Mathematical creative thinking ability of junior high school students’ on polyhedron

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Abstract. Mathematical creative thinking ability is an important component that must be possessed by students because the problems in modern times are very difficult and require a high level of problem solving. The aims of this research is to illustrate and analyze the mathematical creative thinking ability of junior high school students in polyhedron topic. This research used a qualitative descriptive research approach and case study research design. Data collection techniques used in the form of written tests and interviews. The subjects was chosen from 35 students’ of class VIII in MTsN 1 Kota Serang in the academic year 2019/2020. This research used inductive data analysis techniques, the steps in analyzing data include: data reduction, data display, conclusions drawing and verification. The results showed the students’ mathematical creative thinking ability on polyhedron was in the medium category with a percentage in the high category 14%, medium category 69%, and low category 17%. The percentage of mathematical creative thinking ability based on aspects shows the aspect of originality 59%, fluency 61%, flexibility 62%, and elaboration 75%.

1. Introduction
Creative thinking can be interpreted as a combination of logical thinking and divergent thinking based on intuition but it has a purpose [1]. Besides creative thinking is defined as a variety of expressions, and consists of four main components: fluency, flexibility, originality, and elaboration [2].

The importance of mathematical creative thinking to optimize the ability of 4C (critical thinking, Communication, Collaboration, and Creativity). That is because the problems in modern times are very difficult and require a high level of problem solving [3]. Creative abilities makes the next generation not only develop their behavior but also to improve their intuition and ideas that needed to solve the next problems. In learning mathematics, creativity is an important skill and needs to be improved. Because it can make students solve the complex problems to provide high quality learning [4]. Creative learning is a necessity and the objective of improving the quality of education [5]. Furthermore, the development of students' creative thinking skills is considered important in the educational revolution [6].

On the other hand on this creative thinking research under the title of "Analysis of Mathematical Creative Thinking Ability of Junior High School Students in Mathematical Modeling" shows students' creative thinking abilities on the aspect of fluency by 79% giving correct answers and 21% of students
giving incomplete answers. In the aspect of flexibility, 50% can solve by answers the two solutions, 43% of students solve problems in one solution and 7% don't find solutions. In the aspect of originality, 57% of students can find unique answers while 43% use commonly used answers. Based on these results, some students in the high category can solve problems appropriately, while students in the medium and low categories have difficulty in solving mathematical modeling problems [7].

Furthermore, research on "Mathematical Creative Thinking and Difficulties of Middle School Students in Resolving Geometry Problems Viewed from Gender Aspect" shows the ability of Students Masculine (SMM) they solved three answers from four problems that were given. In the aspect of fluency, some SMM gives wrong answers and they did not write the formula to solve the problem. In the aspect of originality, some SMM of confusion. The didn’t know what kind of method that can they used to calculate without using the usual formula. In the aspect of elaboration, some SMMs have difficulty in detailing the information provided. While the SMM flexibility aspect does not answer the problem completely because the problem given looks complicated and is different from the problems encountered normally. Overall students' difficulties in solving geometry problems are influenced by several factors such as lack of experience, understanding, and practice questions [8].

Based on the research above, each research has different results and problems in measuring students' mathematical creative thinking abilities. This is influenced by the variety of abilities of each student is different. Either of their understanding related to the material, a talented student in mathematics, learning environment, or their interest in learning, and experience working on high order thinking.

This research will measure students' mathematical creative thinking abilities based on aspects of originality, fluency, flexibility, and elaboration in the polyhedron topic. The importance of mathematical creative thinking ability on polyhedron topic because students need the power of reasoning and authenticity of thinking in solving problems. Besides, polyhedron material is part of the geometry material that needs to be learned because it can train the ability to think logically, systematically, and turn on creativity in developing innovation [9].

2. Methods
This research used a qualitative descriptive and case study design to explain the results of students' mathematical creative thinking abilities in polyhedron topic. The research subjects consisted of 35 students class VIII MTsN 1 Kota Serang. Research instruments include written tests that can measure aspects of mathematical creative thinking and interview guidelines. Data collection by provide essay tests of creative thinking ability and interviews. The research instrument was validated by three mathematicians.

This research uses inductive data analysis techniques which are a way to find patterns and meaning data so that it can be accepted by the public regarding the phenomena under investigation and analysis [10]. The steps in analyzing data include: Data Reduction, Data Display, Conclusions Drawing and Verification.

