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Mathematical creativity profile of elementary school students in solving mathematical problems by considering technology role

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Abstract. This study was aimed to describe mathematical creativity of elementary school students in solving mathematical problems by considering technology role in mathematics learning process in the classroom. Data collection technique was done by giving questionnaires to students and providing creativity tests on the components of fluency, flexibility, originality, and elaboration. The research subjects were 34 fifth graders at one of elementary schools in Palangkaraya. Based on the results of the creativity test, the results showed that 30% of students were able to produce various ideas or questions (fluency), 10% were able to express various solutions (flexibility), 2% were able to provide relatively unique new ideas or answers, 15% were able to specify the answers they wrote in detail (elaboration). Based on the questionnaires results, the results of the study showed that the role of technology was still in a minimum category. It is recommended to integrate technology in mathematics learning process in order to improve students' mathematical creativity in solving mathematical problems.

1. Introduction

Learning objectives at schools are not intended not only to gain knowledge but also to create new knowledge. Creativity is needed to achieve these objectives. Therefore, one of the important skills that needs to be cultivated and improved at schools is the creativity of students [1]. Creativity is one of the main assets for one's success. Creative individuals will be more open minded to their own ideas or other people's ideas. Moreover, a creative person will be able to make breakthroughs and create new things in solving the problems they face as it is stated by Sarooghi that creativity can increase innovative activities [2]. Creativity is a way of thinking and acting to make original [3, 4], inventive and new propositions [4]. Creativity requires a balance among synthesis, analytical and practical abilities [5]. If it is viewed from the cognitive aspect, creativity refers to some certain skills, such as fluency, flexibility, originality, and elaboration skills [6].

The development of creativity is necessary in order to face the challenges of changing era. Creativity is very useful in solving various problems [7] and for finding various solutions toward problems [8]. Creativity and problem solving are two things that cannot be separated. Creativity is influenced by the types of problem that needs to be solved [9], whereas problem solving requires creativity in finding various solutions [8] and strategies as well as discovering new things [4].



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Creativity and problem-solving ability are part of the skills that must be prepared to face 21st century learning [10]. One way to develop and improve these skills is through the application of technology in learning activities in the classroom [11, 12]. Integrating technology into learning activities is one of the learning objectives in 21st century. In this research, mathematics is the focus area that can support cultivating and developing creativity in solving problems by integrating technology into learning activities in the classroom.

Learning mathematics cannot be separated from problem solving. Solving mathematical problems requires creativity in finding various solutions, strategies and discovering unique or new solutions/strategies. Some researchers suggest that to support creativity development and enhancement in solving mathematical problems, the application of technology in learning mathematics at class can be considered [11, 12]. The results of previous studies also revealed that the use of technology was able to stimulate students' creativity to produce various ideas and solutions in solving mathematical problems [13]. Based on this description, it is important to describe the mathematical creativity profile of elementary school students in solving mathematical problems by considering technology role in mathematics learning process in the classroom.

2. Method

This research was a survey research conducted in one of elementary schools in Palangkaraya, Indonesia. This survey involved 34 fifth grade students of elementary school. Students selected as research subjects have taken Information Technology subject.

Data collection techniques used in this study was test, questionnaire and interview. The test used in this study was a mathematical creativity test. The test is in the form of structured questions that were adjusted, thus it was able to explore data about students' creativity in solving mathematical problems [14]. The measured components of creativity were fluency, flexibility, originality, and elaboration. If the students' fulfill those four criteria of the test, then, they can be categorized as creative students'. However, when they cannot fulfill the criteria, the students' can be characterized as less creative ones [8]. The data collection through questionnaire was aimed to determine students' responses regarding the role of technology that has been used in mathematics learning. It was also aimed to know the students' expectations about the use of technology so that it could support the students' creativity improvement in solving mathematical problems. The questionnaire had 3 main statements, namely: (1) Technology was able to concretize abstract mathematical problems; (2) Technology had a role in helping students to design mathematical problem solving independently or with teacher guidance; (3) Technology was able to develop students' creativity in solving mathematical problems. Meanwhile, interview was used to support and strengthen the results of test and questionnaire.

