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Mathematical Creative Thinking Leveling on Non-Mathematics Department Students

Flavia Aurelia Hidajat[1,2)*], Cholis Sa'dijah[2)], Susiswo[2)], Sudirman[2)], Abdur Rahman As'ari[2)]
[1)]University of Panca Marga Probolinggo
[2)]Mathematics Education–Universitas Negeri Malang
Jl. Yos Sudarso 107, Pabean, Dringu, Probolinggo, 67271, Indonesia
E-mail: flavia.aurelia.1603119@students.um.ac.id[*]

Abstract: This paper seeks to explore and describe a mathematical characteristic of creative thinking level on non-mathematics department students. This paper took 56 college students of Faculty of Economy at University X as a research subject. The data were obtained through the test, interview, and observation. This research dealt with the five existing level and two additional level of creative thinking. The results indicated two additions of creative thinking leveling, namely level 5 which included the ability of students to elaborate ideas and be fluent in various problem solutions; and Level 6 which includes the ability of students to carry out idea elaboration, fluency, and flexibility in a variety of problem-solving strategies. Elaboration of ideas means that students are able to describe, develop previous ideas, and add some new ideas for the solutions generated.

Key Words: creative thinking level, creative thinking, non-mathematics students

Abstrak: Penelitian ini bertujuan untuk mengeksplorasi dan menggambarkan karakteristik tingkat berpikir kreatif matematis pada mahasiswa departemen non-matematika. Penelitian ini mengambil 56 mahasiswa Fakultas Ekonomi di Universitas X sebagai subjek penelitian. Data diperoleh melalui tes, wawancara, dan observasi. Data tersebut berupa deskripsi naratif. Penelitian ini menggunakan lima tingkat berpikir kreatif yang sudah ada dan dua tingkat tambahan. Hasilnya menunjukkan dua penambahan tingkat berpikir kreatif, yaitu tingkat 5 yang termasuk kemampuan siswa untuk mengelaborasi ide dan fasih dalam berbagai solusi masalah; dan tingkat 6 yang mencakup kemampuan siswa untuk melaksanakan elaborasi ide, kelancaran, dan fleksibilitas dalam berbagai strategi pemecahan masalah. Elaborasi ide berarti bahwa siswa mampu menggambarkan, mengembangkan ide-ide sebelumnya, dan menambahkan beberapa ide baru untuk solusi yang dihasilkan.

Kata kunci: tingkat berpikir kreatif, berpikir kreatif, mahasiswa non-matematika

INTRODUCTION

Mathematics is the basis of science. Daryanto (2013) argues that mathematics is the source of all other sciences. This indicates that mathematics is often applied as the basis for the emergence of other sciences. One application of mathematics that is very important in other sciences is economics. The statement is supported by Gilat & Amit (2013) which state that an increase in the economic application requires the application or innovative development of mathematics. Innovative development of mathematics does not only introduce and use mathematics in a simple way but also is able to think mathematically to produce new thought and idea. The mental process of producing new thought and idea as well as providing the right and unusual solutions in dealing with a problem is called creative thinking (Glassner & Schwarz, 2007).

Every individual generally possesses the ability of mathematical creative thinking. However, each of the individuals possesses a different level. Siswono (2008, 2010) discovers four level of mathematical creative thinking in mathematics department students. The four levels discovered are level 4 which indicates originality and flexibility or fluency, flexibility, and originality to solve problem; level 3 which indicates idea originality and fluency and thinking flexibility, level 2 which indi-

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Suatu Industri kerajinan mengahsilkan sebuah produk dengan biaya variabel per unitnya Rp. 9.000,00. Sedangkan biaya tetap dalam kegiatan produksi yang dikeluarkan sebesar Rp. 6.000.000,00. Tentukan harga perunit & jumlah unit produk yang harus dijual agar pemilik usaha tersebut tidak mengalami kerugian?

Figure 1. Mathematical Creative Thinking Problem in Economics

cates fluency and originality; thinking originality or flexibility, level 1 which indicates fluency in providing solution; and level 0 which indicates inability to achieve fluency, flexibility, and originality in solving problem.

Mathematical creative thinking levels according to Siswono (2008, 2010) are based on three creative thinking aspects, fluency, flexibility, and originality. This is in line with the research conducted by Shriki (2013). She reveals that creative thinking indicator includes three aspects namely fluent in providing an appropriate solution (fluency), flexible in providing problem-solving strategy (flexibility), and have an original solution and thought for problem-solving (originality). According to Varzaneh & Baharlooie (2015), an individual who possesses mathematical creative thinking is able to understand the problem. Creative thinking also offers individually to be able to explore learning materials based on his or her preferences and finding some theories or other approaches to solving the problem (Ruseffendi, 2006). It encourages the individual to have open-ended thinking from the available perspectives.

