Preservice Teachers' Techniques for Generating New Problems

Dini Kinati Fardah
FMIPA, Universitas Negeri Surabaya
email: *dinifardah@unesa.ac.id*

Abstract
Evaluating students' achievement is one significant part of teachers' pedagogical competency. However, teachers should give problems in vary to their students. The ability of the teachers in developing the new problem from the existing or available problems is necessary to be mastered. This paper aimed to analyze preservice teachers' techniques in developing new problems. Twenty-nine preservice teachers who had experience in internship program were given three mathematical problems each in probability, trigonometry and number and pattern. They were asked to generate new problems from those problems given. The techniques used by the teachers on generating new problems from the original problems were analyzed and classified as replacement, addition, modification, contextualizing the problem, turning around the problem, and reformulation technique. In summary, teachers are most frequently taking the same given information but changing the problem from the old one. Teachers were still unfamiliar to turn the problem around by taking the end goal as given and the given as the end goal. The implication of this study is lecturers of mathematics education program especially in the subject that contains assessment and evaluation need to consider about developing the preservice teachers' ability to generate new problems from the old or existing problem given in all types of the development.

Keywords: *generating new problems technique, problem posing, good problem, preservice teacher's ability, assessment.*

1. INTRODUCTION

Doing an assessment after a learning process is one of competence that have to be mastered by teachers. In school, assessment that done by teachers mostly defined as giving a test as a measurement whether the learning objective has achieved or not. In consequence, having ability to create an instrument to assess their students is a must for teachers. According to Peraturan Menteri Pendidikan Nasional Nomor 16 [1], one of basic competencies that Indonesian teachers should have is doing assessment and conducting learning process and learning achievement evaluation. One competence that support that basic competence is developing a valid and reliable instrument to assess and evaluate the learning process and learning achievement. Therefore, Indonesian teachers are required to have a good ability in developing the instruments. Considering that background, posing problems become one important part that support teachers' pedagogical competence especially in assessment and evaluation.

Posing problems becomes a significant ability that teachers must be fluent with it [2]. In mathematics, posing a problems is important as posing good problems to students will bring the students in depth concept understanding [3], as it is part of the mathematics education reform vision that seeks to promote mathematics as an worthy intellectual activity.

Osana and Pelczer [4] had reviewed some researches on teacher education in posing problems and had grouped the function of teachers' posing problems into three categories: as practice of teaching mathematics, as an activity separate from teaching, and as tool to assess an outcome variable or assessing the development of preservice teachers' knowledge or beliefs. Zakaria and Salleh [5] studied about teachers' creativity in posing problems in certain topic of mathematics. While Chen, Dooren, Chen and Verschaffel [6] investigated teachers' ability in posing and solving realistic problems. Xie and Masingila [7] found that teachers' problem posing contributes their problem solving effectiveness. It can be said that a teacher that has good problem posing ability also will has good problem solving ability. However, this research was more focused on problem posing as tool to assess preservice teachers' knowledge and mapping the problems by classifying the new problems that generated or posed by preservice teachers. New problem in this study is defined as problem that generated by the teachers from given problem. This study is significant to conduct as Indonesian teachers usually teach several big parallel classes. Therefore, the ability to pose good problems for those different big classes are really important for teachers here.

Vistro-Yu proposed [8] six techniques in generating new problems from the old ones can be practiced by teachers are replacement, addition, modification, contextualizing, turning the problem around, reformulation. Replacement technique means the teacher pose the same problem but changing the quantities, amounts, units, shapes, etc. Addition technique can be done by posing the same problem but adding a new given or constraint or adding an obstacle. Taking the same given but could be totally new is called modification technique. The solving step is still following the solution of the original problem. Contextualizing means the problem made more relevant to students but basically it is still the same problem with the original. Turning the problem around means taking the same problem but taking the goal as the given and the given as the end goal. It is completely different. Reformulation means posing the same problem in a different type but using knowledge of the same concept or skill as required from the original problem, for the example from a proving problem to a situational problem.

