Analysis of Students’ Creative Thinking Skill in Solving Algebra Problem

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Abstract. This study aimed to describe the students’ creative thinking skill in Junior High School to solve the problems in two-variable linear equations system. The indicators of creative thinking skill included fluency, flexibility, and novelty. This research was a qualitative descriptive study with 8 students in SMP N 4 Playen Gunung Kidul as the subject. The data collection used in this research was tests that were adjusted to some indicators of creative thinking skill. Researchers also conducted validated interviews by using triangulation methods. The results showed that 12.5% of students conformed with two indicators of fluency and novelty (it could be categorized as creative), 37.5% of students conformed with one indicator of flexibility or novelty (it could be categorized as adequate creative), and 50% of students conformed one indicator of fluency (it could be categorized as less creative). Based on the results, it could be concluded that most of students were categorized as less creative. This was caused by the difficulty of students in changing the story questions into mathematical form, misunderstanding of algebraic concepts, and lack of practice working on problems that refers to students' creative thinking skill. Therefore it was necessary to emphasize the understanding of algebraic concepts and the appropriation of questions based on the students' creative thinking skill.

1. Introduction

Mathematics is the important science to be learned because it is the basis for other sciences. If people learn mathematical concepts properly, certainly people will learn the other sciences well. Therefore the concept of mathematics is highly emphasized in education sector, especially in primary and secondary education. In addition, people cannot be separated with the context of mathematics in everyday activities, because mathematics in general is an activity related to calculations and numbers. To be able in learning mathematics properly, it requires a good understanding the concepts and the skill to calculate algebra form correctly.

The concept of algebra was introduced earlier in mathematics education and required the students to think using algebraic arithmetic operations [1]. Algebraic logical is very important to be emphasized for the students in learning mathematics because it is a process in which the students undertake some activities to find the patterns from a particular mathematical problem or contextual situation. In fact, many students have difficulty to solve algebra problem in various equations. The difficulties when the students learn algebra such as solving algebraic equations and lack of understanding of algebraic form regarding the equivalence and the negative numbers, it is very fundamental part of algebraic logical [2]. Therefore understanding the concept of algebra is emphasized in teaching and learning process.
especially in mathematics because it is closely related to the activities of thinking and understanding the patterns to make the generalizations. Mathematics lessons are given by the teacher to equip the students so the students can implement the mathematics model into daily life and be able to complete other sciences that contain some elements of mathematics. Therefore mathematics is a science that is mutually sustainable, because mathematical material that the students have learned in the school will be used when they are studying mathematics for or in the next material, especially in solving mathematical problems. Besides mathematics can be considered as a network concept because it consists of several concepts related to others. The main difficulty faced by the students in learning mathematics is connecting one concept with another concept [3].

Facing the demands and the development nowadays, mathematics is emphasized to improve the quality of education. The manners that can be used by the teacher are encouraging the students' thinking skills in learning and solving non-routine problems with open ended. These can be done by using experimenting, guessing, and communicating mathematical ideas that involve students' experiences and students' skill [4]. To be able to solve the problems properly, it requires the integration of ideas to determine mathematical patterns or structures, connecting various mathematical ideas as a basis for understanding new mathematics form, and connecting mathematical ideas with a broader context [5]. So, divergent thinking skills are needed, which emphasizes the creativity of each student. Students' mathematical creativity is defined as the act of students to solve the problems in new ways or the combination of ideas from mathematics with other conceptual abilities to enrich the students' understanding of mathematics concept [6]. Creativity is a product of creative thinking skill which has high-level thinking skill in dealing with the problems in various aspects. Creative thinking skill has the standard of problem solving that implemented by National Council of Teachers of Mathematics (NCTM), one of them is implementing and adjusting various strategies in solving the problems [7]. Creative thinking skill can affect the students' success in learning mathematics and other sciences, because this learning model emphasizes the understanding of concepts that used by students to find new ideas included the combination of information that is obtained from their previous experiences [8]. In addition, creative thinking processes can be classified into three dimensions including mathematics which requires thinking of various ways to solve the problems with additional solutions and applying mathematical ideas in different contexts and in various ways [9].

