An analysis of tenth grade students’ mathematical creative thinking ability in vector

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Abstract. This study aims to describe the level of mathematical creative thinking ability of tenth graders in vector material. In this research, descriptive qualitative method was used and 34 tenth grade students of a senior high school in Tasikmalaya were involved as subjects of the study. A written test consisting four items in the form of description was used to collect the data and also through interviews. The data analysis technique was done by giving a score in accordance with the scoring guidelines and categorizing criteria to measure the level of students’ mathematical creative thinking ability. The result showed that the majority of students’ mathematical creative thinking ability was at the quite creative level. Thus, the students need to be given learning that can develop their mathematical creative thinking ability.

1. Introduction

The ability to think creatively is one of the essential abilities in the learning process and has an important role in improving student learning achievement. Creativity in mathematics plays an important role in the cycle of advanced mathematical thinking that will help to develop theories and generate new knowledge [1]. In addition, creative thinking can help explain abstract concepts, allowing students to achieve better mastery of concepts, especially in mathematics. Creative thinking ability as one of the important abilities of the twenty first century [2].

The focus of the material in this paper is vector. Vector is one of the important material which is discussed in high schools. There are aspects of algebra and geometry that can be collaborated to understand vector concepts. However, it is not very easy to collaborate aspects of algebra and geometry, so that it requires good understanding concepts. Students have difficulty connecting various concepts in learning mathematics [3]. Therefore, students need to understand the basic concepts needed to solve problems related to vectors.

A study concluded that only 39.1% of students understood the concept of vector [4]. This shows that more than 50% of students are still lack understanding regarding vector concepts in mathematics learning. In addition, the inability of students to solve the questions given is due to the lack of mastery of vector concepts [5].

The next problem is that most students answer problems related the addition of two vectors in a two-dimensional plane incorrectly because they forget that vectors can be moved to make connections [6]. These problems certainly show that the students’ through process in determining a strategy in vector addition needs to be developed further, because between one student and another student
certainly has different ideas in solving the problem. The problem also shows that the ability of students to express ideas and apply them in problem solving and the ability to associate the concepts used in solving problems is still low.

Difficulties experienced by students in learning vectors involve several topics, namely vector magnitude and direction, vector addition and subtraction, vector components and unit vectors [7]. Thus, the vector concept learned by these students must require a good understanding of the concept and thinking strategies in sparking ideas to solve the problem. Therefore, creative thinking ability is needed in solving problems related to vector material. Mathematical creative thinking as the ability to analyze a given problem and produce some ideas and choose the right method for solving non-routine mathematical problems [8].

PISA 2012 shows that Indonesia gets an average score of mathematical abilities which is 375 and the score is still below the average of OECD score which is 494 [9]. From the result, as many as 0.3% of Indonesian students can work on mathematics problems at level 5 or 6. This shows that Indonesian students’ creative thinking ability in solving high-level problem is still low. So, there needs to be further analysis of the condition and one of them is analyzing how students solve problems related to vector material in terms of their ability to think creatively. Based on the description, there needs to be a further study related to students’ creative thinking ability, especially in vector material.

There are four indicators of the ability to think creatively: fluency, flexibility, elaboration and originality [10]. Fluency shows when students can solve problems smoothly, flexibility shows when students can solve problems in more than one way correctly, elaboration shows when students can elaborate in detail the process of solving problems and originality shows when students are able to express the process of solving problem that are new and unique.

2. Methods
This study used descriptive qualitative method to determine the level of creative thinking ability of tenth grade students on vector material. The study subjects consisted of 34 tenth grade students in the Tasikmalaya area.

Data collection techniques consisted of test instruments where students worked on the test of creative thinking ability in the form of essays. This creative thinking ability test aims to determine the ability of students to solve problems using different or unique ways smoothly and systematically. The test questions consist of four items with each item based on indicators of creative thinking ability. Furthermore, using a non-test instrument was interviews to several students. In the activities of interviews with several students conducted using open questions. This is intended to give students freedom to express how the mindset and strategy of answering students to the problems given. The instrument’s validity was validated by two experts.

Data analysis technique was done by giving a score for each item then converting the data into five predetermined categories. Each problem solving step from students was given score in accordance with predetermined scoring guidelines. Scores obtained by students are converted into grades in the range of 0-64 by

\[ \psi = \frac{\sigma}{m} \times 64 \]

Furthermore, the obtained scores are classified into criteria for the level of creative thinking.

3. Result and Discussion
3.1. Creative Thinking Ability Test Result
The results of the acquisition of creative thinking ability test scores that have been converted into the form of criteria and percentage of achievement for each indicator are presented in the following Table.
Table 1. The Results of Creative Thinking Abilities

| Value | Category           | Frequency | Percentage (%) |
|-------|--------------------|-----------|----------------|
| 0-12  | very not creative  | 1         | 2.94           |
| 13-25 | not creative       | 9         | 26.47          |
| 26-38 | quite creative     | 13        | 38.24          |
| 39-51 | creative           | 8         | 23.53          |
| 52-64 | very creative      | 3         | 8.82           |
|       | Total              | 34        | 100%           |

Table 2. Percentage of Indicator Achievement

| No  | Category   | Percentage (%) |
|-----|------------|----------------|
| 1   | Fluency    | 61.75          |
| 2   | Flexibility| 46.25          |
| 3   | Elaboration| 56.50          |
| 4   | Originality| 44.75          |

Table 1 shows what is meant by the category of students’ level of creative thinking. Guidelines for this criteria are adapted based on references [11]. Based on Table 1, there are still less than 50% of students who have ability to think in the creative and the very creative category. Thus, it can be said that there is only 32.35% of students’, or as many as 11 students who can be said to have good creative thinking ability. Table 2 shows the percentage of students’ achievement for each indicator. Based on the description above, the indicators of flexibility and originality have a lack. The three criteria for creative thinking are flexibility, elaboration and originality that can make limited achievement in the criteria of originality [12].