The data obtained were analyzed using quantitative descriptive analysis techniques. The steps in this research were scoring the data, tabulating the data, calculating percentage of the data, presenting the data and concluding the data.

3. Result and Discussion

3.1. Mathematical Creativity Profile

Data analysis result showed that generally the students' mathematical creativity profile can be categorized as not fairly creative (94%) as shown in Figure 1.

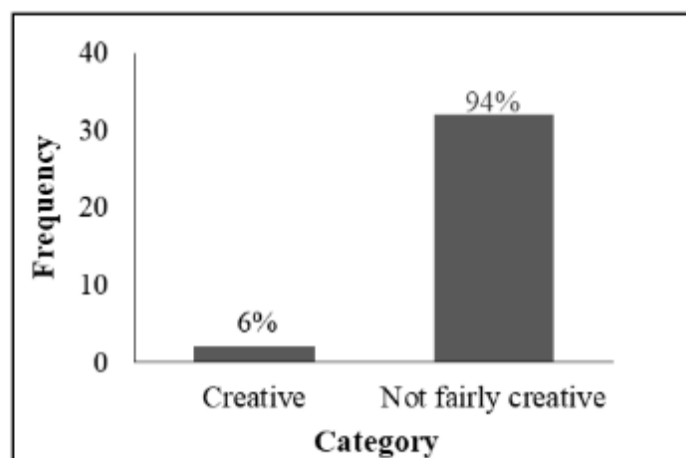


Figure 1. Mathematical creativity profile.

Figure 1 shows that the mathematical creativity of 94% of fifth graders in Elementary School was categorized as not fairly creative, meanwhile 6% was categorized as creative. Of the 34 students, only 2 students (6%) met the four indicators of creativity in solving mathematical problems, i.e. fluency, flexibility, originality and elaboration. This group of students was categorized as creative students. Meanwhile, the remaining 32 students (94%) failed to fulfill all four indicators of creativity. Therefore, this group of students was categorized as not fairly creative.

The following data are an example of the result of the students' work on the test as an instrument to measure students' creativity in figuring out the solution to math problems. The test given is as

See the following image carefully!

- Arrange the above square units into one complete group (2 different forms of units are the least). Then, give at least 2 different colors on the square units.
- State the simplest fraction symbols formed of each same color on all square units.

follows:

One of the students' work below shows that students' creativity in solving Math problem is still low.

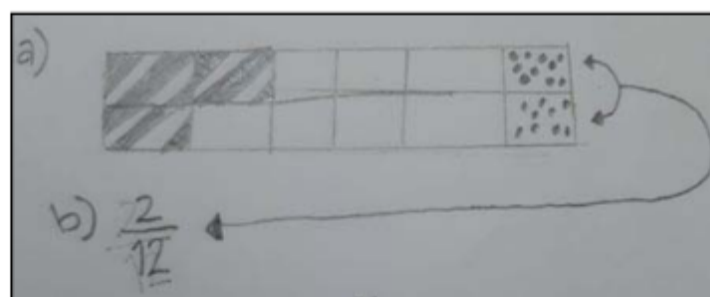


Figure 2. Students' work showing not fairly creative.

From the result of one of the students' work above, it can be seen that the student only gave one solution when asked to create an arrangement of more than one square unit. In addition to that, the solution given can not be said as a perfect one. The student only gave a fraction symbol on one of the colors; while in fact, they were required to give each color a symbol. This shows that the students have

not yet shown fluency in giving various solutions toward math problems they face. On the second part, the student only gave a fraction symbol that was in line with the picture only which was $\frac{2}{12}$. Even though, the solution given was correct but it was not the same as what had been expected, that was the simplest fraction symbol. This makes the student is not considered flexible in giving the right strategy to the solution found. This student is also said not yet to give an original solution since that given one is actually a common type of solution found among the class level and tends to look similar to the results of his classmates. Relatively, this student served his solution in a short way and straightly went onto the solution he wanted to give without any detailed explanations. This makes the student is considered to not have had a good skill in elaborating or giving any further details clearly. Thus, this student is categorized as not creative in solving math problems.