Different from the opinion of Shriki (2013), Jha (2012) opines that the indicators of creative thinking are fluency, flexibility, originality, and elaboration. Elaboration is one aspect of creative thinking which did not mention in the mathematical creative thinking level by Siswono (2010). Meintjes & Grosser (2010) define thinking elaboration as the ability of an individual to develop, elaborate ideas and include some details for the obtained information. In this research, creativity criteria about fluency, flexibility, originality, and elaboration are important to determine mathematical creative thinking leveling in open-ended problem-solving. According to Hobri (2009), open-ended problem solving is not only oriented to the final answer given by students. But also, students should be able to develop various methods or approaches in providing an answer for the problem and providing a new and appropriate solution. Hence, according to the above-mentioned explanation, this research will describe mathematical creative thinking leveling on non-mathematics department students based on fluency, flexibility, originality, and elaboration aspects.

METHOD

This qualitative research is a case study which aims at describing the characteristics of mathematical creative thinking level on non-mathematics department students. This research took 56 students of Faculty of Economics at University X. To obtain the data, test, interview, and observation was done. To identify students creative thinking ability and classify in mathematical creative thinking level, the test was given to them. Figure 1 presents the example of the test item. After completing the test, students expression and behavior were observed directly and by recording using video. Tests and observation activities were carried out to select subjects who meet the criteria of thinking elaboration ability when students solve mathematical economic problems. When the subject was selected, the interview was conducted to check the students' creative thinking skills particularly in thinking elaboration skills. Test, observation, and interview results were analyzed to describe the characteristics of mathematical creative thinking levels for non-mathematics students (economics students).

RESULTS

The results of the study include two levels of mathematical creative thinking for non-mathematical students which is an addition to mathematical creative thinking levels by Siswono (2008, 2010), namely level 5 and level 6. Levels 0 to 4 include 29 students, while levels 5 and 6 in research this includes 27 students. Two of 27 students were chosen to describe level 6 and level 7. This article only discusses the work of students who are at level 5 and level 6. Both of these levels are described as follows.

Level 5

Level 5 is the development of level 2 of Siswono (2008, 2010), namely the elaborated aspects of novelty. At this level, six students were able to elaborate, develop previous ideas, and add some new ideas for the

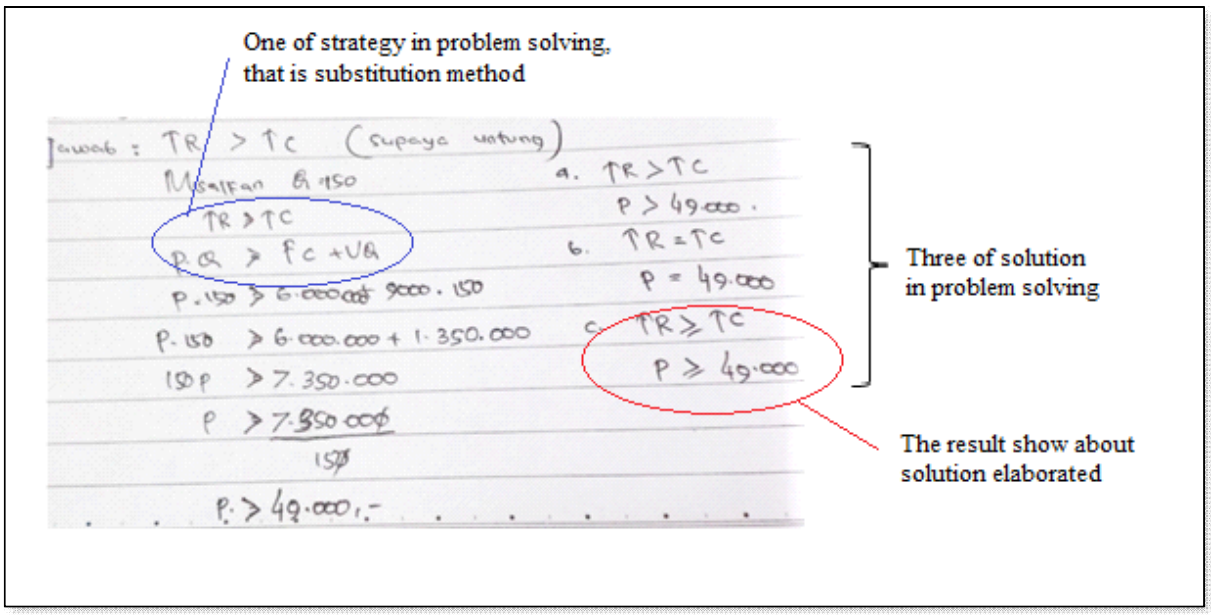

Figure 2. Students Work Result which Meets Elaboration and Fluency Aspects

solutions generated. Student work results related to the problem of Figure 1 can be seen in Figure 2.