3.2. Description of the answers to one of the creative thinking ability test question
The problem refers to the flexibility indicators. In this problem, students are required to be able to provide answers or alternative answers of at least two correct ways. The comparison of the students’ work for each category of creative thinking abilities is portrayed as follows.

Figure 1. The students’ work is categorized as creative

Figure 1 shows that students have been able to give answers using two different methods. The aspect of flexibility can be seen from the ability of students to provide two different answers. Strategies in solving problems in these two ways are certainly different. The use of the first method is
geometric analysis by depicting Cartesian coordinates and calculating as many as four units from point P to Q. In this case, students can represent the vector shapes that can be formed which are presented in the form of Cartesian coordinates. The second method uses algebraic analysis using vector length formulas. Students substitute points known to the problem, then perform calculations systematically. Based on the calculation results the same results are obtained with those using the first method.

Figure 2. The students’ work is categorized as quite creative

Figure 2 shows that students only used one method, namely analysis with the algebraic concept and the correct answer was obtained. It can be seen that the students have already been able to interpret their ideas related to the concept of the length of the vector from the problem given using the concept of algebraic and do the problem solving process with the long vector formula that has been studied before. However, if it is viewed from the aspect of student flexibility, at this stage they have not been able to provide several alternative answers. Students at this stage tend to use procedural completion processes that have been studied previously.

Figure 3. The students’ work is categorized as not creative

Figure 3 shows the absence of relevant ideas that can be used to solve the problem. Students’ answers which are categorized as very not creative are almost the same as in this category. Based on the picture above, students try to use the strategy by describing Cartesian coordinates. However, the image created is not perfect so it is difficult to determine the next completion step. Therefore, no solution was found.

Based on the results of the analysis of some students’ answers that the majority of the ability to think creatively includes are in the quite creative. The results of creative thinking with the medium category have also been proven in a research on a national scale [13]. There are many factors which cause this condition. One of the factors that influence students’ creative thinking ability is the ongoing learning process. The learning process that only uses conventional approaches as would limit the ability of students’ to express their ideas. In mathematics learning the creativity of students can be
formed from how the teacher manages a good learning process. The characteristics of a teacher can also provide an important role in the approach to foster creativity in others [14]. The teacher must be able to provide opportunities for students to think creatively and be open to their ideas [15]. In addition, some factors that can influence the development of creativity include: intelligence, knowledge, motivation, social environment, cultural context and personality [16].

Based on the result of interviews with several students, the problem given regarding vector material is still similar to the problem given in the previous example. Therefore, it can be identified that students find it difficult to be able to develop creative thinking ability because the problem presented are still routine problem that do not stimulate students’ to be able to think higher. The problems that are prepared should be able to demand students to be able to carry out the process of creative thinking. In addition, the process of creative thinking involves the ability to generate original ideas, understand new connected and unexpected relationships or build a unique and better order between factors that seem unrelated [17].

Mathematical learning that involves interaction between friends can develop the ability to think creatively. This is because they can freely exchange ideas and share experiences to create ideas in the problem solving process. This means that ideas from a student can complement the conceptual understanding of the other students. Based on Vygotsky’s theory, peer interaction is beneficial for children by requiring them to arrive at the perspective of the same problem [18]. Therefore, through interaction with peers, students’ will share experiences and knowledge to be able to solve questions of about creative thinking ability.

The results of the answers analysis of the students’ category “not creative” and “very not creative” have reached 29.41%. Students are difficult in determining problem solving strategies and they do not use rules and appropriate steps to solve them. This is most likely due to students’ difficulty in representing how the concepts that have been obtained previously can be used as a solution for solving the problem. Representation helps students to explain concepts or ideas so as to increase students’ flexibility in answering mathematical questions [19]. Creativity demands an extension of this context in a way that has not before been conceived [20]. This implies that the experience of students’ plays an important role in developing creative thinking. The creative activity of the imagination depends on rich and varied previous experience [21]. Creativity needs time to develop and thrives on experience [22].

The result of the analysis of answers with the category “quite creative” have reached 38,24%. Students are still focused on solving problems with ordinary strategies. Students are only able to solve problems in one way so that the ability to generate ideas to develop other ways needs to be developed. Students at this stage tend to only be able to apply the problem solving process that has been studied before and have not been able to produce new ideas.

The results of the answer analysis of students’ with the category “very creative” and “creative” have reached 32,35%. Students have begun to be able to develop mathematical ideas so that they can provide several alternatives to answers correctly in different ways. To be creative one must first decide to generate new ideas, analyze these ideas and sell to others [23]. Creativity activities require competencies and skill that can help students achieve the desired success [24]. Therefore, in mathematics learning students’ should need to be given non-routine and more complex problems so that their creative ideas can be channeled properly.

4. Conclusion
The majority of students’ creative thinking ability is at quite creative level, which in 38,24%. Therefore, students need to be given learning that can develop their creative thinking abilities. The ability to think creatively needs to be developed in mathematics learning because it can help solve problems more effectively and it needs to be owned by every student to face the current era of globalization.
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