2. RESEARCH METHOD

This is a qualitative descriptive research. Three problems of the topic probability, trigonometry, and number and pattern of junior and senior high school level were given to 29 preservice teachers of mathematics education study program of Universitas Negeri Surabaya of seventh semester (academic year 2014). They were chosen intentionally as they had experienced internship program. It means that they have been taught almost all subjects in the mathematics

education study program curriculum that were related to pedagogical content knowledge such as basic of education, assessment, learning instructional development, learning theories, school mathematics, microteaching, and other related subjects. In addition, they had implemented what they have learned into their real teaching practice when experiencing the internship program.

The teachers were asked to generate new problems that have difficulty levels higher than the given problem. Specifically, they were required to pose problems that has cognitive process of analyzing, evaluating, or creating according to Bloom's Taxonomy revised [9]. The data were obtained from preservice teachers' work in generating one new problem from each three problems given namely probability, trigonometry, and number and pattern problem. Then, those problems created by the teachers were analyzed and categorized using categorization that proposed by Vistro-Yu [8] i.e. replacement, addition, modification, contextualizing, turning the problem around, or reformulation and also analyzed by using dimension of cognitive process of Bloom's Taxonomy revised [9]. The data of the numbers of the teachers using a certain technique are presented in table in the form of percentage and then described descriptively.

3. RESULTS AND DISCUSSION

The result of this study is divided into 3 parts, categorization of problems made by preservice teachers for the probability, trigonometry, and number and pattern problem. Here presented each problems which was actually given answered in Indonesian, but then translated into English.

3.1. Categorization of problems generated from the probability problem

Probability problem that was given to the preservice teachers is presented in Figure 1.

Dua buah dadu dilambungkan bersama-sama. Berapakah peluang dari munculnya dadu berjumlah 9?	*"Two dice were rolled together. What is the probability of the sum being 9?"*
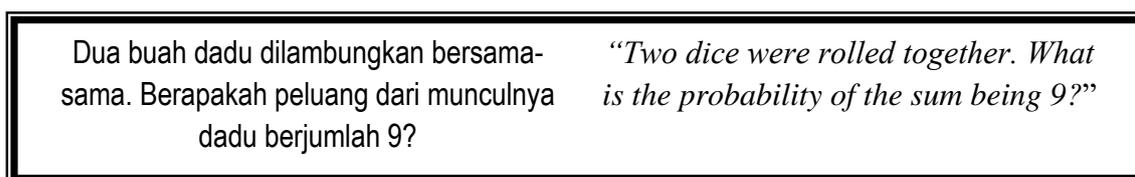
Figure 1. The probability problem given to the teachers

The dimension of problem shown in figure 1 can be categorized is applying dimension because the process of solving the problems above merely applying the formula of determining the probability after determining the sample points of the appearing two dice with the sum of being $9 = \{(3,6),(4,5),(5,4),(6,3)\}$. Determining the sample points can be categorized as understand, while determining the probability after this step can be classified as apply. The percentage of innovation made by teachers is summarized in the Table 1 below.

-------------------- **Jurnal Ilmiah : SOULMATH, Vol 6 (1), Maret 2018, Halaman 37-45** ----------------

Table 1. Percentage of new problems categorization of probability problem

	Replace	**Add**	**Modify**	**Contextualize**	**Turn around**	**Reformulate**
Number of teachers using technique	**6**	**5**	**4**	**6**	**3**	**6**
Percentage	20.69%	17.24%	13.79%	20.69%	10.34%	20.69%

There one teacher (3,45%) that failed to generate new complete problems. That teacher did not modify the old problem. He was failed to understand the instruction given. But, impressively, there were also two students (6,89%) that used more than one techniques. In the table 3.1, those two students count twice, on in the contextualize column, and the other in reformulate column. For the example, one of them change the problem as shown in Figure 2 below.

