

Students' Creative Thinking Ability in Solving Open-Ended Questions

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ABSTRACT

Students must be able to think creatively to deal with problems in the 21st century. The aim of this study is to analyse the students' creative thinking skills in order to solve the open problems on algebraic operation material. The type of this study is qualitative descriptive study which used interview and test in collecting the data. There were seventh grade students at SMP IT Nur Hidayah as the subject of this study. There are three stages in analysing data of the study, including: data reduction, data collection, data presentation, and data conclusions. The findings of this study showed that the fluency aspect is only fulfilled by students with high mathematical abilities, while students with low mathematical abilities have not been achieved in solving the third problem. Further, only students with high mathematical abilities who can achieve the aspect of flexibility. Those students can explain well and give the reason properly how to get a written answer solution in solving the question. The students with high mathematical abilities also can achieve the originality aspect. In contrast, students with low mathematical abilities have difficulties in understanding the question and it makes them have no unique idea in answering the given question.

Keywords: Ability, Creative, Open-ended.

1. INTRODUCTION

The main objective of education now days is to increase the way of students' thinking. Mathematics lessons have been taught to children from an early age. This is because mathematics is very close and has relevance in various human lives. Mathematics is applied in various fields, including social fields as well as science and technology. Thus, the concept of mathematics is highly emphasized in education, especially in primary and secondary education. As we know that context of mathematics in everyday life can not be separated in human's life, because mathematic is relate with activity which include calculations and numbers. According to [1] to learn mathematics well, it takes an understanding of concepts and skill to calculate algebraic forms properly and correctly.

Further, mathematics leads students to have the ability to think logically, analytically, systematically,

critically, and creatively. This is in line with [2] who stated that mathematics is a means to develop logical, systematic, and creative ways of thinking. According to [3], creative thinking is something that must be mastered in facing the challenges of the 21st century. It is not only useful for solving problems at school but also in dealing with everyday problems [4]. Creative thinking skills are underdeveloped in mathematics because logic is more emphasized in discussion than creativity [5].

Creative thinking is seen as a process that a person uses to come up with new ideas. According to [6], creative thinking must produce a variety of appropriate products. Silver [7] stated that to identify the students' creative thinking ability by solving and proposing problem. There are three components of creative thinking ability, namely fluency, flexibility, and originality. [8] proposed three components of creative thinking to complete the task in alternative way, these

components are including: fluency, flexibility, and originality. Fluency refers to the ability to generate large amounts of thought. However, flexibility is the ability to think in a new or unique way among common ways, it means the idea is newest. One of the characteristics of a higher level of thinking is creative thinking, it refers to a logical and divergent thinking approach that is used to generate new ideas caused by non-routine problems and challenging problems [9].

Teachers always develop and teach creative thinking skills to the students in classroom learning activities by giving them the appropriate learning models. The aim of the activities is to develop the students' creative thinking abilities. In line with the data analysis, students' creative ability, especially in problem solving, understanding, and communication can be improved in several ways ([10], [11]). When a student is given a question, he does not want to do it and gives up first before trying to solve the problems contained in the problem. Therefore, to develop students' creative thinking skills, it can be done by using open-ended questions or in mathematics called open questions.

The openness aspects in open-ended according to [12] are classified to three types, namely 1) in solving it using an open solution process or various ways of solving it, 2) the final result is open, that are having many correct answers, and 3) advanced development is open. After students solve the problems, they can develop new questions, change the terms, and conditions of the questions being solved. [13] stated open-ended questions require students' creativity in thinking which is needed to answer more than just considering standard procedures in solving problems.

2. RESEARCH METHOD

This study is qualitative descriptive study which takes two students of seventh-grade who have high and low mathematical abilities at SMP IT Nur Hidayah. This study used test in the form of open-ended questions from the operation material in algebraic forms. The triangulation method is used in this study to validate the data. In addition, there were tests and interviews to collect data in this study. The data analysis used in this study refers to the stages of qualitative data analysis according to Miles and Huberman [14] namely data reduction, data presentation, and conclusion drawing. The division of students' completion which leads to indicators of creative thinking. Guidelines for assessing students' creative thinking skills in Table 1

Table 1. Creative thinking ability assessment

Indicator	Assessment
Fluency	Correct answer and can provide explanation, score 2 Correct answer but unable to provide explanation, score 1 Wrong answer, score 0
Flexibility	Correct answer and can give more than one method, score 1 Correct answer but cannot give more than one method, score 0
Originality	Correct answer and can explain more than one, score 1 One answer and cannot provide an explanation, score 0

3. RESULT AND DISCUSSION

The ability to think creatively in solving open-ended questions have been analyzed based on three aspects namely, fluency, flexibility, and originality. Fluency has been related to the answers given by students. Flexibility is related to the ideas that students find, while originality is about the uniqueness of ideas from students. These three aspects have been investigated from the student answer sheets which are then followed by interviews.