For data mathematical creative thinking abilities students use the following formula;

\[
v = \frac{\text{score}}{\text{maximum score}} \times 100\%
\] (1)

3. Result and Discussion
3.1. Mathematical Creative Thinking Ability
Mathematical creative thinking ability expect students to make various ways or solutions in answering the given problem [11]. The character of students in mathematical creative thinking can be seen from the level of students' ability to solve problems based on aspects of creative thinking ability. According to mathematicians, there are four aspects of mathematical creative thinking abilities that include aspects of originality, fluency, flexibility, and elaboration. This research analyzed 35 answers to mathematical creative thinking abilities on polyhedron. The following is a recapitulation of answers based on aspects of mathematical creative thinking.
Table 1. Student Scores Based on Mathematical Creative Thinking Aspects

| No. | The aspect of creative thinking | Scores | Ideal Scores | Average |
|-----|---------------------------------|--------|--------------|---------|
| 1   | Originality                     | 0      | 10           | 6       | 4       | 2.23    |
| 2   | Fluency                         | 3      | 4            | 16      | 8       | 4       | 2.63    |
| 3   | Flexibility                     | 1      | 3            | 20      | 7       | 4       | 2.28    |
| 4   | Elaboration                     | 1      | 2            | 9       | 15      | 8       | 4       | 2.77    |

Table 1 shows the number of students who answered the mathematical creative thinking test according to the scores obtained and converted to grades in the range 0-16. For the following categories, students' mathematical creative thinking abilities are presented in Table 2.

Table 2. The Category of Mathematical Creative Thinking Abilities

| Category Determination | Criteria          | Category | Student | Percentage |
|------------------------|-------------------|----------|---------|------------|
| Scores ≥ Mean + SD     | Score ≥ 12,61     | High     | 5       | 14%        |
| Mean – SD ≤ Scores < Mean + SD | 7,22 ≤ Score < 12,61 | Medium   | 24      | 69%        |
| Scores < Mean - SD     | Score < 7,22      | Low      | 6       | 17%        |

Table 2 shows that the mathematical creative thinking ability in the high category is 14%, the medium category is 69%, and the low category is 17%. Overall students are in the category of medium creative thinking. Based on the results of interviews with mathematics teachers, 5 students in the high mathematical creative thinking category are students with high ability in mathematics and are often the school's representative for math competitions. This is in line with research that says a significant correlation between students' creative thinking and their learning achievement [12]. Then 24 students in the medium category match their abilities in mathematics, while 6 students in the low category have poor abilities in mathematics.

3.2. discussion

The results showed the creative thinking ability of students in the high category could complete the overall test with a percentage of 92%. The difficulties of students in the high category were included difficulty in drawing of polyhedron sketches and a lack of confidence to answer given. On the other side, the category of medium. Students’ can complete the 60% creative thinking test. The causes was included in their understanding of the direction of the questions, misunderstanding of information, and also the difficulty to describe of polyhedron sketch, and the last it because of lack of confidence to answer. Meanwhile, the percentage of students' creative thinking abilities in the low category was 41%. It because they did not understand the instruction of the questions, and they have difficulty to describe of polyhedron sketches, misunderstanding information, not yet accustomed to dealing with problems with unknown elements, unable to manipulate formulas to find one of the elements, hurry in solving problems and lack of confidence with the answers obtained. This is in line with research that says a students with high ability in mathematics succeed in understanding problems, bringing up ideas, and making steps in problem solving, can solve problems fluently and systematically and also in a detailed, and structured manner, and they may use some strategies of solutions. Students with medium category have some difficulties in understanding problems, difficult in raising ideas and making solutions in a detailed, structured and systematic. Students with low categories seem to have some difficulties in understanding problems. Their ideas in making steps of the solution are trial-and-error in nature, don’t make use of clear rules and manners. They were also difficult in determining strategies [13].

In addition, there will be discussed about students' creative thinking abilities based on aspects of mathematical creative thinking. In the aspect of originality, students are asked to make two problems about the diagonal area of a cube and solve them. The test results show that the ability of high category
students answered 95% by giving two problems about the diagonal area of the cube area through the correct process and calculation, but 5% gave the wrong answer because there was an error in determining the side of the cube. The ability of students in the category is to answer 51% appropriate to the problem instructions, while 49% giving wrong answers such as errors in one solution, answering by counting the number of sides of the cube, and calculating the volume of the cube. While the low category students gave answers according to instructions as much as 29% and 71% did not answer this problem because to determine the diagonal area of the field required side of the cube while it can be obtained through the information contained in the problem. This happens because students in the low category misunderstand information, are not accustomed to problems with unknown elements, and are not accustomed to solving high order thinking. This is in line with research that says that the ability of students to identify the adequacy of the data on the questions is still low so they cannot solve the questions [14].

