Investigating undergraduate students’ mathematical creative thinking skill in social arithmetic problem

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Abstract. Mathematical creative thinking skill is one of the 21st century skills that students must possess to work in the world of work. This article address to investigate the mathematical creative thinking skill of mathematics education students. In order to do so, we carried out a three-step of small-scale qualitative study involving 20 undergraduate students of mathematics education program. First step, we designed three social arithmetic problems to assess creative thinking skill. Second, we tested the problem to students of mathematics education program and then we interviewed the students about their solutions. The test lasted for 60 minutes. Finally, we analyzed students’ written work based on indicators of mathematical creative thinking skill. The result showed the lack of flexibility of the undergraduate students of mathematics, but undergraduate students had been able to provide unique ideas in solving problems and detailing what is needed in solving them. In other words, undergraduate students as prospective teachers have been able to think creatively in solving mathematical problems but difficult to solve the problem which has some solution.

1. Introduction

Working competition in the 21st century is increasing, so it is necessary to formulate new competencies and skills to face the 21st century. The formulation of competencies and skills must be applied in the national education system which is one of the means for us to develop our potential. One of the results of the 21st century skill formulation that is deemed necessary is creative thinking skills [1, 2, 3, 4].

Creative thinking skills can be interpreted as thinking skills that can bring innovative ideas in solving problems or can be said to be divergent thinking skills [1]. Creative thinking skills in students can be triggered and developed by providing open-ended problems that require creativity in solving them [5, 6]. Creativity can be defined as being more sensitive to problems such as incompatibility, missing information or element, and so on; identify problems, searching the solutions, make hypotheses and then test them until at the stage of communicating the results [3].

Creativity itself is a product of creative thinking, where in mathematics creativity plays an important role in advanced mathematical thinking as in the discovery of new theories, or in analyzing new phenomena mathematically [7]. These skills are then referred to as mathematical creative thinking skills. In Indonesia, mathematical creative thinking is one of the goals of mathematics learning which is regulated in the national education system. The ability to think creatively mathematically follows two abilities namely convergent and divergent thinking that have characteristics including fluency of thinking, flexibility, elaboration, originality [8, 9, 10]. Before training students to think creatively, a
teacher must first be able to think creatively too [11]. The results of other studies on creativity show that preservice teachers have difficulty in assessing mathematical creativity in the classroom, so the lecturers must pay more attention to the creativity of prospective teacher students [12].

This study aims to explore the mathematical creative thinking skills of undergraduate student as prospective mathematic teachers in more complex social arithmetic problems. Social arithmetic problems are arranged as open-ended problems where this problem is an entrepreneur's problem that can be solved mathematically.

2. Experimental Method
To investigate undergraduate student Mathematical Creative Thinking Skill in Social Arithmetic Problem, we carried out a three-step of small-scale qualitative study involving 20 undergraduate students of mathematics education program. First, we designed three mathematical entrepreneur problems to assess creative thinking skill. The three problem are presented in Table 1. The problems that we design are open-ended question. Second, we tested the problem to student of mathematics education program and then we interviewed the students about their solutions for the problem given. The test lasted for 60 minutes. Finally, we analyzed student written work based on indicator of mathematical creative thinking skill.