Problem 1.

Adi, Bima, and Cika simplify the algebraic form $3p - 4p$. Each of them got the result -1 , $-p$, and $-1p$. Write down which answer is correct and explain your reasons!

In the first problem, students were asked to evaluate the work of Adi, Bima, and Cika in simplifying algebraic forms. In the first problem, there are two aspects of creative thinking, includes fluency and flexibility. The students' answer with the first rank are presented in Figure 1.

$$\textcircled{1} \quad 3p - 4p = -p / -1p$$

Karena jika $3-4$, maka menghasilkan nilai -1 dan terdapat variabel p , maka hasilnya $-1p$ atau bisa ditulis $-p$

Figure 1. High ability students' answers to the first problem

Figure 1 shows students can assess the correct answers from Andi, Bima, and Cika but they are not quite right in assessing. It shows that students have an aspect of flexibility, namely students are being able to write down what they know and during the interview they can explain fluently how to find and get the answer. Therefore, students have reached the aspect of flexibility even though the final answer written is not quite right. [15] concluded that students with high mathematical abilities can write down the information in the questions correctly and are not confused in understanding the questions. In Figure 1 the students did not write down whose answer was correct. Students only write down the step to solve the problem question and finish the problem well, it can be seen that they are able to understand the problem and determine the steps for solving the problem properly and correctly. During the interview, it turned out that she was able to explain the answer to number 1 but it was not written on the answer sheet. It can be seen from the following interview excerpts:

P1 : Which one the correct answer of number one? Adi's answer, Bimas's answer or Cika's answer?

S1 : Bima's answer and Cika's answer Miss

P1 : Why their answer are correct?

S1 : Because $3p - 4p$ is 3 minus 4 the result is -1 , then there is p variable. $-1p$ can be written in $-p$, so both of them is correct

Based on the results of interview in the first problem, the subject of S1 is able to explain how to get the answer. In addition, students have already understood the concept of algebra in general, this can be observed from how students write or explain if the coefficient is 1 then the coefficients or only variables may be included.

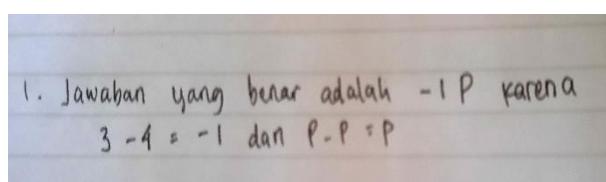


Figure 2. Low ability students' answers to the first problem

Figure 2 shows students with low abilities have not answered the questions. Students just write down the procedure for solving $3p$ minus $4p$ and the answer is $-1p$. However, the reason that given by them is wrong. Students operate the coefficients and variables separately. It can be seen that students write

$3 - 4 = -1$ and $p = p = p$. It shows that students do not understand the concept of algebraic form operations on subtraction. So, the flexibility aspect has not been achieved.

Problem 2.

Make an algebraic form that contains 4 terms and can be simplified to 2 terms!

In the second problem, students were asked to make a mathematical equation containing four terms and simplified into two terms. Therefore, the second problem contains three aspects of creative thinking, namely fluency, flexibility, and originality. The answers of students with high abilities are represented in Figure 3.

$$\begin{aligned} \textcircled{2} \quad & 3p + 5q - 2p - q \\ &= (3p - 2p) + (5q - q) \\ &= 1p + 4q \end{aligned}$$

Figure 3. High ability students' answers to the second problem

Figure 3 shows that high students can meet the flexibility aspect in solving problems. Although students do not write down information, students are able to make an equation containing 4 terms and simplify it into 2 terms. The achievements of the three aspects were clearly seen during the interview process. He explained their written answer fluently.

P1 : How did you solve question number 2?

S1 : Number 2 asks us to make an equation with 4 terms and simplify it into 2 terms, so I made the question $3p + 5q - 2p - q$

P1 : Okay, then what is the next step?

S1 : I grouped similar terms, then got $1p + 4q$

P1 : Why are the variables used only p and q ?

S1 : That's because in the question asked to simplify into 2 terms, so I used two variables

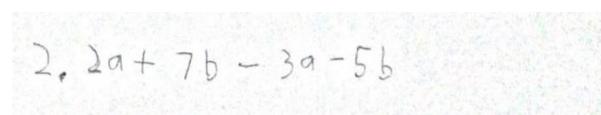
P1 : Should you use the letters p and q ?

S1 : No, we can use variable freely, it does not have to use p and q

P1 : Do you think there are other answers to answer question number 2? If there is an example, can you give me the example?