Figure 2 is a solution of test item presented in Figure 1 given by students with the initials AKR. In Figure 2, AKR initially provides an answer solution, explaining that business owners do not experience losses, then TR > TC, so that for the number of goods sold as much as 1500, then the selling price that must be received is more than Rp 49,000.00. Based on the solution to this problem, AKR then provided other answer solutions, the selling price that must be received in order to avoid a loss is Rp 49,000.00 (alternative 1), more than Rp 49,000.00 (alternative 2), and more than equal to Rp 49,000.00 (alternative 3). AKR also explained the results of his work through interviews.

P: Why did you generate this equation (while pointing out to the third alternative)

AKR: According to the theory of economics, break-even point (neither profit nor loss) is showed by the TR > TC equation and for-profit (obtaining profit) is showed by TR = TC equation.

P: Yes, It is. However, how did you obtain the new equation (pointing out the third alternative)

AKR: From the break-even point and profit equation, I conclude that the person will not obtain both loss and profit if TR $\geq$ TC.

The third alternative is a new solution or answer which was developed or elaborated from the initial theory; break-even point equation (when the individual does not obtain profit or loss), TR > TC (alternative 1); and profit equation (when the individual obtain a profit), TR = TC (alternative 2) and hence he concluded a new equation where TR $\geq$ TC (alternative 3) which confirms that the result is "greater than or equal to Rp. 49.000,00" (alternative 3). In Figure 2, it shows that AKR only employed one strategy or method to solve the problem, that is a substitution.

Level 6

Level 6 is the development of level 4 suggested by Siswono (2008, 2010) which includes elaborated novelty aspects and flexibility in solving the problem. In this level, 21 college students were able to express fluency and novelty in solving the problem in Figure 1. The results generated by students were presented in Figure 3.

Figure 3 presents the answer generated by a student named PS. PS provides three different solution, Total Revenue (TR) > Total Cost (TC) if the individual obtains profit (alternative 1); Total revenue (TR) = Total Cost (TC) if it is break-even point (alternative 2); Total Revenue (TR) Total Cost (TC) (alternative 3). PS employed two methods of solving the problem, elimination, and substitution. The third alternative is a new solution or answer which was developed or elaborated from the initial theory, alternative 1 about profit in economic and alternative 2 about break-even point. This is also supported by the interview result regarding the answer generated.

