Students’ creativity level on solving mathematics problem

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Abstract. There have been many attempts in order to build and train students’ creativity. However, there have been many obstacles faced regarding to how to encourage the students’ to be creative in the class. One of those obstacles faced is how to assess student’s creativity in solving mathematical problems; because there is a distinctive aspect for normal assessment and creativity assessment. Assessing creativity requires more specific limitations to creativity. By knowing the way to assess creativity, it will help teachers to understand to what extent students’ creativity can be used as a reflection in the effort to build creativity. This study aims to determine students’ creativity level on solving mathematics problem. The information of to what extend students’ creativity level. Moreover, this could be used as a consideration on planning learning strategy in order to increase student creativity on solving mathematics problem. This study employed qualitative research method. The subjects of this research are two 7th grade students of SMPN 1 Ngraho Bojonegoro. Data were collected through three steps namely writing test, interview, and observation. The conclusion of this study indicates that students’ creativity level on solving mathematics problem could be classified based on Siswono’s level of creativity. These levels are categorized into level 4 (very creative), level 3 (creative), level 2 (quite creative), level 1 (less creative), and level 0 (not creative). The first subject has the category of level 1 creativity (less creative). The second subject has the category of level 3 creativity (creative).

1. Introduction
Creativity is key to the future as a result of technology in order to answer the various competition in all fields. Moreover, natural resources and the complex social problem are the challenges we are facing in this millennial era. Creativity has become key role for millennials in order to survive in their future. Creativity is also helpful in resolving our everyday problems. Thus, Education that has emphasized memory and routine problem solving needs a metamorphosis and the measures described in this issue portend a brave new educational world. Education plays great role in nurturing and building students’ creativity as well as in mathematics education [1]. The importance of creativity is not only seen in mathematics education but also in technology development. It is in line with Leikin and Pitta-Pantazi who states that Technological progress and inventions and the development of mathematics are interwoven: mathematical developments facilitate technological progress, while developments in technology and science require development of mathematics [2]. Moreover, creativity in mathematics education can be built and be trained in order to issue various ideas and new solution so the problem can be precisely solved.

There have been many attempts in order to build and train students’ creativity. However, there have been many obstacles faced regarding to how to encourage the students’ to be creative in the class. One of those obstacles faced is how to assess student’s creativity in solving mathematical problems; because there is a distinctive aspect for normal assessment and creativity assessment. Kim states that
creativity is distinct from intelligence [3]. Thus, the assessment is also different. However when creativity is fostered, intelligence’s ability to operate in ill-defined problem space may be fostered, likewise [4]. Assessing creativity requires more specific limitations to creativity. By knowing the way to assess creativity, it will help teachers to understand to what extent students’ creativity can be used as a reflection in the effort to build creativity. It is line with Benedek which states that assessing creativity is important as it can give selective feedback and build creativity [5].

There are various theories in what creativity defines. Haylock states that there is no single definition of creativity that is generally accepted or used in research [6]. Creativity, in general, is a manifestation of creative thinking. Creative thinking is a process to resolve the problem. It is in line with Torrance states that creative thinking is a natural human process motivated by strong human needs [7]. Then Lin states that everyone has the potential to be creative [8]. Thus, it concludes that everybody has the potential to possess creative thinking ability as long as they are stimulated by needs to be fulfilled. These needs can be in the form of encouragement in resolving problems. Creative thinking and problem are correlate to each other: problem solving requires an impulsive creative thinking. This is in accordance with Bruner states that creativity as an act that produces effective surprise [9]. Then, Heilman state that creativity is the new discovery, understanding, development and expression of orderly and meaningful relationships [10]. Creativity can also be seen as a multifaceted phenomenon which entails the generation of new ideas to solve problems and produce innovation [11]. So creativity is an act that produces surprises and innovations obtained from understanding and development of many ideas.

According to survey on mathematical creativity conducted in six countries, Romania is one of them, shows that one of the ways to train and build creative thinking is to solve unconventional problems [12]. It is in line with Kandemir and Gur states Creativity can be learned and improved via activities of on-going training and creative problem solving [13]. Based on the earlier statements, there is a relation between creative thinking and problem solving. The problem, in this case, is the situation which forced students to link up the information they have already known and the way to solve them by using newer ways [14]. If students have already known the way to solve the problems, then, that question is no longer a problem.

There are three components to assess students’ creativity in solving mathematic problems, namely fluency, flexibility, and novelty [15]. The relation between mathematical problem solving and creativity can be seen in Table 1.

**Table 1. Mathematical problem solving and creativity**

| Problem solving | Creativity |
|-----------------|------------|
| Student explore open-ended problems, with many interpretations, solution methods, or answers | Fluency |
| Student solve (or express or justify) in one way, then in other ways | Flexibility |
| Student discuss many solution methods | |
| Student examine many solution methods or answers (expressions), then generate another that is different | Novelty |

These relations can be used as an approach to assess students’ creativity in solving mathematical problem: planning problem solving questions based on the indicators above.