"Adi, Budi, and Citra played a game using two dice. The rules are: two dice will be rolled and everyone has only one chance to toss. Adi will be a winner if the sum of two dice is 5. Budi will be a winner if the sum of two dice is 7. Citra win the game if the dice show 9 as the sum. Are those rules fair enough for everyone?"
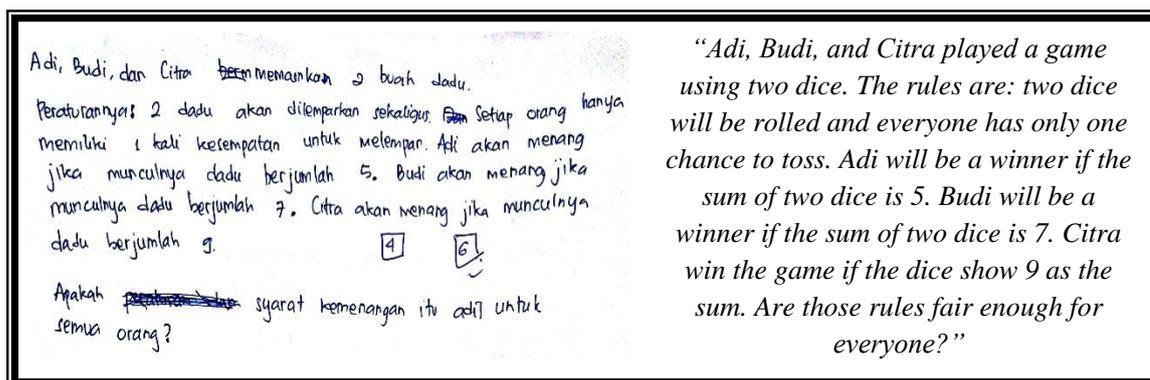
Figure 2. Problem generated by teacher by implementing two different development in one

The problems made by preservice teacher above changing from the old problem into more contextual problem. Besides, he also reformulate the different type from the old one. The solution need students to determine the probability of everyone who played the game also justify the rules fair are enough or not by comparing the probability of each players. This problem can be categorized as evaluate dimension as it requires the students to judge and compare to get the solution.

The most frequently technique used by the teachers are replacement, contextualizing and reformulation (20,69%). The two last technique obtained the similar problems as showed in the figure 2. The problems posed by doing a replacements are in vary. For the example students change nine become 8, 10 or other numbers, or change it into odd or even numbers as conditions. The technique that less used by the teachers is turning the problem around (10.34%). Although it was used by small numbers of teachers, the problems

appeared from implementing this technique was interesting. The example is as presented in figure 3.

Modifikasi soal : Dua buah dadu dilambungkan secara bersamaan. Carilah kemungkinan-kemungkinan muncul jumlah dadu tertentu yang peluangnya 0,11 !	*"Two dice were rolled together. Find the possible events so that the probability of the sum being a certain number is 0.11.*
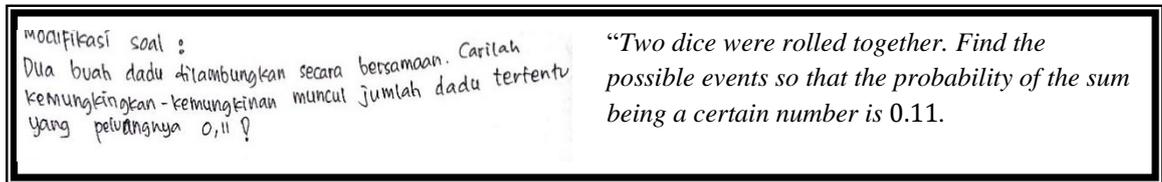
Figure 3. Problem generated by teacher by turning the problem around

The old problem was closed or the answer was unique. But the new problem made by preservice teacher in figure 3 is an open-ended problem and the answer is not unique. It took the difficulty level of the problem become higher than the old one. Students need to think higher to solve this problem. They need to explore the event that meet that probability. For the example is the event of appearing two dice where the sum of the dice less or equal to 4 and die 1 is not equal to die 2. Similarly, the appearance of two dice where the sum of the dice more or equal to 10 and die 1 is not equal to die 2 is also can be the solution of the problem in figure 3.

