Students’ difficulties in solving mathematical creative thinking problems on derivative application

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Abstract. This study aims to analyze the difficulties experienced by students in solving mathematical creative thinking problems. Twenty six students at the eleventh grade of Mathematics and Natural Sciences program in a senior high school in Tasikmalaya were involved as research subjects. The research method used in this study was descriptive qualitative in order to describe the difficulties experienced by students in solving creative thinking problems on the topic of derivative application. Problems that are designed refer to mathematical creative thinking indicators including fluency, flexibility, elaboration and originality. The results of the study concluded as follows (1) on the fluency indicator, the majority of students had smoothly applied the concept of function derivatives so that no difficulties were identified, (2) on the flexibility indicator, students difficulties applying other concepts as a different way, (3) on the elaboration indicator, students difficulties in constructing the formulas used and (4) on the originality indicator, students difficulties in representing the shape of images into mathematical equations.

1. Introduction
Mathematics as a science is very essential and important for students to learn. Mathematics is one branch of science that plays an important role for the development of science and technology, both as a tool in the application of other fields of science and in the development of mathematics itself [1]. In addition, mathematics can increase students’ thinking potential in the learning process and in understanding cause and effect [2]. The development of the potential of thinking can certainly be enabled so that students are able to deal with the current conditions related to technology and science that are increasingly advanced and developed. Therefore, learning mathematics gives a very positive influence on increasing the potential of students, especially in the formation of thinking patterns.

Creative thinking is one of the abilities that can be developed through mathematics learning. Creative thinking as a problem solving that offers the possibility of producing more than one solution path of answers or correct answers at various levels of quality solutions to solve a given problem [3]. Creative thinking as a process used by someone in developing new ideas, panning and applying them to a new product smoothly and flexibly [4]. This emphasizes that through the ability to think creatively students can solve every problem they face in everyday life effectively and efficiently. Therefore, students need to be accustomed to solving problems that can bring up their creative ideas. There are four indicators of creativity that can be measured, namely 1) fluency as the ability to generate a large number of ideas; 2)
flexibility as the ability to generate ideas from various categories or approaches; 3) elaboration as the ability to develop ideas and produce them in detail; 4) originality as the ability to produce unusual ideas [5,6]. Therefore the four indicators can be used as a reference by the teachers in compiling issues about creative thinking.

One of the problems to measure students’ creative thinking abilities is on function derivatives that is one of the topics studied at the senior high school level. Derivative functions are new functions formed from the functions given [7]. Function derivatives material is quite complex to be learned because there are many mathematical concepts that can be associated with it. Therefore, it does not rule out the possibility that students have difficulty in solving problems related to function derivatives. One difficulty that arises is the difficulty of students to make the relationship between graphs derived function and original function [7].

The difficulties experienced by the students certainly need to be analyzed further so that student achievement can increase. Problems that can be designed from the concept of derivative functions are quite diverse, such as the tangent equation on a curve, the interval of a function up or down, the maximum value and the minimum value. In measuring the ability to think creatively on derivative of function material, the designed problems are truly related to daily life that leads to the concept of maximum value and minimum value.

2. Methods
This research was designed by using qualitative descriptive research. Qualitative research methods were chosen to analyze each difficulty experienced by students in solving mathematical creative thinking problems. The subjects of this study were 26 students in 11th grade Mathematics and Natural Sciences in a senior high school in Tasikmalaya in the academic year 2019/2020. The research instruments in this study were creative thinking tests and interview guidelines. The creative thinking test questions are presented in Table 1 below.

| No | Indicator | Test Question |
|----|-----------|---------------|
| 1  | Fluency   | Mr. Firman will renovate his office room. The renovation activities can be completed in x days with the project cost stated by function \( B(x) = x (2x - 180 + \frac{6300}{x}) \) (in thousand rupiahs). What is the minimum cost for completing the work? Bring up your idea! |
| 2  | Flexibility | Uncle has a rectangular garden with a circumference \((2x + 20)\) meters and width \((6 - x)\) meters. What is the length and width of the garden so that it has maximum area? Use more than one way! |
| 3  | Elaboration | The sister will coat the outside of a block without a lid using \(8 \times 8 \) cm paper. The beam has a length \((p)\) equal to width \((l)\). The volume of beams to be coated is \(2048 \) cm\(^3\). If the minimum beam surface area and the entire beam surface are coated without gaps, then how much paper do need? Explain in detail! |
| 4  | Originality | Mr. Andi has 180 meters of wire. The wire will be used to form a frame as shown below. What is the value of \(x\) for maximum area? |

![Diagram of a frame made from wire]

What is the value of \(x\) for maximum area?
3. Result and Discussion
To find out the difficulties experienced by each student so that it can be generalized so the analysis of students’ creative thinking test results is divided into three categories of students’ creative thinking namely high creative thinking (S-1), medium creative thinking (S-2) and low creative thinking (S-3). Therefore, the findings obtained can provide detailed information about each difficulty experienced by students in solving creative thinking problems.

