Creative thinking in mathematics: The capacity of vocational school students

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Abstract. Creative thinking is the capacity to generate ideas and new ideas. For vocational students, creative thinking is a basis for applying knowledge in their fields. Preliminary studies demonstrate that students experience difficulties in solving geometry and other problems that require creative thinking. This study aims to analyze students' creative thinking ability and the factors that influence it. This qualitative research was conducted at SMK (Vocational School) Negeri 1 Panga Aceh Jaya. It involved 113 students in answering the tests, in which six of them were selected to be interviewed. The research instruments were creative thinking tests and interviews. Data were analyzed descriptively. The results showed that 47.79% of students fulfilled the fluency indicator, while 49.78% met the originality indicator. The interview demonstrated that the lack of capacity was due to poor ability of fluent thinking. Students could not generate various or new ideas; therefore, they had difficulties reaching the originality level. Based on these findings, it is recommended to provide students with tasks or activities to develop their creative thinking skills.

1. Introduction

Knowledge and creative thinking are critical in mathematics education. This is consistent with one of the objectives of mathematics learning as stated in the 2013 curriculum, i.e., preparing Indonesian students to have the capacity to live as creative individuals and citizens [1]. Furthermore, the National Education Association (NEA) [2] stated that every student must have four skills in the 21st century to compete globally, i.e., communication, collaboration, critical thinking, and creative thinking. Thus, creative thinking, otherwise known as the 21st century skill, is one of the skills that must be mastered by students [3]. There are at least five essential skills that must be mastered in the 21st century, i.e., adaptability, complex communication, non-routine problem-solving, self-management, and system thinking. The systems thinking skill include creative thinking ability, i.e., the process of generating or bringing up a new idea [4].

Students are considered to have creative thinking skills if they can solve problems with various ideas or strategies. Munandar [5] stated that the indicators of creative thinking ability are (1) fluency (the ability to develop ideas); (2) flexibility (the ability to employ various problem-solving approaches); (3) elaboration (the ability to explain in detail); (4) originality (the ability to use new strategies). Thus, students must improve their mathematical creative thinking patterns.
Students' creative thinking skills are critical; therefore, teachers should provide extra attention to this issue. However, in reality, students' creative thinking skills remain poor. Students often have difficulties answering questions that require them to think creatively. Furthermore, some students are reluctant to complete the task and refuse even to try. Sugilar [6] mentioned that lack of motivation in learning leads to poor creative thinking skills. In other words, students only receive lessons as is without any effort of critical discussion.

Several studies on high school and vocational high school students' creative thinking skills have been conducted. Lestari [7] found that the creative thinking skills of Cimahi City vocational school students remain low, with an average of 42.24% for all indicators, the highest indicator is fluency (91.38%) and the lowest is originality (10.34%). Ismayani [8] demonstrated that vocational school students’ mathematical creative thinking skills in Cianjur have increased after learning with the STEM approach. A similar study was conducted by Iqbal [9], which focused on the creative thinking skills and mathematical dispositions of high school students in Banda Aceh. The study showed that the improvement of students’ creative thinking skills and mathematical dispositions taught using the PBL model was better than conventional approaches, based on high, medium, and low student groups.

Previous studies were carried out in senior high schools and vocational schools outside Aceh; therefore, studies on vocational school students’ creative thinking skills in Aceh have not been conducted yet. Creativity is vital for vocational students because a creative thinking mindset is fundamental to apply knowledge in life. Therefore, this study serves as the starting point that will contribute to the body of research and become the basis for future research on creative thinking in the context of Aceh vocational schools. This study aims to analyze students' creative thinking ability and the factors that influence it. Therefore, the research problem of this study is how the creative thinking ability of vocational high school students in Aceh Jaya Regency?

2. Method

This research is a qualitative descriptive study. The subjects were all students at SMK (Vocational School) Negeri 1 Panga Aceh Jaya Regency, Indonesia. There are only six classrooms in this school, i.e., two classes at level 10, two classes at level 11, and two classes at level 12. The total number of students was 113.