Mathematical creative thinking ability on the aspect fluency ask students to find a variety of ideas in solving problems related to the concept of a cube so that it can produce a variety of answers. The results showed the high category students answered 90% by finding gift sizes that could be wrapped through the process of completion and correct calculation while 10% gave answers in the wrong way. Medium category students can find gift sizes according to instructions as much as 71% but 29% give incorrect answers because there are errors using formulas and misunderstand information. In the low category students, only 25% of students could find the gift size correctly and 75% could not solve the problem. Here are presented tests of creative thinking aspects of fluency and students’ answers in the high, medium, and low categories.

2. **Firas will use 90 cm x 40 dm of paper to wrap the gifts in cubes.**

**What size gifts can you wrap but no wrapping paper left?**

| Figure 1. Test of mathematical creative thinking ability on the fluency aspect |
|---|
| In english |
| Number 2 |
| Noted that: Paper surface area = l x w |
| = 90 dm x 40 dm = 3600 dm² |
| Asked: what size gifts can you wrap but no wrapping paper left |
| Answer: can be as much ….. if the size…. |
| a) 6 gifts if the size = 10 dm |
| The surface area of cube |
| = (10 dm x 10 dm) x 6 = 600 dm² |
| = 3600 |
| = 6 gifts |
| b) 150 gifts if the size = 2 dm |
| = (2 dm x 2 dm) x 6 = 24 dm² |
| = 3600 |
| = 150 gifts |
| c) 24 gifts if the size = 5 dm |
| = (5 dm x 5 dm) x 6 = 150 dm² |
| = 3600 |
| = 24 gifts |
| d) 600 gifts if the size = 1 dm |
| = (1 dm x 1 dm) x 6 = 6 dm² |
| = 3600 |
| = 600 gifts |

| Figure 2. Mathematical creative thinking test answers in high categories |

Based on figure 2, the highest category of students can solve problems in the fluency aspect by affixing information that is known and asked. And then, looking for gift sizes that can be wrapped by calculating the area of the gift paper and dividing it by the size of the area of the cube-shaped gift until
it has nothing left. High category students get 4 different gift sizes with the correct calculation despite having difficulty in matching the size they get. In general, this is in line with research that says a students with high category can find the correct solution on the fluency aspect.

In english
Number 2
Noted that: Paper surface area = l x w = 90 dm x 40 dm = 3600 dm²
Asked: The surface area of cube?

Solution 1
The surface area of cube = 6 x s x s
3600 = 6 x s²
6 x 600 = 6 x s²
s = 10
6 gifts if the size = 10 dm
The surface area of cube = 6 x s x s
3600 = 6 x s²
24 x 150 = 6 x s²
5² = s²
s = 5
24 gifts if the size = 5 dm

Figure 3. Mathematical creative thinking test answers in medium categories

Figure 3 shows a category student being able to solve a problem by giving them two correct gift sizes. But there is a mistake in the second way where rectangular gift paper is divided into several sizes to wrap a cube-shaped gift so this method is wrong.

In english
Number 2
Noted that: long = 90 dm = 900 cm
weigh = 40 dm = 400 cm
Answer:
The surface area of cube = 900 x 400 = 360.000 cm²

Figure 4. Mathematical creative thinking test answers in low categories
Figure 4 shows the ability of low category students to solve problems by finding several measures but using the wrong formula. Based on the results of the interview, this happened because they did not understand the sentences and information contained in the problem and were wrong in using the formula. By giving two correct gift sizes.

Mathematical creative thinking ability on the aspect flexibility ask students to solve problems related to the concept of volume using a variety of different solutions. The results showed students in the high category could solve these problems 90%. Some students find three different solutions to find the overall wake volume despite the difficulty in drawing the figure. While 10% give a wrong answer because it does not provide information to find the overall wake up the volume. 54% of students in the category are finding two different solutions to find the overall volume of builds but 46% give answers in the right solution and some students are wrong in finding the volume because some shapes are not counted but have the right answer. While students with low categories can solve the problem 41% by finding the overall wake volume and 59% giving incorrect answers because the problem is not solved completely so that it does not get the overall wake up the volume. Based on the interview this happened because of an error in understanding the purpose of the problem, difficulty in making sketches, and not confident about the answers given. In this problem, the average student has difficulty in making sketches to build space to get the overall wake up the volume. This is in line with research that says a difficulty in identifying images is a common problem solving problems regarding geometry material [15].