3.1. Mathematical Creative Thinking Test Result
Creative thinking test results aim to provide an overview of each students’ category of creative thinking abilities. The results of the calculation of creative thinking tests are shown in Table 2 below.

| No | Category | Frequency | Percentage |
|----|----------|-----------|------------|
| 1  | High     | 3         | 12%        |
| 2  | Medium   | 18        | 69%        |
| 3  | Low      | 5         | 19%        |

Table 2 shows that students’ creative thinking abilities still need to be further developed. This indicates that there are still difficulties experienced by students in solving mathematical creative thinking problems. Therefore, students need guidance and the role of teachers who are more active in developing their creative thinking abilities. The ability to think creatively must be trained and developed by teachers in their learning activities in the classroom [8]. The Efforts to improve creative thinking must supported by the efforts in improving the quality of teaching [9]. The condition of student learning environment also needs to be considered so that each learning activity can support the ability to think. Developing creative ideas is always related to what one has received from the results of interacting with others [10].

3.2. Analysis of the answer to question number 1
This problem requires students to generate a number of ideas in solving creative thinking problems especially smoothly applying the concept of the first derivative of function to the problem. The detailed answers to each category of creative thinking are shown in Figure 1 below.

| Answers of S-1 | Answers of S-2 | Answers of S-3 |
|----------------|----------------|---------------|

In Figure 1 it can be seen that S-1 students are able to solve problems by applying the concept of derivative of functions smoothly and getting final answers. The completion step taken by S-1 students is by first simplifying the equation and using the concept of derivative \( B'(x) = 0 \) to find the value of \( x \) then substituted into the previous equation to get the minimum value sought. The completion step done...
by the S-2 students is almost the same as the S-1 students, which is to simplify the equation then perform the calculation process using the concept of a derivative of functions. S-3 students’ answers have quite different completion. S-3 students’ steps using the concept of quadratic equation. The concept of quadratic equations leads to a turning point namely \((-\frac{b}{2a}, -\frac{D}{4a})\). The ideas used by S-1, S-2 and S-3 students in the first problem are in accordance with the core problem. Although there are differences in the completion steps but the final results obtained lead to the correct answer. These results are in line with Apriliani’s research [11] which found that students only reach indicator of fluency out of the aspects of creative thinking. Based on the description, the first problem is not identified the difficulties experienced by students.

3.3. Analysis of the answer to question number 2
The second problem is adjusted with the flexibility indicator. This problem requires students to use more than one way to solve problems related to the area of flat shapes using the concept of function derivatives. The answer to the second problem is shown in Figure 2 below.

![Figure 2. Students’ answers to the second problem](image)

Figure 2 shows that S-1 students did the problem solving process correctly and appropriately and has understood the core problem. The concept of derivative of functions has been well applied to the mathematical models which were used to solve the problems. Therefore, S-1 students were able to answer the questions correctly. It is quite different from the answers written by S-2 students which had a similar solving process, but it does not lead to the right answer. In the S-3 students’ answer, the completion steps were done almost the same as S-1 and S-2 students, but the answers written did not lead to the core problem. If it is analysed further, students of S-1, S-2 and S-3 only use the step of completion in one way which is still included in the common way that is constructs mathematical models and then broke them down into simpler quadratic equations. It shows that students’ was still lack in understanding of derivative of functions. If the basic concepts of function derivatives have not been understood by students as a whole, students will not know the application, formulas and their meaning of it [7]. Students can develop and demonstrate mathematical thinking habits in a way that is right from their initial experience with mathematics [12].

3.4. Analysis of the answer to question number 3
The third problem refers to the elaboration indicator. The problem designed is to measure the ability of students in detailing each step of the completion by using several concepts that are relevant to the problem. The designed problem was of course related of the build flat side space that had been studied previously. Therefore students need to use ideas and concepts that have been studied previously that are related to the concepts being studied to solve this problem. A serious problem is when new ideas are not
maximally accommodated [13]. The students’ answers to the third problem were portrayed in Figure 3 as follows.

Based on Figure 3, S-1 students carry out a not detailed completion process. The selection of the beam formula used was correct but the use of the formula to solve the problem was still wrong and it did not show the use concept of derivative of function on the problem. S-2 students did the incorrect completion process. Although the beam formula namely volume and surface area had been used, the formula did not lead to a solution that was relevant to the problem presented. S-3 students provided the solutions which did not lead to the core problem. It showed that the answer were incorrect and the students were not able to use the beam formula that is associated with the concept of function derivatives to solve the problem. Based on these descriptions, the difficulty experienced by students was not being able to construct the formula to solve the problem.

