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Creative Thinking Ability of Junior High School Students in Solving Open-Ended Problems on Plane Geometry

Dicky Ardiansyah[1], Tatag Yuli Eko Siswono[1], Novita Vindri Harini[1], Limalin Heng[2]

[1]Mathematics Education Study Program, Universitas Negeri Surabaya, Surabaya, Indonesia
Email: dicky.23250@mhs.unesa.ac.id
[2]Hun Sen Kampong Cham High School, Krong Kampong Cham, Kamboja

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ABSTRACT

This study aims to analyze the creative thinking abilities of Junior High School students in solving open-ended mathematical problems. Creative thinking ability is an essential aspect of mathematics, particularly when solving problems that require varied solutions. This research employs a descriptive qualitative approach involving five seventh-grade students. Data were collected through open-ended problem-solving tests and interviews. The analysis was conducted by identifying indicators of creative thinking, such as fluency, flexibility, and novelty, based on students' responses. The results show that students' creative thinking abilities vary. Some students were unable to produce multiple different solutions (flexibility). Elaborating on their answers also posed a challenge for 60% of the students. This study provides implications for the development of mathematics learning that emphasizes enhancing students' creative thinking abilities through open-ended problems.

Keywords: *Creative thinking, problem solving, open-ended*

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INTRODUCTION

Mathematics learning at every level of education aims to help students understand concepts and apply them in various situations. This learning is expected to equip students with the ability to think logically, analytically, systematically, critically, and creatively, as well as other mathematical abilities (Depdiknas, 2006). Creative thinking skills are very important in learning mathematics because they allow students to generate various ideas and strategies in solving problems, especially in open-ended problems that have more than one correct solution. Khalid et al. (2020) stated that creative thinking in mathematics includes the ability to see problems from various points of view and produce unconventional solutions. In addition, Pratiwi et al. (2023) emphasized that open-ended problems encourage students to explore various possible solutions and show their potential mathematical creativity. Cahyani et al. (2019) showed that learning with an open-ended approach significantly improved students' mathematical creative thinking ability compared to conventional learning. Therefore, it is important to examine the extent of junior high school students' creative thinking skills in solving open-ended problems, especially on flat building materials, in order to design more effective and meaningful learning.

Santrock (2011) states that thinking is an activity of manipulating and transforming information in memory to form concepts, reason, think critically, make decisions, think creatively, and solve problems. In line with that, He (2017) states that creative thinking is a mental activity that a person uses to build new ideas or ideas. Creative thinking ability itself can be interpreted as a person's ability to place a number of existing objects and combine them into different forms to achieve new goals (Ritter & Mostert, 2017). In the process, the search for various information that supports the understanding of science will greatly help improve creative thinking skills. According to Silver (1997), creative thinking ability can be measured through three main indicators, namely fluency, flexibility, and novelty. *Fluency* refers to the number of ideas or answers that students produce in response to a problem. *Flexibility* refers to the diversity of approaches or solution methods used by students. Meanwhile, *novelty* relates to the originality of ideas or answers produced by students, which are different from the others. Based on these three indicators, creative thinking ability can be classified into five levels, namely level 0 to level 4 (Siswono, 2011). This classification is needed to measure variations in students' creative thinking abilities. This is reinforced by the findings of Benedek et al. (2020) which show that differences in creative thinking abilities can still be found even though students are at the same level. Students are categorized as creative if they have reached level 3 or 4, because at that level students have the potential to find new ideas. The ability to think creatively allows the birth of new findings in the field of science and technology (Ozkan & Topsakal, 2021). Students who have creative thinking skills will try to create new concepts or see things from a different perspective (Awang & Ramly, 2008).