The research instrument was a test that consists of six problems related to mathematical creative thinking in solving geometry problems. The test was carried out online using a WhatsApp application. The students submit their answers to the researcher within two days after the questions were provided. The method was chosen due to the COVID-19 pandemic.

Based on the results, six students who completed both indicators of creative thinking skills, i.e., fluency and originality, were selected to be interviewed. The selected students were the ones who gave correct answers and presented high levels of creative thinking skills. The purpose was to gather information on the students’ skills on each of the assessed indicators. The interview was conducted directly between the researcher and the students at school, one week after the test was carried out. This activity was carried out by following the health protocols per government recommendations.

The students’ answers were assessed based on the scoring rubric of mathematical creative thinking skills, which includes indicators of fluency and originality in geometry [10] as presented in Table 1. The two-stage data analysis was conducted qualitatively. In the first stage, the researcher provided creative thinking tests to students, including indicators of fluency and originality. While in the second stage, the students’ answers were analyzed, and several students were summoned to be interviewed.
Table 1. Guideline for Assessment of Mathematical Creative Thinking

| Measured Aspects | Student Responses to Questions | Score |
|------------------|--------------------------------|-------|
| Fluency          | Provide no answer              | 0     |
|                  | Provide one idea that is relevant but unclear | 1     |
|                  | Provide one idea that is relevant and clear | 2     |
|                  | Provide more than one idea that is relevant but less clear | 3     |
|                  | Provide more than one idea that is relevant and clear | 4     |
| Originality      | Provide no answer              | 0     |
|                  | Provide an answer by developing original methods but cannot be understood | 1     |
|                  | Provide an answer by developing original methods, the calculation process is directed, but not completed | 2     |
|                  | Provide an answer by developing original methods with correct reasons, but not showing anything unique | 3     |
|                  | Provide an answer by developing original methods with correct reasons and showing something unique | 4     |

3. Results and Discussion

3.1. Results

Table 2. Analysis of Creative Thinking Skills Indicators

| Indicators | Score | Total score | Percentage |
|------------|-------|-------------|------------|
| Fluency    | 0 12 24 24 21 | 216 | 47.79 |
| Originality| 26 8 36 27 16 | 225 | 49.78 |

Table 2 shows the creative thinking ability, the percentage for fluency indicator in questions 1, 2 and 3 is 47.79%. The percentage of originality indicator in questions 4, 5 and 6 is 49.78%. Grade 10 students answered the first and second questions. The third and fourth questions were answered by grade 11 students, while grade 12 students answered the last two questions.

3.2. Discussion

Students’ creative thinking ability is low, as indicated by the percentage of the two indicators: fluency (47.79%) and originality (49.78%). The result shows that the level of students’ creative thinking skills is low. The following are the provided questions and the students’ answers.

3.2.1. Question 1. Based on the concepts that you understand, mention geometric shapes that are composed of four vertices! The student’s answer to Question 1 is presented in figure 1.

![Figure 1. The answer of a high-skilled student to Question 1](image)
Figure 1 demonstrates that the student has provided more than one relevant idea, and the solution is complete and clear. The student provided more than one idea or approach to solve the problem. By initially using four points, the student developed as many spatial shapes as he knows. This can be explained from the following interview.

*Teacher*: Can you explain the answers you wrote on this answer sheet?
*Student*: From the question, we were asked to create plane figures that we are familiar with, starting with four points.

*Teacher*: Then, what else did you know?
*Student*: With four points, I created a square, a rectangle, a parallelogram, and a rhombus.

*Teacher*: Did you answer this question by yourself? Please explain the reason.
*Student*: Sir, I answered it by myself, and I still remember this lesson from middle school.

*Teacher*: Do you have any other ideas besides the ideas you wrote on this answer sheet?
*Student*: No, Sir, because I have written all the ideas on this sheet.

*Teacher*: Did you understand each step written? Please explain it.
*Student*: I did, Sir.

The fluency indicator shows a mean percentage of 47.79%, indicating that some students could answer questions correctly.