| No. | Indicator                                                                 | Problem                                                                                       |
|-----|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| 1   | The ability to find alternative answers uniquely from the problems given   | You have money about 14 million to open a business. From the results of your investigation, there is someone who offers his business to be sold and his business is an internet cafe. He sold everything at a price about 25 million with the business conditions running but the shop contract has expired. The shop rental price can only be 24 million per year. After checking the business document, it was found that during the last 6 months the net income of the cafe was 3 million per month. If the bank provides a loan with an interest of 10% per year and is paid in installments every month a. How much do you have to borrow from the bank to buy a business b. How long can you repay all of the loans c. How long you reach capital returns |
| 2   | The ability to do calculations or explain problems with the right and correct mathematical concepts(Elaboration) | Agung is an online businessman who sells electronic devices. For reservations in the city, he thought of using an online taxi service to deliver the ordered items to customers. In the city there are 2 online taxi companies with different rates. The first online taxi service is Rp 7,000 + Rp 200 / Km while the second online taxi service is Rp 6,500 + Rp 250 / Km. Which online Taxi service should Agung choose? |
| 3   | The ability to provide clear strategies or approaches in solving problems   | Rama opened an apple shop in the city of Bandung. For the purposes of his shop he supplies apples from the city of Malang. Delivery of Apples from Malang to Bandung is done every 3 days as many as 15 apple boxes. In order not to be damaged, every 1 apple box is packed in a wooden box. 5 apple boxes were weighed and had a gross weight of 350 kg, with a net weight of 98% of gross weight. If added with 10 other boxes, the net weight is more than 1000 Kg. The apples will be sold by Rama for Rp 25,000 / Kg a. Mention the information needed to determine the weight of a wooden box, then calculate the weight of one wooden box used to package the apple. b. Mention what information is needed to calculate Rama turnover in one month if it is assumed that all the apples are sold out and the first shipment is done at the beginning of the month. Then calculate the gross income |
3. Result and Discussion

Table 2 summarizes the results of undergraduate student written work on social arithmetic problems. The columns #Correct mean the numbers of correct answers. According to Table 2, the results are surprising; the undergraduate student lacked flexibility in creative thinking. The students are easily fooled by problems that have more than one solution.

Table 2. Summary of student written work

| Indicator | Problem | #Correct (%) |
|-----------|---------|--------------|
| Originality | 1a | 20 (100) |
| | 1b | 13 (65) |
| | 1c | 13 (65) |
| Flexibility | 2 | 8 (20) |
| Elaboration | 3a | 14 (70) |
| | 3b | 14 (70) |

Figure 1 showed the variation of the answer the first problem that is a question to see originality from mathematical creative thinking. For the problem "how much money do you have to borrow?" (Problem 1a), there is no different answer from the sample. All of the sample give the same answer that is 35 million because the total cost to buy is 49 million and we have 14 million. But for the problem "how long can you return the money" (Problem 1b), we found there are 2 variation of answers. See Figure 1, the first answer, they think that not all net profits earned must be paid to the bank (net opinion assumption of 3 million per month). When interviewed regarding the answers, they assumed that some of the net profits were used for other purposes, some answered daily living expenses and some answered for storage to pay for the shop rent when the shop's contract expired (Figure 1 (a)). That answer is logic, but there is a mistake in the calculation. In Figure 1 (a) the students calculate interest only for one year whereas, the payback period is 13 months or more than one year. For the answers about the money used to pay shop rent, there is a misinterpretation of net profit. In principle, net profit is profit after deducting operational and non-operational costs, including the allowance for money to pay rent for the future. Whereas the second answer, Figure 1 (c) and (d), they use all the benefits obtained to pay off debts in the bank. When interviewed, they considered other needs such as personal needs were covered by other income outside the newly built business, while to pay the next shop rent was set aside outside the net profit. From these two answers, it can be seen that the students have been able to build ideas for a unique solution even though there are still some errors in the calculation.

The second problem is to measure the elaboration of the sample, see Figure 2. In this problem there are two types of answers that we found. The first answer, Figure 2 (a), (b), they answer based on the basic rates without seeing the distance traveled, so they think the second rate must be chosen. While the second answer by considering the distance, there are three possibilities, namely, if the distance is less than 10 Km then the second online motorcycle taxi is used, if the distance is more than 10 Km then the first online motorcycle taxi will be chosen because it will be cheaper, and if the distance is exactly 10 Km then it's free to choose between the first or second online taxi (Figure 2 c). This second answer is more appropriate because it can explain the problem with the right and correct mathematical concepts. 80% of the sample is stuck to only choose one answer based on the basic fee alone without considering the distance traveled, see Figure 2. So that in the case of sample elaboration there is still a shortage.
Translate:
If viewed from net income for the past 6 months, 
\[ - \frac{10}{100} \times 35,000,000 = 3,500,000 \] interest per year. The money that must be returned \( 35,000,000 + 3,500,000 = 38,500,000 \). Monthly profits of 3,000,000 are used to pay interest. If you think half of the profit is 1,500,000 to pay to the bank and the rest is for living expenses.