3.5. Analysis of the answer to question number 4

The fourth problem was in accordance with the indicator of originality to measure the use of ideas as the authenticity of itself. The students’ answers to the fourth problem are shown in Figure 4 below.

Based on Figure 4, S-1 students were able to use ideas that were relevant to solve the problem correctly. It indicates that the idea was indeed as an authenticity owned by S-1 students. Unlike the S-2 and S-3 students who worked on the fourth problem, but did not get the correct answer. S-2 and S-3 students were still unsuccessful in determining the number of x and y sides in accordance with the picture in the problem. It indicates that students of S-2 and S-3 had difficulty in representing the picture into mathematical equations. Only S-1 students were able to determine the mathematical equation
according to the picture in the problem shown. The fourth key problem was that it must be precise in determining the number of x and y sides in the circumference. Derivative concepts can be represented through numerical, symbolic and graph representations [14].

3.6. Analysis of Interview Results
Based on the results of interviews with several students representing each category of creative thinking abilities, those difficulties arose because students rarely solved complex problems and were associated with other concepts in daily learning. Students experienced difficulties in solving the problem because they did not yet accustomed to the problem of creative thinking [15]. Therefore, teachers need to design further learning strategies that can develop students’ creative thinking patterns.

4. Conclusion
Based on the analysis results, it can be concluded that the fluency indicator, the students have smoothly applied the concept derivative of function to the problem so that there is no indication of difficulties in this indicator, in the flexibility indicator students have difficulty in applying other concepts to find another way of solving problem, in the elaboration indicator students have difficulty in constructing the formula applied to solve problems and in the originality indicator that students is difficult to represent the form of image into mathematical equations.

5. References
[1] Siagian M D 2016 Kemampuan koneksi matematik dalam pembelajaran matematika MES J. Mat. Educ. Sci. 21 p. 58-57
[2] Sriwongchai A 2015 Developing the Mathematics Learning Management Model for Improving Creative Thinking In Thailand Int. Educ. Stud. 811 p.77
[3] Livne N L and Milgram R M 2005 Creative Thinking in Mathematics in Israeli High School Students Gift. Educ. Int. 202 p. 155-165
[4] Siswono T Y E 2007 Konstruksi Teoritik Tentang Tingkat Berpikir Kreatif Siswa Dalam Matematika J. Pendidikan, Forum Pendidik. dan Ilmu Pengetah. 24 p. 1-10
[5] Guilford J P 1975 Varieties of creative giftedness, their measurement and development Gift. Child Q. 192 p. 107-121
[6] Simsek C L and Kiyici F B 2010 How much science and technology lesson student studying books support creative thinking? Procedia – Soc. Behav. Sci. 22 p. 2105-2110
[7] Orhun N 2012 Graphical Understanding in Mathematics Education: Derivative Functions and Students’ Difficulties Procedia – Soc. Behav. Sci. 55 p. 679-684
[8] Puspitasari L In’am A and Syaifuddin M 2018 Analysis of Students’ Creative Thinking in Solving Arithmetic Problems Int. Electron. J. Math. Educ. 141 p. 49-60
[9] Nuha M A Waluya S B and Junaedi I 2018 Mathematical creative process wallas model in students problem posing with lesson study approach Int. J. Instr. 112 p. 527-538
[10] Sitorus J and Masrayati, 2016 Students’ creative thinking process stages: Implementation of realistic mathematics education Think. Sci. Creat. 22 p. 111-120
[11] Apriliiani L R Suyitno H and Rochmad 2016 Analyze of Mathematical Creative Thinking Ability Based On Math Anxiety in Creative Problem Solving Model with SCAMPER Technique Int. Conf. Math. Sci. Edu. p. 131-141
[12] Handayani A D Herman T Fatimah S Setyowidodo I and Katminingsih Y 2018 Inquiry based learning: A student centered learning to develop mathematical habits of mind J. Phys. Conf. Ser. 10131
[13] Tall D 2002 The Psychology of Advanced Mathematical Thinking Adv. Math. Think. 21 p. 3-21
[14] Desfitri R 2016 In-Service Teachers’ Understanding on the Concept of Limits and Derivatives and the Way They Deliver the Concepts to Their High School Students J. Phys. Conf. Ser. 6931
[15] Hudanagara M A and Anita I W 2018 Analisis Kesulitan Yang Dialami Siswa Smp Pada
Kemampuan Berpikir Kreatif Matematis Pokok Bahasan Segitiga Dan Segiempat J. SILOGISME Kaji. Ilmu Mat. dan Pembelajarannya 3 1 p.14.

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