S1 : Yes. For example $2a + 8b + 3a - 2b$, then it simplified to $5a + 6b$

Based on the results of interviews with subjects of S1, students have already understood the concept of similar and dissimilar terms. This can be observed when students are able to simplify algebraic forms which were originally 4 terms into 2 terms, and are able to give other examples, namely $2a + 8b + 3a - 2b$ which is simplified to $5a + 6b$.



$$2, 2a + 7b - 3a - 5b$$

Figure 4. Low ability students' answers to the second problem

Figure 4 shows that students are able to make an equation containing 4 terms. However, students have not been able to simplify the equation into 2 terms. It is known that when the interview was conducted, students were still a little confused about what was asked in the question. Students write answers on the answer sheet obtained from the results of composing. This indicates that students have not reached the aspect of flexibility in mathematical creative thinking.

Problem 3.

It is known that the quotient of the algebraic form A by B is $(2x-1)$. Determine the possible algebraic forms of A and B that you can find!

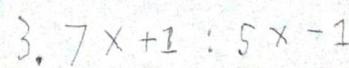
In the third question, students are asked to make algebraic forms of A and B by knowing that the quotient of A and B is $(2x-1)$. So, the question contains three aspects of creative thinking, namely fluency, flexibility, and originality. The answer sheets of students with high abilities are shown in Figure 5.

$$\begin{aligned} \textcircled{3} \quad A \div B &= (2x-1) \\ \therefore A &= (2x-1)(2x+2) = 4x^2 + 2x - 2 \\ \therefore B &= (2x+2) \\ \therefore \frac{A}{B} &= \frac{(2x-1)(2x+2)}{(2x+2)} \end{aligned}$$

Figure 5. High ability students' answers to the third problem

Figure 5 shows that students are able to solve the third problem. It can be seen that students are able to make equation A, which is $4x^2 + 2x - 2$ and equation B, which is $2x + 2$. When interviewed, he is able to explain fluently how to find the answer. The student has reached the aspect of flexibility even though he was confused with the information contained in the questions. When I asked them to make another equation, students take a long time to answer it. This confirms the research conducted by [16] that students with high abilities generally can solve open problems in the right way as an aspect of flexible thinking.

The difficulties in solving open-ended questions are seen in students with low mathematical abilities as shown in Figure 6.



$$3, 7x + 1 : 5x - 1$$

Figure 6. Low ability students' answers to the third problem

Students with low abilities cannot answer questions in number 3, it can be seen in Figure 6. Students cannot make algebraic forms A and B correctly. He wrote $7x + 1 : 5x - 1$ which showed that the students did not understand the problem well. When the interview was conducted, the student explained that he felt difficult and confused while answering on the problem. It shows that he has not yet reached the fluency aspect. Therefore, students with low abilities are less able to think creatively mathematically well.

As shown in solving the first and second problems, students with low mathematical abilities have not yet reached the aspects of fluency and originality in solving the third problem. She/he still doesn't understand the information written on the problem so she/he can't solve the problem at hand. This is similar to [15] who stated that the high thinking ability of students can meet the fluency aspect. This research is in line with [17] who says that students with low abilities do not meet the fluency aspect. In this study, it can be seen that students with low abilities have not met fluency, flexibility, and originality aspects.

The aspect of originality is the least achieved from the three aspects of creative thinking. It is rare to find students who meet these three aspects, only students with high mathematical abilities are able to fulfill these aspects. Supported by [18] it shows that there is a close relationship between aspects of originality and creative thinking skills. As a result, students who have reached the aspect of originality are already possible to reach the level of creative thinking

4. CONCLUSION

First, there is only student with high mathematical abilities who can achieve the fluency aspect. Students can explain and mention more than one answer. Conversely, the fluency aspect has not been achieved by students with low mathematical abilities for the third problem question. Second, only students with high mathematical abilities who can achieve the aspect of flexibility. Students can explain how to get a written solution and give the right reasons. Further, students with low mathematical abilities have not met the flexibility aspect. It can be seen when students solve the first and third problems, they have not been able to give the right reasons and explain the answers they have written. Third, the originality aspect can only be achieved by students with high mathematical abilities. Students can provide other ideas obtained through trial and error.

Based on the results, it can be briefly observed that students still do not understand the concept of operating algebraic forms. Therefore, teachers can get used to students with working on open questions so they can improve students' creative thinking skills. This is because creative thinking is one of the skills that students must have.

ACKNOWLEDGMENTS

The researcher would like to thank the principal and mathematics teacher of SMPIT Nur Hidayah who has supported and helped to conduct research at the school.