Kholid et al. (2024) stated that students' thinking ability can be identified through solving non-routine problems, namely open-ended problems. This statement is in line with the opinion of Getzel and Jackson (in Silver, 1997) who mentioned that creativity in mathematics can be measured through open-ended questions that allow more than one answer. These types of problems provide space for students to explore various possible answers and solution approaches. Open-ended problems are a type of math problem that allows students to provide more than one correct answer and use various solution strategies (Bingölbali & Bingölbali, 2021; Keh et al., 2016). The problem is designed to encourage students to think creatively, explore various possibilities, and develop higher-order thinking skills. In mathematics learning, the use of open-ended problems is important because it can improve students' creative thinking skills by involving them in exploration, finding valid solutions, and developing new ideas. Students' creativity is needed during the mathematics learning process, especially when solving problems that encourage creative thinking (Sitorus & Masrayati, 2016; Ni'mah & Shodikin, 2022; Rusmana & Shodikin, 2024). They hope that giving open-ended problems can encourage students to find creative new ideas in analyzing and solving problems.

The open-ended problems discussed in this study are related to the material of flat shapes. The selection of this material is based on the fact that flat shapes are introduced since elementary school and studied more deeply in junior high school (Riyeni et al., 2017). This shows that flat shapes are basic materials that have continuity between educational levels. By definition, flat shapes are two-dimensional shapes that have length and width, but no height or thickness (Bribiesca, 1992; Ephraim & Tertsea, 2024). In the junior high school curriculum, especially grade VII, this material is taught with a focus on the concepts of area and perimeter (Riyeni et al., 2017). Although it is a basic material, many students still have difficulty understanding and mastering the concept of flat shapes thoroughly. Riyeni et al. (2017) stated that flat shapes are considered difficult by students, especially in linking geometry concepts with contextual problem solving. Based on this, this study chose flat shapes as a context for developing and analyzing open-ended problems, which are relevant because they can encourage students to develop creative thinking skills through problem solving with various possible answers. This study aims to analyze the creative thinking ability of junior high school students in solving open-ended problems on flat shapes, focusing on three main indicators, namely fluency, flexibility, and novelty. By understanding the variations in students' creative thinking abilities in this context, this research is expected to contribute to the development of mathematics learning models that emphasize the exploration of ideas and creative problem solving. In addition, the results of the study can serve as a foundation for teachers in designing open-ended problem-based learning that not only emphasizes the achievement of the final answer, but also the students' creative thinking process in reaching the solution.

METHODS

This research is a descriptive research using a qualitative approach. The research was conducted by describing and analyzing the results obtained during the research. In this study, the instruments used consists of two types, namely the main instrument and supporting instruments. The main instrument in qualitative research is the researcher himself, who acts as a planner, data collection executor, analyzer, as well as data interpreter (Pezalla et al., 2012). Meanwhile, supporting instruments include open-ended problem solving tests given to students and interview guidelines. Through this combination of instruments, the data collected is expected to provide a comprehensive picture of the process and results of students' creative thinking.

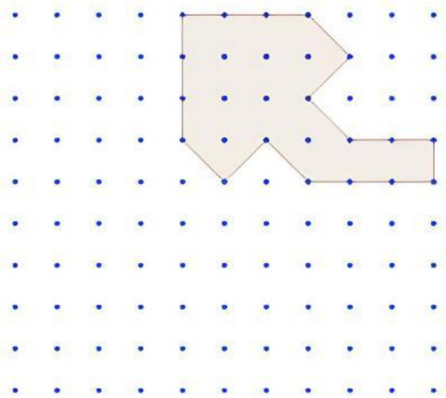
The subjects of this study were five seventh-grade junior high school students. The five students were selected based on their average academic performance at school, consisting of three students with low ability, one student with moderate ability, and one student with high ability. These students were asked to complete an open-ended problem-solving test designed to measure their creative thinking abilities. The students' responses were analyzed based on the indicators of creative thinking adapted from the model developed by Siswono (2011). This analysis resulted in the classification of students' creative thinking abilities into five levels: level 0 (non-creative), level 1 (less creative), level 2 (fairly creative), level 3 (creative), and level 4 (highly creative). Table 1 presents the levels of students' creative thinking abilities as adapted from Siswono (2011).