3.2.2. *Question 2*. Create two other plane figures in which its area equals the rectangle area in the following image!

The student’s answer to Question 2 is shown in Figure 2.

![Figure 2. The answer of a high-skilled student to Question 2](image-url)
Based on Figure 2, the student provided answers by developing their original method. Both the calculations and results are correct. The student provided a correct two-step approach. Firstly, the student drew the figure, then the length and width of the shape were determined. By drawing the figure, the student finds it easier to determine the area of the shape. The following interview confirms this.

Teacher : What concept did you use to solve highlight this problem?
Student : Geometry, Sir.
Teacher : How many ways did you use? Please explain them.
Student : (He responded based on the answer of the written test)
Teacher : Did you answer this question by yourself? Please explain.
Student : Yes, Sir, I answered it by myself.
Teacher : Do you have any other ideas besides the ideas you wrote on this answer sheet?
Student : Yes, Sir, there are several other shapes that I can create.
Teacher : Did you understand every step that you wrote? Please explain them.
Student : I did, Sir. If the figure that I created has the same size as the known shape, then the area would be the same.

The fluency indicator shows a mean percentage of 47.79%, indicating that some students could answer questions correctly.

3.2.3. Question 3. One day Sulthan received a gift from his father, a saving box in the form of a regular hexagon prism. The box is 10 cm long and 40 cm high. How many ways can you determine the volume of the box?

A student’s answer to Question 3 is presented in Figure 3.

![Figure 3](image-url)

**Figure 3.** The answer of a high-skilled student to Question 3

Figure 3 demonstrates that the student has provided more than one relevant idea, and the solution is complete and clear. Firstly, the student drew a hexagon prism as described in the question. He drew the cover of the prism separately and divided it into several triangles. Next, the length of the unknown
sides was calculated until the student determined the shape’s volume. The following interview describes this well.

Teacher : Can you explain the answers you wrote on this answer sheet?
Student : The question described a saving box with a hexagon prism shape. We were asked to determine the volume of the saving box.
Teacher : Then, what else did you know?
Student : I drew a saving box with the hexagon prism shape. I divided the base into several triangles. Then, I calculated the volume.

Teacher : Did you answer this question by yourself? Please explain the reason.
Student : Sir, I answered it by myself. I still remember this lesson when I was in middle school.
Teacher : Do you have any other idea, other than the idea you wrote on this answer sheet?
Student : No, Sir, because I have written all the ideas on this sheet.
Teacher : Did you understand each step written?
Student : I did, Sir.

The fluency indicator shows a mean percentage of 47.79%, indicating that some students could answer questions correctly.

3.2.4. Question 4. Look at this picture.

Identify the possible geometry shapes (plane figures) that you can get from the picture above!

A student’s answer to Question 4 is presented in Figure 4.

![Figure 4](image)

Figure 4. The answer of a high-skilled student to Question 4

Based on Figure 4, the student provided an answer using their original approach. The calculations and results are correct. The student provided several steps that are correct. Firstly, the fragments from the picture were separated, then the plane figures were identified. This description is expressed in the following interview.
Teacher : What concept did you use to solve this problem?
Student : Geometry, Sir.
Teacher : How many ways did you use? Please explain them.
Student : (He answered based on the answer of the written test)
Teacher : Did you answer this question by yourself? Please explain it.
Student : Yes, I did, Sir. I answered it by myself. I cut the fragments off from the original figure and identified the new plane figures.
Teacher : Do you have any other ideas, other than the ideas you wrote on this answer sheet?
Student : No, Sir.
Teacher : Did you understand each step written? Please explain them.
Student : Yes, I did, Sir. I created the plane figures based on what was asked in the question.

The originality indicator shows a mean percentage of 49.78%, indicating that some students could answer questions correctly.

3.2.5. Question 5
You have a wire that is 40 cm long. You are asked to frame the blocks with the wire. What is the possible volume of blocks that you can get?
A student’s answer to Question 5 is shown in Figure 5.