Mathematical creative thinking skill is a combination of logical and different thoughts that based on the intuition, it has a conscious purpose to be applied in solving practical problems and different thoughts to generate many ideas in seeking the answers [10]. Mathematical creative thinking skill can be seen from measuring several aspects of problems solving, including fluency, flexibility, and novelty [11]. In addition, the criteria according to the type of Torrance test for measuring creativity (creative thinking products) are fluency which is means as the number of responses that can be received, flexibility which is means as the number of different types of responses, and authenticity (novelty) which is means as the rarity of responses [12]. Then the indicators for assessing students' creative thinking skill included fluency, flexibility, and novelty that used in problem solving [13]. In order to produce creative thinking skill, the students need some activities that consist of learning material development and also find out the students' ways to solve the problems [14]. Then to achieve mathematical creative learning, personal skills are needed in order to the students can express themselves efficiently and can find the similarities or the differences from the problems that the students face in teaching and learning process so that the students become more independent in solving the problems [15].

2. Research Method
This research was a qualitative descriptive study. This research was conducted at the ninth grade students of SMP Negeri 4 Playen Gunung Kidul. The students had taken Two Variable Linear Equation System material and the sample based on the consideration of researchers and mathematics teacher in the research class. The subjects of this study were 8 students of IX A SMP Negeri 4 Playen Gunung Kidul Yogyakarta. The data collection techniques used in this study was written tests and
some interviews. Written technique using essay test that consists of 3 questions was used by the researchers to determine the students' creative thinking skill. While in-depth interviews were used to strengthen the students’ answers which be used for determining to what extent the students' understanding related to the concept of the Two Variable Linear Equation System. These interviews were conducted semi-structured, and then to find out the validity of the data, the researchers used triangulation methods. These steps were done by comparing the results of tests and the results of interviews on the same data sources. The research instruments were validated by three Lecturers including two Lecturers from Mathematics Education Department of Universitas Sebelas Maret Surakarta, and one Lecturer from Teacher Training and Education Faculty, Universitas Sarjanawiyata Tamansiswa. The result of validation showed that the test instruments that were used in this research to collect the data were valid. The levels of mathematical creative thinking skill that proposed by Siswoyo in the table as follows [16].:

| Levels                          | Characteristic                                                                 |
|--------------------------------|-------------------------------------------------------------------------------|
| Level 4 (Very Creative)        | The students could show their fluency, flexibility, and novelty               |
| Level 3 (Creative)             | The students could show their fluency and novelty, or, fluency and flexibility.|
| Level 2 (Adequate Creative)    | The students could show their flexibility or novelty                          |
| Level 1 (Less Creative)        | The students could show their fluency                                       |
| Level 0 (Not Creative)         | The students could not show their fluency, flexibility, and novelty           |

3. Result and Discussion

3.1 Result

To measure the students' mathematical creative thinking skill in solving the problems, researchers provided some tests that refer to the indicators of creative thinking skill, such as fluency, flexibility, and novelty. The test questions consisted of 3 essay questions, each number contained one indicator of creative thinking. After giving creative thinking skill test, then an in-depth interview was conducted to find out to what extent the students' understanding towards two-variable linear equations system material and the various obstacles that encountered when students worked on these problems. Interviews were conducted with eight students based on the results of the tests that they were working on. The results of tests and interviews were used by researchers to determine the students' creative thinking skill in solving the problems based on the indicators of creative thinking skill. The levels and percentages of mathematical creative thinking skill of eight students were presented in the following table:

| No | Students’ Initials | Fluency | Flexibility | Novelty | The Level of Mathematical Creative Thinking Skill | Percentages |
|----|--------------------|---------|-------------|---------|--------------------------------------------------|-------------|
| 1  | AS                 | ✓       |             | ✓       | Creative                                         | 12.5%       |
| 2  | AN                 | ✓       |             |         | Adequate Creative                                | 37.5%       |
| 3  | AY                 |         | ✓           | ✓       | Adequate Creative                                | 37.5%       |
| 4  | FA                 |         | ✓           |         | Adequate Creative                                | 37.5%       |
| 5  | RA                 | ✓       |             |         | Less Creative                                    | 50%         |
| 6  | MA                 | ✓       |             |         | Less Creative                                    | 50%         |
| 7  | DP                 | ✓       |             |         | Less Creative                                    | 50%         |
| 8  | EH                 | ✓       |             |         | Less Creative                                    | 50%         |

From the result in the table above, the data showed that the classification of 8 students in the level of mathematical creative thinking skill based on the achievement of creative thinking indicators. The results showed that one student conformed with two indicators of fluency and novelty (it was
categorized as creative), 3 students with 2 students conformed with the indicator of flexibility and 1 student conformed with the indicator of novelty (it was categorized adequate creative) and 4 students conformed with one indicator of fluency (it was categorized as less creative).