The result of the following student gives some information about students' creativity in solving math problems, which is categorized as the creative one.

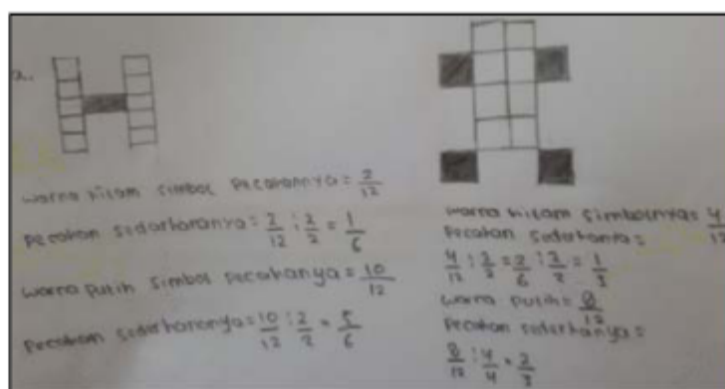


Figure 3. The result of students' work that is categorized as creative.

From the result of one student' work above, it can be seen that the student gave more than one solution when asked to create an arrangement of square units. Besides, the solution given was also relevant to the problem. This makes the student considered to have shown fluency in giving various solutions toward math problems given. On the second part, the student gave a fraction symbol that was in agreement with the picture up to the simplest fraction along with the correct strategy. This makes the student considered to have been flexible in serving the strategy of the solution. This student is also said to have given an original solution for the one given was relatively unique in the class level and tends to look different from the results of his classmates. In general, this student has given a detailed and clear solution. Thus, this student is said to have elaborated or provided further details on the solution. Of all 34 students taking the test, only 2 (6%) were found capable of giving creative solutions to math problems since they have completed all components of creativity, which are fluency, flexibility, originality and elaboration. While, the rest 32 students (94%) gave some solutions to the math problems they faced without being creative since the result shows that they did not pass the components of creativity.

From the results of the research, it appeared that students have not been able to provide various solutions and strategies to mathematical problems given. The solutions given by the students for their grade were commonly considered average (not unique) and tend to look similar to the results of their classmates (not original), and not elaborate the solutions of the math problems in details and clearly. This fact could happen since the students were not used to and rarely put in situations in which they need to solve complicated math problems (not their routine), that require them to think deeper and dig their creativity. On the other hand, however, the students, in fact, normally face math problems in routine forms or, in other words, the one they only face is limited to problems given by their school. This was in line with the results of previous studies that students were generally able to solve routine mathematical problems because they were less challenging. Students were not required to develop new solutions to answer the problems; therefore, they were easier to solve. On the other hand, non-routine problems were more difficult and required several steps to solve as well as creativity skills in finding solutions [15]. Based on these findings, it can be inferred that the learning activity has not fully

facilitated students in developing creativity in solving mathematical problems. whereas, the creativity or the skill to solve any problems is a form of competency that is required as a result of learning in 21st era [10]. Through creativity, the students are hoped to be able to find various solutions even to relatively unique problems. As what has been said in the previous result of a similar study, in which it stated that creativity is highly beneficial to help us find various solutions to any problems we face [8].

3.2. Student Creativity Profile Reviewed from Indicators

Data analysis result showed that students' creativity profile based on indicators can be categorized as very low as shown in Figure 2.