Siswono categorized the level of creativity into 5 levels. These levels are categorized into level 4 (very creative), level 3 (creative), level 2 (quite creative), level 1 (less creative), and level 0 (not creative) [16]. Creativity level 4 is when students are able to show fluency, flexibility, and novelty or novelty and flexibility in their problem solving process. Creativity level 3 is when students are able to show fluency and novelty or fluency and flexibility in their problem solving process. Creativity level 2 is when students are able to show novelty or flexibility in their problem solving process. Creative level
1 is when students are able to show fluency in their problem solving process. Creative level 0 is when students are not able to show the three indicators, fluency, flexibility, and novelty.

This level of creativity can be used to help classifying students’ creativity in solving mathematical problems. A comprehensive understanding of the level of creativity will help showing the ways to facilitate and encourage the development of students’ creativity [17]. Teacher knowledge on student mathematic problem correlates positively to students’ problem solving achievement [18]. This will ease the teacher in determining the level of creativity of students. Thus, information on how to increase student creativity in solving these problems can be used as a consideration to devise new learning strategies. Teacher should learn to develop problem solving method [19].

Based on the description above assessing the level of student creativity is very necessary to determine the initial position of student creativity in learning. The initial position of student creativity in learning can be used as a reference to reflect on the learning process related to creativity development. See in the fact that some obstacles are often not realized by the teachers in an effort to increase student creativity one of which is to assess student creativity. Then this study aims to determine students’ creativity level on solving mathematics problem.

2. Method
This study used qualitative as the research method. This study was executed in VII grade B class at SMPN 1 Ngraho Bojonegoro. This study applied purposive sampling in order to get the subject of the study. Subject was chosen based on the needed criterion and were able to communicate their ideas both written or oral. The subject of this study were 2 students suggested by mathematic teacher in their class. The subject was then given a code name in order to make the analysis easier. The code name was based on their 2 initial word of their name and their number.

The collected data were written text and interview on lines and angles material. The problems were made based on the fluency, flexibility, and novelty indicator. Problem number 1a and 1b measured fluency indicator, Problem 3 and 5 measured flexibility indicator while Problem number 2 and 4 measured novelty indicator. The result test was analysed based on the correct answer as well as their correctness in following the Problem instructions. Then it was analysed based on fluency, flexibility, and novelty indicator. There were six problems as follows.

**Look at the picture!** (Students look at Figure 1).

![Figure 1](image)

**Figure 1.** Picture on the problems given to students.

1. a) Name the opposite angle in the picture above! (fluency)
   b) ∠VQR is an acute angle which its angle is divided by 3. How much is the possibility of the ∠VQR? Explain your answer. Then look for the ∠PQV! (fluency)
2. Is there another possibility? Name it at least two if it has another possibilities! (novelty)
3. Check again your answer. Show two or more different ways in order to get the answer! (flexibility)
4. Make at least two more questions about the angels relations based on the picture above! (novelty)
5. Look at the questions you made. Show your way in solving that question! (flexibility)
The data analysis on interview was done by reducing the data, explaining the data, and making conclusion. Triangulism method was used in order to get the validity of the data.

3. Result and Discussion

3.1. The result of Subject 1’s written test and interview

The result of Subject 1’s written test in DA8 Problem 1 and 2 are in Figure 2.

![Figure 2](image)

1. a. $<S VT$ is a corresponding to $<S QR$, $<TV Q$ is a corresponding to $<R QX$
   b. $<V QR$ is 60° because it has been divided by 3 and 60° is less than 90° so it is an acute. Angle $<P Q V = 60°$
2. It is $<V QR = 60°, 84°$ because it is divided by 3
   $<P Q V$ has another possibility that 6°, if $<V QR = 84°$
   And $<P Q V$ has another possibility that 15°, if $<V QR = 60°$

Figure 2. Subject 1’s written test of DA8 Problem 1 and 2.

Meanwhile, the results of Subject 1’s written test of DA8 Problem 3, 4, and 5 are presented in Figure 3.

![Figure 3](image)

3. a. $<V QR$ is a complementary angle $<P Q V$
   b. $<P Q R$ is a complementary angle $<V Q R$
4. a. Determine the $<P Q R$
   b. Determine the $<V Q R$ if $<P Q V = 30°$
5. a. $<P Q R = 90°$
   b. $<V Q R$ can be measured by subtracting 90° to $<P Q V$ so $<V Q R = 60°$

Figure 3. Subject 1’s written test of DA8 Problem 3, 4, and 5.