3.1.1 Test for Mathematical Creative Thinking Skill
1. (Indicator: Fluency).
   Determine the solutions set of equations system from \( x + 2y = 2 \) and \( 2x + 4y = 8 \) for \( x, y \in \mathbb{R} \), Don’t forget to give the conclusions! (Provide more than one way to find the answers!)

2. (Indicator: Flexibility)
   If we have two numbers, three numbers of the first number plus five in the second number, as the result are -9, then seven numbers of the second numbers plus five in the first numbers are -19, and three numbers of the second numbers equals four numbers in the first number plus 41. What is the value of the two numbers? (Provide more than one way to find answers!)

3. (Indicator: Novelty)
   It is known that two right triangles with area ratio of the first and second triangles are 2: 1. If the height of the first triangle is equal to the base length minus 1, then the sum of the base length and height is 7 cm and the sides of incline and the circumference are 5 cm and 12 cm. How many area of the second triangle? (Provide more than one way to find answers!).

3.1.2 The Analysis of The First Subject’s Answers
Category: Creative

![Figure 1. The Result of the First Subject](image)

**The First Subject Interview Transcript**

T : “What is the information that has you obtained from the questions number 1 and 3?”
S1: “In the problem number 1 we looked for the values of x and y and made the conclusions, while in the problem number 3 we looked for the area of the second right triangle.”

T: “How did you solve those two questions?”

S1: “In the question number 1 we looked for the values of x and y using elimination and substitution methods. Then in the question number 3 we looked for the value of the second right triangle area.”

T: “Why could you get the values x = 0 and y = 0 in the elimination and substitution methods?”

S1: “In the elimination method, the values of x and y were equal to negative 4 divided by 0, so the result was 0, then the substitution method was obtained x equals 2y minus 2, the result was 0 and y equals 2 divided by 2, so the result was 0 too. Because all the values of x and y were 0, there was no solution.”

T: “Then how did you do in the number 3?”

S1: “We looked for the base and height values in the first right triangle, then we found the area, then we looked for the second right triangle using the area of the first right triangle divided by 2.”

T: “Could the problem be solved using another way? For example you used two-variable linear equation system?”

S1: “Yes, sir, but I found it easier using the other method of two-variable linear equation system.”

T: “Why did you can get the value x = 25?”

S1: “Because on the left side 2x\(^2\)-2x = x, the conclusion was we can reduce it, sir, and on the right side it was 25 and there were no other numbers, so x = 25.”

T: “Did the two variables that were same but have different numbers of power operations could be calculated using addition or subtraction methods? And why did you get the value of y = 24?”

S1: “Yes, sir, because the variables were same. Then for the roots of 600 it was very difficult to find and usually was 24. Because 24\(^2\) equal 576 and less than 600, so the answer was 24.”

From the result of test and interview above showed that the student made problems solving related to fluency and novelty indicators. There was 1 student who could complete in this stage and it could be categorized as creative. But there were some errors in the process of her/his work. These errors included the understanding of algebraic concepts, namely the student assumed that two variables were same but it had different powers of numbers could be done by using the operations of addition or subtraction methods. The student assumed that variables could be performed subtraction operations for the numbers that did not have variables. The students assumed that the division of two numbers was same, so the result was zero, and then students concluded that the number divided by zero the result is zero too. In addition, the students also had difficulty in finding root values. If this did not corrected by the teacher, it would be hard for the student when they learned quadratic equation material.

3.1.3 The Analysis of the Second and the Third Subjects’ Answers
The second and the third subjects
Category: Adequate Creative
The Second Subject Interview Transcript

T : “What is the information that has you obtained from that problem?”
S2 : “I changed the problem into x and y then made an equation Sir.”
T : “How did you solve that problem?”