Tabel 1. Students' thinking ability levels (STAL)

Level	Criteria
Level 4 (Very Creative)	Students can solve *open-ended* problems by showing three indicators of creative thinking, namely *fluency*, *flexibility*, and *novelty*.
Level 3 (Creative)	Students can solve *open-ended* problems by showing two indicators of creative thinking, namely *flexibility* and *fluency* or *novelty* and *fluency*.
Level 2 (Quite Creative)	Students can solve *open-ended* problems by showing one indicator of creative thinking, namely *flexibility* or *novelty*.
Level 1 (Less Creative)	Students can solve *open-ended problems,* but only show one indicator of creative thinking, namely flexibility *fluency*.
Level 0 (Not Creative)	Students are not able to solve *open-ended* problems*,* so no creative thinking indicators were shown.

The *open-ended* problems given to students are as follows:

Problem 1: Look carefully at the picture below



Determine the area of the shape bounded by the red line. Work with at least 2 different strategies (ways)! (*Note: the distance between points is 1 cm*)

Problem 2: Make a combination of 2 different flat shapes whose area is the same as problem 1!

Problem 1 is used to measure *fluency* and *flexibility* indicators because in problem 1 students are asked to answer more than one strategy and allow students to use diverse approaches when answering the problem. While problem 2 is used to measure the *flexibility* and *novelty* indicators because it allows students to use a variety of approaches when working and produces different student answers from the others.

After the test, the researcher conducted in-depth interviews with each student to further explore their thinking processes in solving the problems. Through these interviews, the researcher obtained information about the students' strategies, considerations, and reasoning in choosing their problem-solving approaches, allowing for a deeper understanding of each student's creative thinking ability.

RESULTS AND DISCUSSION

Based on the analysis of students' answers, researchers interpreted the creative thinking aspects of *fluency*, *flexibility*, and *novelty* in Table 2, which contains the calculation results and percentage of each aspect.

Table 2. Percentage of each aspect of students' creative thinking

Aspect	Number of Students	Percentage
Fluency	2	40%
Flexibility	0	0%
Novelty	1	20%

Table 2 shows that the students' average achievement in the fluency aspect of the test reached 40%, indicating that their ability to generate many ideas is very good. In contrast, the other two aspects, flexibility and novelty, only reached 0% and 20%, respectively, indicating that students' ability to produce varied and unique ideas is still relatively low. This is because students tend to stick to one problem-solving method that they consider correct and are not yet accustomed to exploring various alternative solutions. Thus, in this study, the fluency aspect is the most dominant aspect of students' creative thinking ability.

At the next stage, researchers grouped the test results of five students based on the level of creative thinking ability (STAL) according to the previous explanation. From the grouping results, three of the five STAL categories were found, namely STAL 0, STAL 1, and STAL 3. Details of the classification results can be seen in Table 3.

Table 3. Percentage of students' creative thinking ability levels

Aspect	Number of Student	Percentage
STAL 3 (Creative)	1	20%
STAL 1 (Less Creative)	1	20%
STAL 0 (Not Creative)	3	60%

Table 3 shows that the creative thinking skills of the five junior high school students studied are still relatively low. This can be seen from the percentage of students in the STAL 0 category of 60%, which means that more than half of the students have not shown adequate creative thinking skills.

For further analysis, the researcher selected three students who represented each of the STAL categories found. Subject KH was chosen to represent STAL 0, subject SM represented STAL 1, and subject MI represented STAL 3. The results of working on problems in Problem 2 by the three subjects are presented in Figure 1 and Figure 2. The results of working on problem 1 of SM who is at STAL 1 can be seen in Figure 2.

