provide more than two ways of solving which are new | 3 Creative |
| S2      | Students can provide answers smoothly and correctly | Students have not given more than two different solutions | Students have not provided a solution which is something new | 2 Quite Creative |
| S3      | Students cannot give answers smoothly and correctly | Students cannot provide two different completion events | Students cannot come up with new solutions | 0 Not Creative |

**Figure 6.** The results of the S3 answer to question number 1 with fluency and flexibility indicators.

**Figure 7.** The results of the S3 answer to question number 2 with novelty indicators.
4. Conclusion and Suggestion
Based on the results of research conducted from 32 students of class VIII, it was found that 10 students have high mathematical logical intelligence (31%), 12 students have moderate mathematical logical intelligence (38%), and 10 students have low mathematical logical intelligence (31%). So, it can be concluded that students who have high mathematical logical intelligence are at level 3 (creative) thinking. Students who have mathematical logical intelligence are at level 2 creative thinking (creative enough) and students who have low mathematical logical intelligence are at level 0 (not creative). Researchers provide suggestions for further research using quantitative research which says the higher the mathematical logical intelligence of students, the more creative students will be.

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