Figure 2. The Second Subject Test Result

Figure 3. The Third Subject Test Result
S2: “After got 3 equations, we continued to look for the values of x and y with substitution and elimination methods sir.”
T: “Is there any other ways besides what you are working on?”
S2: “Using Graph sir, but I still confused about how to make a graph.”
T: “Why did you do like that in substitution method? How could you write 45x? On the elimination method, why did the result like that? Did multiplication only work on in the variable that would be omitted?”
S2: "Because the equation 3 was easy to be substituted sir, I am confused about using any equation to find out the value of x and y. For 45x, it was obtained from 4x + 41 Sir. Yes, sir. Then in elimination method, we eliminated one of the variables by equating the numbers in the variables to run out or the value is zero, then we looked for the value of the other variables.”
T: “Do you think the multiplication of elimination is only done on variables that will be eliminated only?”
S2: "Yes sir in elimination method, multiplication was done only on the variable that would be eliminated. 

The Third Subject Interview Transcript
T: “What is the information that has you got from that problem?”
S3: “I found the area of the second right triangle by comparing to the area of the first right triangle Sir.”
T: “How did you solve that problem?”
S3: “First, I found the base and height values using special triangles and substitution Sir.”
T: "Is there any other way or method besides what you are working on?"
S3: "By using elimination method, sir.”
T: "Why did you find the base and the height of 3 and 4 in the first triangle right? And why did you write down the area of the second triangle twice?"
S3: “For the base and height in the first right triangle it was in the concept of a special triangle, that is, if the base and height are 3 and 4, then the hypotenuse must be 5. For the value of the area in the second triangle I am confused for the concept of comparison, it divided by 2 or multiplied by 2 Sir”.

From the results of the pictures and interviews above showed that the answers of students only solved one problem and it was categorized as adequate creative. Two students could solve one problem related to the flexibility indicators and one student could complete one problem related to the novelty indicators. From the results of second subject, there were still errors in the process. This happened because of the misunderstanding of algebra concept that was used in the elimination method, which was multiplication way to equalize the variable that would be eliminated by using multiplying. It was used only in the variable that would be eliminated without multiplication of other variables or it was constant in an equation. The operation of adding two numbers which contained variables could be calculated using sum operations. In addition, errors occur due to lack of accuracy in performing algebraic arithmetic operations. If it was not justified, it would have an impact on the students’ understanding the concept when they was studying further material related to the linear equations and elimination methods. Whereas in the third subject, the results of test showed that there was still confusion in determining the value of the comparison, whether in finding the area of the second right triangle was done by dividing 2 or multiplying 2 against the area of the first right triangle. These results had the impact of error in the final result even though the way that they worked out correctly.
3.1.4 The Analysis of the Fourth Subject’s Answers
Less Creative Category

Figure 4. The Fourth Subject Test Result

The Fourth Subject Interview Transcript
T : “What is the information that has you get from this problem?”
S4 : “There are two equations and we looked for x and y values, Sir.”
T : “How did you solve the problem?”
S4 : “I used substitution and graphics methods, Sir.”
T : “Is there another way to solve it?”
S4 : “Maybe using elimination and combination methods, Sir, but I am still confused.”
T : “Why did in your answer, the way of substitution and graphics methods like that? Why did you say there was no solution?”
S4 : “Because the values of x = 2y - 2 = 0 and y = 2: 2 = 0, so there was no solution and also there was no intersecting graph because there was only one line that can be drawn.”

From the result of test and interviews above showed that those students’ answers in solving the problems related to fluency indicators. The subjects who could only worked on this stage were 4 students and it could be categorized as less creative. But there were still errors in the process of doing the test. The students’ errors caused from the misunderstanding of algebra concept. These errors included the students assumed that if the numbers divided by the numbers of themselves (for example 2:2), the result was zero. The students assumed that the variable could be done using addition or subtraction operations with the numbers that did not contain the variables. Then in carrying out a calculation operation on the equation system, if the values of x = 0 and y = 0 were obtained, the conclusion was no solution from this form.