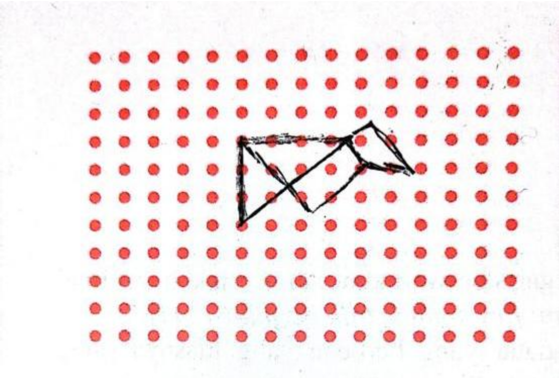


Figure 1. The results of working on problem 2 by MI

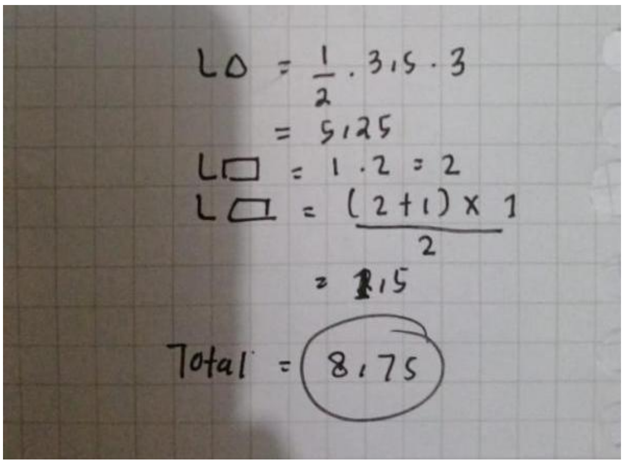


Figure 2. The results of working on problem 1 by MI

Based on the answers described, the subject is able to solve the problem properly and correctly. Thus, the subject showed achievement in two aspects of creative thinking, namely *fluency* and *novelty*. This finding is in line with Silver's opinion (1997) which states that *flexibility* refers to the diversity of approaches or methods of solution used by students, while *novelty* is related to the originality of the ideas or answers produced. This is reinforced by the results of the interview between the researcher (P) and the subject (MI).

P : " How did you do number 2?"
MI : "First, make sure you have answered problem 1 correctly, then we just have to try the combination of flat buildings whose area is the same as problem 1."
P : "Why did you choose that combination of flat shapes?"
MI : "Because in problem 1 there is a combination of rectangle, triangle and trapezoid. So I tried to make the same thing first but with a different arrangement and size of each flat shape."
P : "Can you make a combination of flat shapes other than that?"
MI : "I can, but it takes a little longer."

Based on these findings, the SM subject is categorized as being at Creative Thinking Ability Level (STAL) 2. This classification is in accordance with the opinion of Siswono (2011), which states that students who are able to solve *open-ended* problems, but only show one indicator of creative thinking such as *fluency*, are included in the category of students with low levels of creativity. The results of working on problem 1 by SM who is at STAL 0 can be seen in Figure 3.

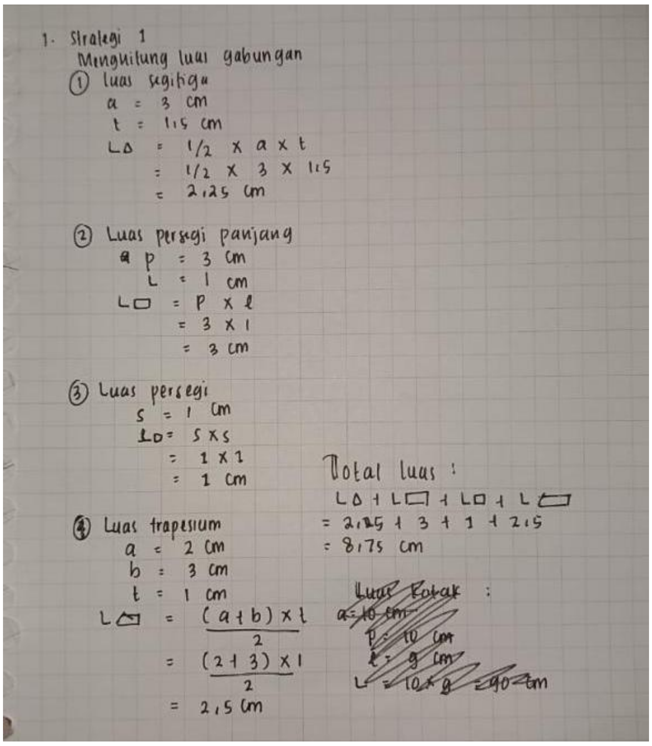


Figure 3. The results of working on problem 1 by SM

Based on the answers described, the subject already understands one of the strategies in solving the problem, namely by dividing the flat shape into several parts and calculating the area of each using the appropriate formula. However, the subject only used one strategy in working on the problem. Therefore, it can be concluded that the SM subject only achieved one aspect of creative thinking, namely *fluency*. This statement is in line with Silver (1997) who states that *fluency* refers to the number of ideas or answers that students produce in responding to a problem. This finding is also supported by the results of the interview between the researcher (P) and the subject (SM).