Figure 2 shows that subject DA8 was having difficulties in solving these problems. However, he began to understand what the problem was. Subject DA8 could finally solve Problem 1a but he failed to solve Problem 1b and 2.
Figure 2 shows that subject DA8 solved Problem 4 and 5 even though he had minor problems in explaining the ways he solved Problem 5. Problem 3 couldn’t give other possible answer as he failed in solving Problem 2. Subject DA8 said “I haven’t done it yet, sir. It is difficult” when he was asked about Problem 3 even though he had already known what Problem 3 was about. Data of the test and interview results were then analyzed through triangulation for their validity. The results can be seen in Table 2.

| No | Creativity indicator | Written test result | Interview result | Conclusion |
|----|----------------------|---------------------|------------------|------------|
| 1  | Fluency              |                     |                  |            |
|    | Problem 1a           | v                   | v                | v          |
|    | Problem 1b           | v                   | v                |            |
| 2  | Flexibility          |                     |                  |            |
|    | Problem 3            | -                   | -                |            |
|    | Problem 5            | v                   | -                |            |
| 3  | Novelty              |                     |                  |            |
|    | Problem 2            | -                   | -                |            |
|    | Problem 4            | v                   | v                | v          |

Note:
v: fulfilled
- : unfulfilled

Based on Table 2, it showed that subject DA8’s fluency indicator in Problem 1a and 1b is all fulfilled. Then, subject DA8 only fulfilled one indicator on flexibility in written test Problem 5. Moreover, subject DA8 only fulfilled novelty indicator in Problem 4. In short, subject DA8 had succeed in fulfilling his fluency indicator and failed to fulfil flexibility and novelty indicator.

3.2. The result of subject MK24 written test and interview.

The results of subject MK24 written test of Problem 1 and 2 are presented in Figure 4.

![Figure 4. Written test results of Problem 1 and 2](image)
Meanwhile, the results of subject MK24 written test of Problem 3, 4, and 5 are presented in Figure 5.

| No | Creativity indicator | Written test result | Interview result | Conclusion |
|----|----------------------|---------------------|------------------|------------|
| 1  | **Fluency**          | v                   | v                | v          |
|    | Problem 1a           | v                   | v                | v          |
|    | Problem 1b           | v                   | v                | v          |
| 2  | **Flexibility**      | -                   | -                | -          |
|    | Problem 3            | v                   | v                | v          |
|    | Problem 5            | v                   | v                | v          |
| 3  | **Novelty**          | v                   | v                | v          |
|    | Problem 2            | v                   | v                | v          |
|    | Problem 4            | v                   | v                | v          |

Note:
* v: fulfilled
  * -: unfulfilled

Based on Table 3, it was found that subject MK24’s fluency indicator on Problem 1a and 1b were fulfilled. MK24’s flexibility indicator only fulfilled on Problem 5 in both written and interview. While
MK24’s novelty indicator was fulfilled on Problem 4 and 5. It concludes that subject MK24’s fluency and novelty indicator are fulfilled and flexibility indicator is not fulfilled, as seen in Table 4.

| Subject | Creativity Indicator | Level of Creativity |
|---------|----------------------|---------------------|
| DA8     | v                    | Level 1 (Less creative) |
| MK24    | v                    | Level 3 (Creative)   |

Note:
- : fulfilled
- : unfulfilled

Based on Table 4, it can be compared to the Polya’s [20] steps of problem-solving. First, step of understanding the problem. Subject DA8 needed relatively longer time to understand the problem. It was due to DA8 could not understand the problem and the instruction of the problem. However, after getting explained on what he was up to, he began to understand what the problems were. Subject MK24, on the other hand, was relatively faster in understanding the problem, even before he was interviewed.

Second, step of devising plan. Subject DA8 was having difficulties in planning how he was going to answer because subject DA8 had a poor concept understanding he needed to answer problems about lines and angles. Subject MK24, on the other hand, was having little difficulties on planning how to solve the problem even though he had already understood the problem. After both subject were explained about what the problem was, they began to understand the problems.

Third, step of carrying out the plan. Both subject DA8 and MK24 began to answer fast without having any problem. Both subject have the same mark in this case.

Last, step of looking back. Subject DA8 began to recheck what his answers were – he was not sure on his answer on some problems. While subject MK24 did not recheck his answer as he was sure with his answers. In this case, subject da8 has better score than subject MK24 even though subject MK24 has more correct answers. Both subjects have the same difficulty at the stage of planning a solution which is due to the lack of knowledge students have about the concept of line and angle material. The understanding of problems, knowledge are keys in assisting of students’ success on solving mathematic problems [21].

4. Conclusion
This study concludes that students’ creativity in solving problem depend on each student. However, it can be classified based on the level of creativity. This study classifies that subject DA8 as a level 1 creativity (less creative) while subject MK24 as a level 3 creativity (creative). Students who have level 1 creativity tends to have slow understanding the problem and explaining their problem solving plans but rechecking what they had done is seen as a good thing. Students who have level 3 creativity, on the other hand, tend to be faster in understanding and solving the given problem even though they are a bit weaker in planning and rechecking their answer.

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