Mathematical creative thinking ability on the aspect elaboration ask students to elaborate problems related to the concept of beam volume where students are given two questions, namely making chocolate sketches and counting the amount of chocolate. The results showed that 95% of high category students could solve the problem in detail by sketching chocolate and counting the amount of chocolate. While 5% give a wrong answer because there is an error in writing the formula. Students in the category were solving problems correctly by 65% and 35% gave incorrect answers. A similar percentage was obtained by students in the low category by solving problems of 67% and 33% giving incorrect answers. The error of the answer is seen when some students can count the amount of chocolate, but the answer does not match the sketch of chocolate that is described, other than that an error in using the formula causes the results of the answers are not correct in solving problems. Problems that are experienced in the medium and low categories are the lack of understanding of the problem, using the formula incorrectly and a hurry to answer because it is running out of time. This is in line with research that says a students with low categories seem to have some difficulties in understanding problems, don’t make use of clear rules and manners, were also difficult in determining strategies [13].

4. Conclusion

The results showed the ability of students at high by 14%, medium 69%, and a low 17%. Overall students’ creative thinking skills are in the medium category. The ability to think creatively based on aspects shows the aspect of originality students can solve problems with a percentage of 59%, fluency 61%, flexibility 62%, and elaboration 75%. The causes by students did not understand about the direction of the question, they also have difficulty to describe sketches of space, misunderstanding information, not accustomed yet to problems containing unknown elements, unable to manipulate the formula to find one of the elements, and also the students in a hurry to solve the problems and the last it causes by lack of confidence in the giving answer. This study has limited scope of the material being tested is still narrow and only looks at mathematical creative thinking based on aspects of originality, fluency, flexibility, and elaboration. Future studies can choose other mathematical material to measure students’ mathematical creative thinking abilities.

5. References

[1] Pehnoken E 1997 The State-of-Art in Mathematical Creativity.[Online] Zentralblatt für Didaktik der Mathematik (ZDM) The International Journal on Mathematics Education.

[2] Cotton K 1991 Teaching Thinking Skills,[online] Northwest Regional Educational Laboratory, School Improvement Research Series.
[3] Maharani HR 2014 Creative thinking in mathematics: Are we able to solve mathematical problems in a variety of way InInternational Conference on Mathematics, Science, and Education.
[4] Kattou M, Kontoyianni K, Pitta-Pantazi D, Christou C 2013 Connecting mathematical creativity to mathematical ability Zdm 45 2 167-81.
[5] Yen TS, Halili SH 2015 Effective teaching of higher order thinking (HOT) in education The Online Journal of Distance Education and e-Learning 3 2 41-7.
[6] Hwang WY, Chen NS, Dung JJ, Yang YL 2007 Multiple representation skills and creativity effects on mathematical problem solving using a multimedia whiteboard system Journal of Educational Technology & Society 10 2 191-212.
[7] Iqbal, R 2019 Analisis Kemampuan Berpikir Kreatif Matematis Siswa Sekolah Menengah Pertama dalam Pemodelan Matematis Repository UPI
[8] Sahliawati, M 2019 Berpikir Kreatif Matematis dan Kesulitan Siswa SMP dalam Menyelesaikan Masalah Geometri Ditinjau dari Aspek Gender Repositori UPI
[9] Fiqri, C. I. A, Gatot, M, Qohar. A. Studi Kasalahan Siswa Dalam Menyelesaikan Soal Luas Permukaan Dan Volume Bangun Ruang Sisi Datar Di Smp.c
[10] Moleong. Lexy J 2005 Metodologi penelitian kualitatif Bandung: Remaja Rosdakarya
[11] Aziz A, Kusmayadi TA, Sujadi I 2014 Proses Berpikir Kreatif dalam Pemecahan Masalah Matematika Ditinjau dari Tipe Kepribadian Dimensi Myer-Briggs Siswa Kelas VIII Mts Nw Suralaga Lombok Timur Tahun Pelajaran 2013/2014 Jurnal Pemelajaran Matematika 2 10.
[12] Anwar MN, Aness M, Khizar A, Naseer M, Muhammad G 2012 Relationship of creative thinking with the academic achievements of secondary school students International Interdisciplinary Journal of Education 1 3 44-7.
[13] Lisdiani, D 2019 Proses Berpikir Kreatif Matematis Siswa yang Mengikuti Model Pembelajaran Creative Problem Solving Repository UPI
[14] Putra HD, Putri A, Lathifah AN, Mustika CZ 2018 Kemampuan Mengidentifikasi Kecukupan Data pada Masalah Matematika dan Self-Efficacy Siswa MTs JNPM (Jurnal Nasional Pendidikan Matematika) 2 1 48-61.
[15] Puspitasari L, In'am A, Syaifuddin M 2018 Analysis of Students’ Creative Thinking in Solving Arithmetic Problems International Electronic Journal of Mathematics Education 14 1 49-60.

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