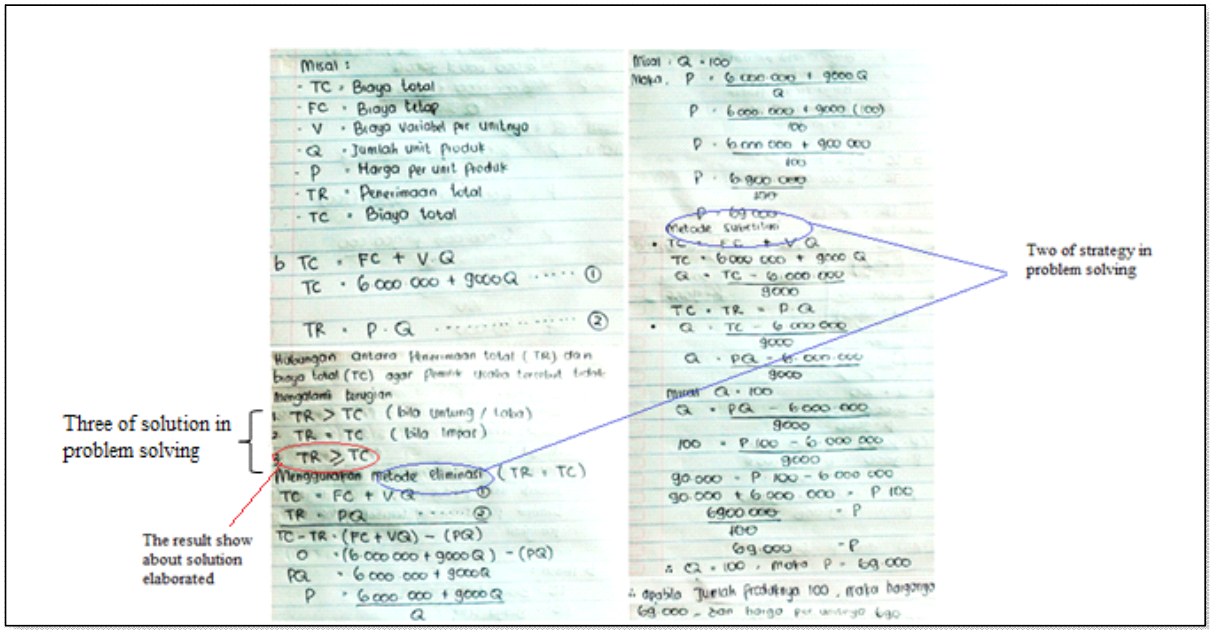

Figure 3. Answers Generated by Students which Fulfill Idea Elaboration, Fluency, and Flexibility Aspects

P: How did you obtain the alternative 3?

PS: I combine break-even point (TR TC) with profit equation (TR TC), hence the profit will be obtained or at least the loss will be obtained if TR TC.

DISCUSSION

Level 5

In this level, AKR solved open-ended problems regarding Mathematics for economics pretty well. AKR was able to generate more than one solution in solving an open-ended problem. AKR generated three solutions, namely (1) Total Revenue (TR) = Total Cost (TC) since break-even point (alternative 1); or (2) Total Revenue (TR) > Total Cost (TC), therefore the total revenue should be more than Rp. 49.000,00 (alternative 2). Shriki (2013) argues that the ability of a person in generating more than one solution appropriately in solving the problem on creative thinking ability is considered as fluency aspect.

In Figure 2, AKR elaborated accurately and developed the first and second alternative and at the end generated new equation; "TR $\geq$ TC" (alternative 3) or Total Revenue (TR) should be greater or equal to Rp. 49.000,00 (alternative 3). The interview result also affirms that,

From the break-even point and profit equation, I conclude that the person will not obtain both loss and profit if TR $\geq$ TC.

This is in line with the argument of Meintjes & Grosser (2010), stating that the ability to explain, develop, and include some ideas for the obtained information is considered as the ability to elaborate.

Moreover, the interview results indicate that AKR could comprehend the items pretty well as well as his conceptual understanding. AKR understands both the break-even point and the profit equation. In addition, AKR employed, developed, and explained break-even point and profit equation theories to discover new elaborated idea. It affirms that the student is able to have creative thinking since he or she could correlate the initial ideas which are not connected before (Amer, 2005). However, the student was difficult to discover a different approach to solving the problem.

Level 6

In this level, PS was fluent in providing an appropriate solution such as (1) Total Revenue (TR) > Total Cost (TC), thus the total revenue should be greater than Rp. 49.000,00 (alternative 1); or (2) Total Revenue (TR) = Total Cost (TC) since it is break-even point (alternative 2); and (3) Total Revenue (TR) $\geq$ Total Cost (TC), thus the total revenue should be greater or equal to Rp. 49.000,00 (alternative 3). This is in line with Sitorus & Masrayati (2016), the fluency of thinking is showed by the number of creative response for solving the problem.

PS was also flexible in providing various problem-solving strategies. PS employed more than one different method to solve the open-ended problem, elimination and substitution methods. This is in accordance with Siswono (2008) which states that the flexibility of stu-dents provides a problem-solving strategy which is served as one indicator of creative thinking which is often referred to as flexibility.

In Figure 3, PS employed and developed alternative 1 and 2 to generate new equation "TR $\geq$ TC" (alternative 3) or (3) Total Revenue (TR) $\geq$ Total Cost (TC), thus the total revenue should be greater or equal to Rp. 49.000,00. It further strengthened by PS statement,

> I combine break-even point (TR TC) with profit equation (TR TC), hence the profit will be obtained or at least the loss will be obtained if TR TC.

This condition is in accordance with Jha (2012), students have demonstrated the ability of elaboration, where they made several steps in detail for the next work plan and generated a new solution. The results of written work and interviews show that PS has demonstrated elaboration skills, fluent in providing various problem solutions, and flexible in providing problem-solving strategies.

CONCLUSION

The results of the study include two additional levels of mathematical creative thinking for non-mathematical students. It develops the mathematical creative thinking level by Siswono (2008, 2010), namely level 5 and level 6. Level 5 includes the ability of students to elaborate ideas and fluent on a variety of solutions problem. Elaboration of ideas means that students are able to describe, develop previous ideas, and add some new ideas for the solutions generated. Level 6 includes the ability of students to elaborate idea, is fluent, and flexible in generating various problem-solving strategies.

Level 5 is the development of level 2, namely the novelty aspect that has been elaborated, while level 6 is the development of level 4 which includes the ability of students to do idea elaboration and be flexible with various problem-solving strategies.

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