REFERENCES

- [1] S. W. P. Nugroho, Riyadi, and Triyanto, "Analysis of Students' Creative Thinking Skill in Solving Algebra Problem," *J. Phys. Conf. Ser.*, vol. 1539, 2020, doi: 10.1088/1742-6596/1539/1/012086.
- [2] A. F. Rachman and R. Amelia, "Analisis kemampuan berpikir kreatif matematis siswa SMA di Kabupaten Bandung Barat dalam menyelesaikan soal pada materi trigonometri," *MAJU J. Ilm. Pendidik. Mat.*, vol. 7, no. 1, pp. 83–88, 2020.
- [3] N. Faiziyah, Sutama, I. Sholihah, S. Wulandari, and D. A. Yudha, "Enhancing Creativity through Ethnomathematics," *Univers. J. Educ. Res.*, vol. 8, no. 8, pp. 3704–3710, 2020, doi: 10.13189/ujer.2020.080850.
- [4] R. Lince, "Creative Thinking Ability to Increase Student Mathematical of Junior High School by Applying Models Numbered Heads Together," *J. Educ. Pract.*, vol. 7, no. 6, pp. 206–212, 2016.
- [5] T. Y. E. Siswono, "Level of student's creative thinking in classroom mathematics," *Educ. Res. Rev.*, vol. 6, no. 7, pp. 548–553, 2011.
- [6] D. P. Utomo, "An Analysis on Creative Thinking Skill on Algebra Materials of Students in Regular, Acceleration, and Olympiad Classes," in *5th International Conference on Community Development (AMCA 2018)*, 2018, vol. 231, pp. 109–112, doi: 10.2991/amca-18.2018.31.
- [7] E. A. Silver, "Fostering creativity through instruction rich in mathematical problem solving and problem posing," *Zentralblatt für Didakt. der Math.*, vol. 29, no. 3, pp. 75–80, 1997, doi: 10.1007/s11858-997-0003-x.
- [8] M. N. Anwar, S. Shamim-ur-Rasool, and R. Haq, "A Comparison of Creative Thinking Abilities of High and Low Achievers Secondary School Students," *Int. Interdiscip. J. Educ.*, vol. 1, no. 1, pp. 1–6, 2012.
- [9] L. Puspitasari, A. In'am, and M. Syaifuddin, "Analysis of students' creative thinking in solving arithmetic problems," *Int. Electron. J. Math. Educ.*, vol. 14, no. 1, pp. 49–60, 2019, doi: 10.12973/iejme/3962.
- [10] S. Saragih and E. Napitupulu, "Developing student-centered learning model to improve high order mathematical thinking ability," *Int. Educ. Stud.*, vol. 8, no. 6, pp. 104–112, 2015, doi: 10.5539/ies.v8n6p104.
- [11] T. S. Yen and S. H. Halili, "Effective Teaching of Higher-Order Thinking (HOT) in Education," *Online J. Distance Educ. e-Learning*, vol. 3, no. 2, pp. 41–47, 2015.
- [12] A. Mahmudi, "Mengembangkan Soal Terbuka (Open-Ended Problem) dalam Pembelajaran Matematika," in *Semnas Matematika dan Pendidikan Matematika*, 2008, pp. 212–222.
- [13] D. Emilya, R. Ilma Indra Putri, and Darmawijoyo, "Pengembangan Soal-Soal Open-Ended Materi Lingkaran Untuk Meningkatkan Penalaran Matematika Siswa Kelas VIII Sekolah Menengah Pertama Negeri 10 Palembang," *J. Pendidik. Mat.*, vol. 4, no. 2, pp. 1–5, 2010.
- [14] Sugiyono, *Metode Penelitian Kuantitatif, Kualitatif dan R&D*. Bandung: Alfabeta, 2018.
- [15] R. Masruroh, I. Sujadi, and D. R. S. S, "Kategori

Berpikir Kreatif Siswa Kelas VII SMP Negeri 1 Surakarta dalam Menyelesaikan Masalah Matematika pada Materi Pokok Himpunan,” *J. Elektron. Pembelajaran Mat.*, vol. 3, no. 3, pp. 305–312, 2015.

- [16] F. Nurdyani, I. Slamet, and I. Sujadi, “Creative thinking level of students with high capability in relations and functions by problem-based learning,” *J. Phys. Conf. Ser.*, vol. 983, no. 1, p. 012102, 2018, doi: 10.1088/1742-6596/983/1/012102.
- [17] H. T. Damayanti and Sumardi, “Mathematical creative thinking ability of junior high school students in solving open-ended problem,” *JRAMathEdu (Journal Res. Adv. Math. Educ.)*, vol. 3, no. 1, pp. 36–45, 2018, doi: 10.23917/jramatheddu.v3i1.5869.
- [18] S. Akgul and N. G. Kahveci, “A Study on the Development of a Mathematics Creativity Scale,” *Eurasian J. Educ. Res.*, no. 62, pp. 57–76, 2016, doi: 10.14689/ejer.2016.62.5.