3.2. Categorization of problems generated from the trigonometry problem

Trigonometry problem that was given to the preservice teachers as presented in the figure 4.

Diketahui segitiga ABC dengan panjang AC = 5cm, $m\angle A = 75°$ dan $m\angle B = 45°$. Tentukan panjang sisi BC.	*Given a triangle of ABC with the length of AC = 5cm, $m\angle A = 75°$ dan $m\angle B = 45°$. Determine the length of BC."*
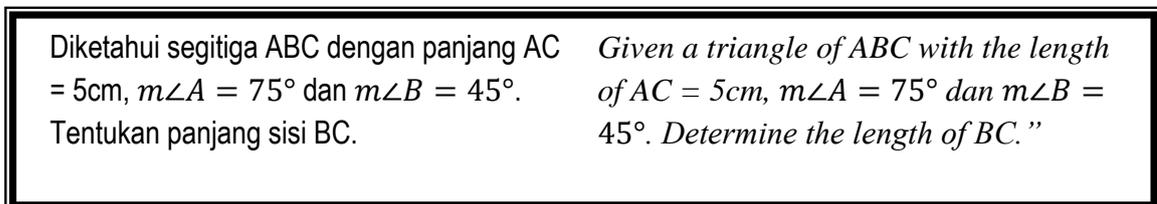
Figure 4. The trigonometry problem given to the teachers

The problem shown in figure 4 can be categorized as understanding dimension because the process of solving the problems above is only using the formula of sinus rule without any constraints. Students are only required to understand the components of the given information and then continue to input the given to sinus rule. The understanding process of the students' thinking also can be helped by drawing the triangle ABC. The correct triangle drawing along with the correct components determining in the problem will bring the students easily use the formula of sinus rule. Memorizing sinus rule which is categorized as remembering process is included in it. The percentage of innovation made by teachers is summarized in the table 2 below.

Table 2 Perecentage of new problems generated categorization of trigonometry problem

	Replace	Add	Modify	Contextualize	Turn around	Reformulate
Number of teachers using technique	2	6	10	4	0	5
Percentage	6.90%	20.69%	34.48%	13.79%	0.00%	17.24%

We can see in table 2, modification was the most favorite technique that used to modify the problems above (34.48%). Teachers are tend to change the problems from asking to determine the length of BC into asking the area of the triangle with the same given information from the old problem. No one tried to turning the problem around for the example by provide the given AC = 5cm, $m\angle A = 75°$ and also knowing the length of AB or BC, then asking the angle of B or C. Although no one tried this technique, it does not mean that the problems they obtain were not interesting. There are many new interesting problems especially for the word problems or implementing contextualizing technique to the given problem as shown in figure 5.

"Mario will tap 3 ribbons with different color into his original handmade of photo frame which is triangle in shape. Each of the side will be tapped by those ribbons. He needs 5cm yellow ribbon. The angle formed from the side for yellow and green ribbon is 75° and the angle formed from the side for green and red ribbon is 45°. How long red ribbon needed by Mario?"
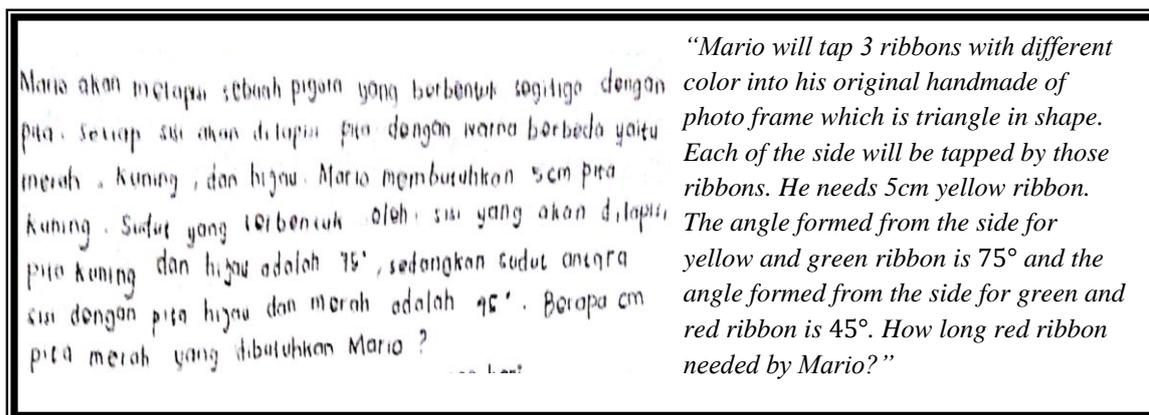
Figure 5. Problem generated by teacher by contextualizing