\[ \frac{38,500,000}{1,500,000} = 26 \text{ months (repayment time)} \]

Translate:
From revenues of 3 million / month, 1,200,000 are saved to pay for the shop rent next year. Residual income: 1,800,000 / month For 2 years 43.2 million in revenue was obtained. If the loan is for 2 years: \( 35,000,000 + 3,500,000 + 3,500,000 = 42,000,000 \)
So the time period needed is 2 years

Translate:
The total must be paid at 10% interest
\[ 35,000,000 \times \frac{10}{100} = 38,500,000. \] because the monthly profit is 3,000,000, the time needed to repay the loan is
\[ \frac{38,500,000}{3,000,000} = 12.83 \text{ months = 13 months} \]

Translate:
he will choose the second online ojek service because by choosing a second online taxi service, the expenses incurred by Agung are smaller than the first online taxi services

Translate:
for 5 Km
I: Rp 9,000 II: Rp 7,750
So the online taxi service that Agung has to choose is the second online motorcycle taxi service

Figure 1. The students’ answer of Problem 1
If \( x < 10 \) choose second (B) online taxi
If \( x > 10 \) choose first (A) online taxi
If \( x = 10 \) may choose one of them
\( x = \) distance (Km)

(c) Figure 2. The student answer of Problem 2

The third problem is to see the flexibility. See Figure 3, we found that the sample was able to specify what data was needed to solve the problem, but there were 2 variations in the settlement. See Figure 3 (a), the first settlement is that the sample calculates the gross weight and net weight for each apple box then calculates the difference between the two to determine the weight of the packing of the wooden box. Secondly, see Figure 3 (b), the sample directly calculates the weight of 5 wooden boxes because it already knows the percentage of net weight of the apple box which is 98%, in other words 2% of the total weight is the weight of the wooden box. In problem 3b there are also two variations of answers in solving problems. The first see Figure 3 (c), students assume the weight of each 5 boxes is the same, so that the net weight of 15 apple boxes is the net weight of 5 apple boxes multiplied by 3, while the second see Figure 3 (d), because there is no weight information every 5 boxes are the same, they can only estimate the income obtained by taking the total weight 15 boxes of more than 1,000 Kg so that a monthly turnover (assuming 30 days) is more than Rp. 250 million with delivery every 3 days which results in 10 times delivery and the total weight of apples for a month is 10,000 Kg. From this third problem, the sample has been able to provide clear strategies or approaches in solving problems.

Translate:
Bruto 5 apple boxes : 350 Kg
Netto : 98% of bruto
Bruto 1 apple box : \( \frac{350}{5} \) = 70 Kg
Netto 1 apple box : 70 \times \frac{98}{100} = 68,6 Kg
the weight of the wooden box = Bruto – Netto = 70 – 68,6 = 1,4 Kg

(a) (b)
Turnover : $1000 \times 25.000 \times 10 = 250.000.000$

so the turnover received in one month is more than 250.000.000

Figure 3. The student answer of Problem 3

After students finish the test, we interview about the tests given. As a result, students find it difficult to work on problems number 1 and 3 because in the usual social arithmetic problems about originality and flexibility but the student still able to solve it, whereas on problem 2 about elaboration that is considered not too difficult, shows very surprising results. The students have not been able to analyze other possibilities in the solution of the problems given and can’t explain the problem with the correct mathematical concepts.

4. Conclusions

From results describe in the previous section, we draw the following conclusions. The result showing the lack of elaboration of the undergraduate student of mathematic educations, but undergraduate students have been able to provide unique ideas in solving problems and provide clear strategies or approaches in solving problems. In other words, undergraduate students as prospective mathematics teachers have been able to think creatively in solving mathematical problems but difficult to solve the problem which has some solution. So in the future we suggest that students be taught more often using an open-ended approach to practice mathematical creative thinking skills.

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