P : "*Why did you use that method to answer?*"
SM : "*Because it is the easiest way to use, from the question it is already visible, just separate it and then calculate the area of each.*"
P : "*Do you know any other strategy to answer that question?*"
SM : "*I don't know, I think that's the only way to answer.*"

The interview results show that students understand how to do the problem correctly but are only able to use one strategy in solving it. This is in line with the opinion of Siswono (2011) who states that students who are able to solve *open- ended* problems but only show one indicator of creative thinking, namely *fluency*, can be categorized as less creative. The results of working on problem 1 by MF who was at STAL 0 can be seen in Figure 4.

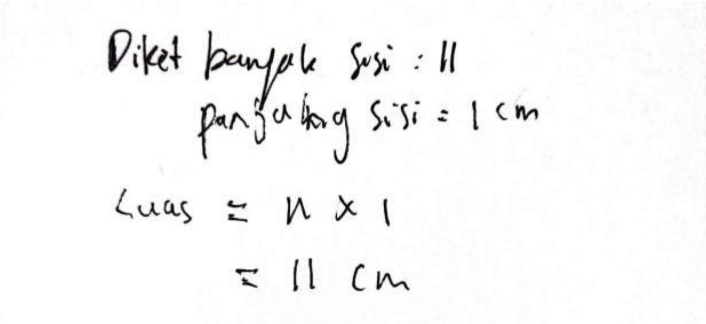


Figure 4. Results of working on problem 1 by KH

Based on the answers described, it can be seen that the subject did not understand the problem well. Subject MF thought that the flat shape in the problem was an 11-sided flat shape because it has 11 sides. And MF thought that the distance between points was the length of the side, so MF multiplied the number of sides by 1 cm and produced the wrong answer. So it can be concluded that MF did not achieve all three aspects of creative thinking. This is reinforced by the results of the interview.

P : "*Why do you consider the flat shape in the 11-sided problem?*"
MF : "*Because the flat shape in the problem has 11 sides.*"
P : "*If it's 11 sides, how long is each side?*"
MF : "*1 cm, according to the question.*"
P : "*That's the distance between points, not the length of each side.*"
MF : "*Yes.*"

The interview results show that MF has not been able to understand the problem well and answer the question correctly. From the interview, it was found that MF was at STAL 0 which is in line with Siswono's (2011) when students are unable to solve *open-ended* problems, so that no creative thinking indicators are shown, it can be said that they are not creative.

CONCLUSION

Based on the results of the study, it can be concluded that the creative thinking ability of junior high school students in solving open-ended problems on flat building material is still relatively low and needs more serious attention. From a total of five students who became the research sample, 60% of students were at the level 0 creative thinking ability or can be said to be uncreative, while 20% of students showed ability at level 1 which is still classified as less creative, and only 20% of students managed to reach level 3, which is the creative category. When viewed based on the aspects of creative thinking ability, the aspects of fluency is the most prominent with 40% of students able to produce fluent and diverse answers, but the flexibility aspect has not been achieved by any student at all, while the novelty aspect has only been achieved by 20% of students. This data shows that although some students have been able to think creatively in terms of fluency, in general, students' creative thinking abilities, especially in the aspects of flexibility and novelty, are still very lacking and need to be developed intensively through learning methods that emphasize the use of open-ended problems that encourage students to innovate and think outside standard patterns. Thus, the development of learning strategies that can improve these three aspects of creative thinking is very important to support the quality of mathematics education at the junior high school level.

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