3.3. Categorization of problems generated from the number and pattern problem

Number and pattern problem that was given to the preservice teachers as presented in figure 6 below.

Perhatikan pola bilangan berikut: 1, 3, 6, 10, … Berapakah bilangan pada pola ke 15?

"Consider the following pattern of numbers: 1, 3, 6, 10, ... What is the number on the 15th pattern?"
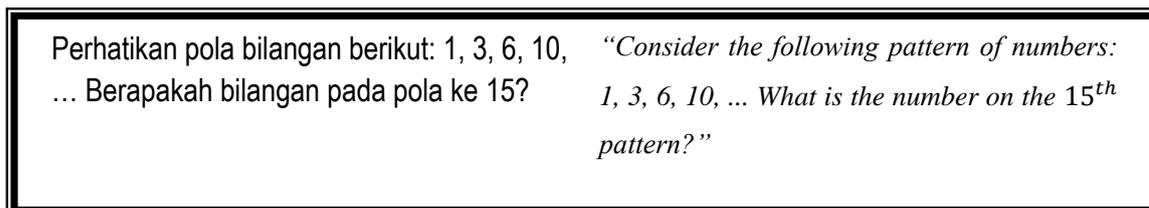
Figure 6. The number and pattern problem given to the teachers

The dimension of problem shown in figure 6 involved understanding process because the process of solving the problems above is only using the formula of arithmetic series formula

or by continuing the pattern until the 15th number appeared. The percentage of innovation made by teachers is summarized in the table 3 below.

Table 3. Perecentage of new problems generated categorization of number and pattern problem

	Replace	**Add**	**Modify**	**Contextualize**	**Turn around**	**Reformulate**
Number of teachers using technique	1	2	13	6	1	3
Percentage	3.45%	6.90%	44.83%	20.69%	3.45%	10.34%

Modification was still the most favorite technique that used to modify the problems above. Teachers were easily changed the question from asking the 15th of the pattern into the asking the students to determine the formula of nth term. That was the most common modification in this topic. Contextualizing also used in vary of context by those teachers. There are money saving, arrangement of seats in a building, arrangement of boxes at an exhibition in the mall and other interesting contexts.

There was one teacher generated new problems imperfectly. He wrote a problem that tend to modify the old problem using replacement techniques but some information were lost. The problem was presented in figure 7.


"Consider the following pattern of numbers: 1, 6, 15, ... Determine three consecutive terms between 10th and 50th"
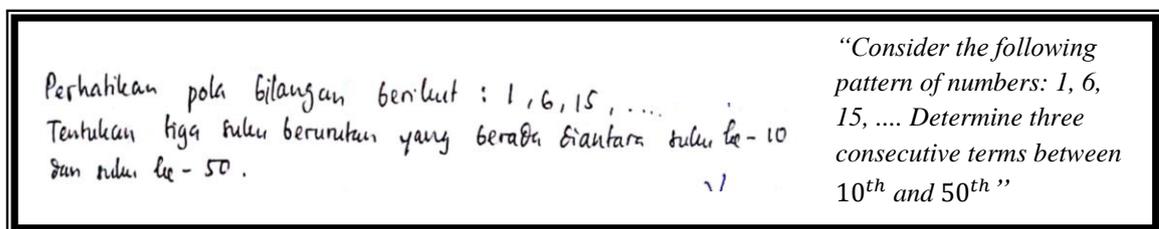
Figure 7. An imperfect problem made by a teacher