![Figure 5](image)

**Figure 5.** The answer of a high-skilled student to Question 5

Figure 5 demonstrated that the student had provided more than one relevant idea, and the solution is complete and clear. Firstly, the student read to understand the question’s details, then, he wrote down the known variables. The student determined the possible volume of blocks. The following interview confirms this.

Teacher : Can you explain the answers you wrote on this answer sheet?
Student : The question described a 40 cm wire, and we were asked to determine the possible blocks that can be created from the wire.
Teacher : Then, what else did you know?
Student : I determined the shape of the blocks, and then I calculated the volume.
Teacher : Did you answer this question by yourself? Please explain the reason.
Student : I did, Sir, I answered it by myself. I still remember this lesson when I was in middle school.
Teacher : Do you have any other ideas, other than the ideas you wrote on this answer sheet?
Student : No, Sir, because I have written all the ideas on this sheet.
Teacher : Did you understand each step written?
Student : Yes, Sir, I did.

The originality indicator shows a mean percentage of 49.78%, indicating that some students could answer questions correctly.

3.2.6. **Question 6.** A number of bricks are arranged according to the picture below.

If the brick measures 20 cm x 7.5 cm x 7.5 cm, determine the object’s volume using approaches that you understand!

A student’s answer to Question 6 is presented in Figure 6.

![Figure 6](image)

**Figure 6.** The answer of a high-skilled student to Question 6

As presented in Figure 6, the student provided an answer using their approach. The calculations and results are correct. The student used multiple steps, which are all correct. The known information in the question was identified and written down, then the volume was determined. The following interview describes this.

Teacher : What concept did you use to solve the problem?
Student : Geometry, Sir.
Teacher : How many steps did you use? Please explain them.
Student : (He answered based on the answer on the written test)
Teacher : Did you answer this question by yourself? Please explain it.
Student : Yes, Sir, I answered it by myself. I tried to understand the question, and I wrote down the details, so it was easier to work on the problem.
Teacher : Do you have any other ideas, other than the ideas you wrote on this answer sheet?
Student : No, Sir.
Teacher : Did you understand each step written?
Student : Yes, I did, Sir.

The originality indicator shows a mean percentage of 49.78%, indicating that some students could answer questions correctly.
The data analysis shows that students' mathematical creative thinking skills remain low for all the assessed indicators. The fluency indicator was 47.79%, higher than the originality indicator, which was 49.78%.

The study’s result is consistent with a previous study, which demonstrated a low level of creative thinking skills in students at an average percentage of 42.24% [7]. The fluency indicator was one of the indicators with a high score of 91.38%, the flexibility indicator was 45.69%, the elaboration indicator was 21.55%, and the originality indicator had the lowest score of 10.34%.

The poor capability of students’ creative thinking is presumably due to the lack of teacher’s effort in exploring the students’ knowledge and understanding creative thinking [11]. Furthermore, Siswono [12] argued that creative thinking in mathematics requires detailed and systematic problem-solving skills that employ various approaches to discover "extraordinary" solutions.

Creative thinking skills can be improved by the active involvement of students in the learning process. One of the approaches is to provide assignments that can develop students' creative thinking skills. This strategy is expected to support the learning process's effectiveness, thus achieving learning objectives optimally.

Providing assignments to students can improve the originality indicator because the students are required to have the ability to solve math problems using their ideas without the help of others. This is consistent with the study by Wandari [13], which found that tasks or activities can increase students’ creativity. Thus, this approach is effectively used by teachers and students, particularly in geometry lessons.

4. Conclusion

Based on the creative thinking skill test, 48.78% of students scored lower than the standard average. The interview revealed that this result is due to the poor fluency. Students do not have an adequate capacity to develop various ideas, problem-solving methods, opinions, questions, or alternative solutions in a short time. This situation leads to difficulties in reaching the originality stage. At this stage, students are expected to develop new ideas that have not been presented previously and express the ideas with unique combinations. Based on the findings, it is recommended to provide students with assignments in the form of tasks or activities to improve their creative thinking skills.

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