3.2 Discussion
Based on the results from the students’ work and the interview above, it was concluded that there are no students who are not creative, all can be seen from the test results. But no student is very creative. One reason is the difficulty of students in turning contextual questions into mathematical sentences and the difficulty in finding various ways of answering. On the other hand that there were errors made by the students in solving mathematical problems related to linear variable equations system. Mistakes not only occurred in the students who had less creativity, but also in the students with adequate creative and also creative. The most frequent mistake that the students made was the understanding
algebraic concepts, such as performing the basic arithmetic operations. Arithmetic operations contained a variable number. Then in performing arithmetic operations, it contained the power elements. In the first subject (creative category), it was found that: 1) There was an error in understanding the concept of algebra, including the numbers that containing variables could be performed using subtraction operations with the numbers without containing the variables, division of two numbers with the same result was zero, and the numbers divided by zero as the result was always zero. 2) If the value of \( x = 0 \) and \( y = 0 \) then there was no solution. 3) There was an error in understanding the concept of quadratic equations, so students assumed that two variables that were same but had different power can be performed by using subtraction operations. 4) The students paid less attention to the changes in hyphen when doing the calculations. 5) The students had difficulty to find the root values. In the second and the third subject (adequate creative category), it was found that: 1) The students were confused in solving problems in the three systems of equations to find out the values of \( x \) and \( y \) (for the second subject). 2) Based on three equations that had been formed, the students assumed that one equation was made by using the substitution method based on different forms of equations and 2 equations used the elimination method because the form of the equation was same (for the second subject). 3) The students assumed that the addition operation could be done even though one of them contained variables (for the second subject). 4) The students were careless in doing algebraic arithmetic operations. 5) The students assumed that in eliminating one of the variables with the elimination method, multiplication was only done on the coefficient that would be eliminated without doing the same multiplication of the other variables and constants in the equation (for the second subject). 6) In finding the base and height of a right triangle, the students referred to the concept of a special triangle (on the third subject). 7) The students were confused in understanding the concept of comparison, whether multiplication or division was carried out, it would cause multiple results (for the third subject). Then in fourth subject (less creative category), it was found that 1) The students assumed that a variable could be used with a subtraction without a variable. 2) The division of 2 equal numbers (for example 2:2) was 0. 3) The graph that there was one line had no solution.

Various kinds of the students’ errors were caused by the students’ weaknesses in understanding algebraic concepts so that the students had difficulty in completing the calculations and the result was incorrect answers. So, there was a change for the improvement in understanding algebraic concepts in order not to have bad consequences, especially when the students learned further material, especially those related to linear equations mathematical material. In addition, it was also necessary to provide non-routine question exercises so that the students were accustomed to solve open-ended questions and had no difficulty in using various (alternative) ways of finding answers.

4. Conclusion

Based on the results in general, it could be concluded that the students' creative thinking skill on algebra material were still low. This was evidenced from the tests of creative thinking skills that refer to the indicators of fluency, flexibility, and novelty. The test results obtained that one student (12.5%) conformed with two indicators of fluency and novelty (it could categorized as creative), 3 students (37.5%), they were 2 students conformed with one indicator of flexibility and 1 student conformed with novelty (it could categorized as adequate creative), and 4 students (50%) conformed with one fluency indicator (it could categorized as less creative). The low skill of students' creative thinking was the misunderstanding of algebraic concepts (such as counting numbers containing variables, division of two equal parts, looking for the root values) and difficulty in choosing a method of solving that should be used in the problems. That was the lack of students in practice problem solving non-routine questions. So when they were given a contextual problem (a matter of story), they had difficulty in changing the problem into a mathematical sentence. Therefore, it was necessary to improve the understanding of the initial concept of algebra and the provision of questions related to algebraic arithmetic operations such as addition, subtraction, multiplication, division, looking for root values, or arithmetic operations on numbers containing variables. This was done then the students were accustomed to solve the problems with the correct concept of algebra and when given contextual questions they could solve them coherently and correctly. In addition, the teachers were also expected
to be able to do the learning that was oriented to the students 'creative thinking skill and often provided the students with open-ended practice questions in order to know to what extent the students' understanding the algebraic concepts and trained the students became accustomed to find the alternative ways of answering mathematical questions that were contextual.

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