The difference between two consecutive terms is not the same. If it was designed to have same difference in the second level, it should have at least one more given term, which was the fourth term of that series. In the second level, we cannot conclude whether the difference is constant or it still growth generating the third level. Three consecutive terms given in the problems above is not enough for students to recognize the pattern of the series.

Similar with the first and second problem, in this problem, preservice teachers also did not choose to innovate by using problem turning technique. It is reasonable since turning the problem around was not always made the problem become more valuable. If we change the given by knowing the formula then asking the first, second, and the third terms, the problem become more simple. But, by giving the known of 6th and 15th term for the example, the problem can be turned around and changing the first term as the question.

4. CONCLUSIONS

From those techniques used by teachers, modification were the most easy to do. By changing the problems yet still maintain the formulation of the given information, teachers can easily change the question. Turning the problem around was still unfamiliar technique to be practiced by the teachers. Not all of those innovation always made the problems obtained be better, sometimes it can be worse, or just the same in terms of the level of difficulty, sophistication, and novelty [8]. When preservice teachers generated the new problems many factors may be influenced them. Turning the problem around was not always changing the old problems become more sophisticated. Therefore, the problems given as the old problem must be flexible to be modified if the posing problems are designed to assess the teachers' ability to pose problems. The implication of this study is lecturer of mathematics education program especially in the subject that contains assessment or evaluation need to consider about developing the preservice teachers' ability to generate new problems from the old problems given.

5. ACKNOWLEDGMENTS

6. REFERENCES

[1] *Peraturan Menteri Pendidikan Nasional Nomor 17 tentang Standar Kualifikasi Akademik dan Kompetensi Guru*, Jakarta: Depdikbud, 2007.

[2] S. Crespo, "Learning to pose mathematical problems: Exploring changes in presertive teachers' practices," *Educational Studies in Mathematics,* vol 52. No 3, pp. 243-270, 2003.

[3] S. Crespo & N. Sinclair, "What makes a problem mathematically interesting? Inviting prospective teachers to pose better problems," *Journal of Mathematics Teacher Education,* Vol. 11, pp.395-415, 2008

[4] H. P. Osana & I. Pelczer, "A Review on Problem Posing in Teacher Education," In *Mathematical Problem Posing. Research in Mathematics Education,* F. Singer, N. Ellerton & J. Cai, Ed, New York: Springer, 2010

[5] E. Zakaria & F. Salleh, "Teachers' Creativity in Posing Statistical Problems from Discrete Data". *Creative Education,* Vol 3, pp 1380-1383, 2012.

[6] L. Chen, W. Van Dooren, Q. Chen, et al. "An Investigation on Chinese Teachers' Realistic Problem Posing and Problem Solving Ability and Beliefs", *Int J of Sci and Math Educ*, Vol. 9, pp. 919-948, 2011

[7] J. Xie and J. O. Masingila, "Examining Interactions between Problem Posing and Problem Solving with Prospective Primary Teachers: A Case of Using Fractions," *Educ Stud Math,* Vol. 96, pp. 101–118, 2017

[8] C. P. Vistro-Yu, "Using Innovation Techniques to Generate 'New' Problems," In *Mathematical Problem Solving*," B. Kaur, B. H. Yeap & M. Kapur, Ed. Toh Tuck Link: World Scientific Publishing Co. Pte. Ltd, 2009.

[9] L. W. Anderson & D. R. Krathwohl, *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. New York: Longman, 2011.

Halaman Ini Sengaja Dikosongkan