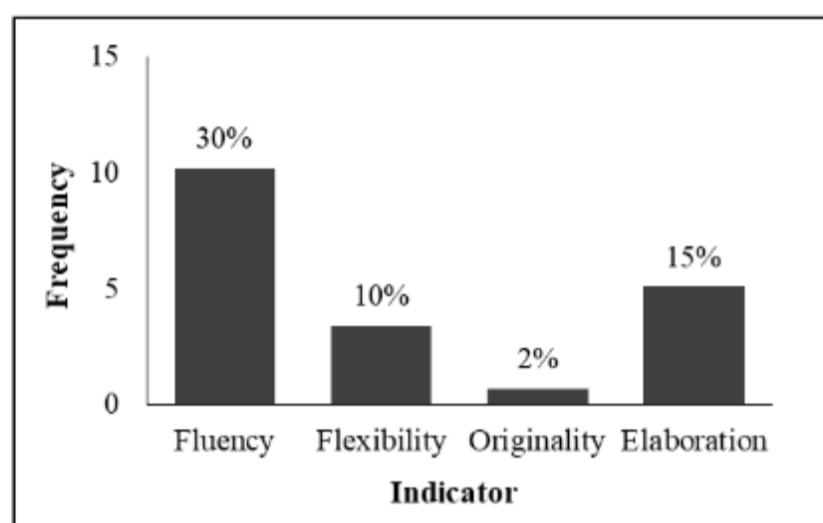


Figure 4. The result of students' creativity based on indicators

Figure 4 shows students' creativity in solving mathematical problems reviewed from creativity indicators, i.e. (1) 30% of students were able to produce various ideas or solutions (Fluency) from a mathematical problem given; (2) 10% of students were able to present various ways of solving mathematical problems (Flexibility); (3) 2% of students were able to produce their own unique/relatively new thoughts (Originality/Novelty); and (4) 15% of students were able to describe the answers in detail systematically (Elaboration).

The four indicators of creativity were in very low category. This happened because mathematics learning process in the classroom still has not yet facilitated students in developing creativity to solve mathematical problems. The presented mathematical problem solving was generally routine problems. They were less challenging, so it was unnecessary to develop new solution methods to answer them since they were easier to solve [15]. If it was reviewed from each indicator, students' creativity in generating numerous ideas or solutions (fluency) to a given mathematical problem obtained the highest results among other indicators of creativity. This happened because students only mentioned the solutions. At the cognitive level, the mentioning-aspect was the most basic cognitive level; thus, it tended to be easier.

In presenting various ways/strategies in solving mathematical problems (flexibility), students needed the ability to connect the problems they encountered with various materials that had been studied. If students experienced difficulties in the previous material, it would become an obstacle to fulfill this indicator.

Creating their own unique/relatively new thoughts (Originality/Novelty) gained the lowest results among other four indicators. It was in accordance with the result of interview with the teachers who stated that generally students had no self-confidence if they had a different problem-solving solution with other students. Students still assumed that being different was incorrect, therefore they decided to have the same solution as the others. On the other hand, novelty was the aspect that most widely stated by experts as an indicator of creativity.

In creativity indicator of deciphering details systematically (Elaboration), students must have the ability to explain, describe and develop answers to the problems well. On the other hand, synthesis and analytical abilities must also develop in a balanced manner. The results of the analysis showed that creativity in elaboration was still very low. It was corresponded with the results of observations in the class which showed that the learning environment had not yet supported creativity development in elaborating answers in detail systematically. This fact was in accordance with the previous researchers' opinions that creativity was the result of interactions between individuals and their environment. Individual respectively would influence and be influenced by the environment where he/she resided. Hence, the variables within the individual and the environment could support or hinder creative efforts. Implication to this opinion was i.e. creativity could be improved through education in the learning process [16].

3.3. The Statement of Technology Role towards Creativity in Solving Mathematical Problems

The results of data analysis showed that the statement of technology role towards creativity in solving mathematical problems in general can be categorized as fairly good as shown in Figure 3.

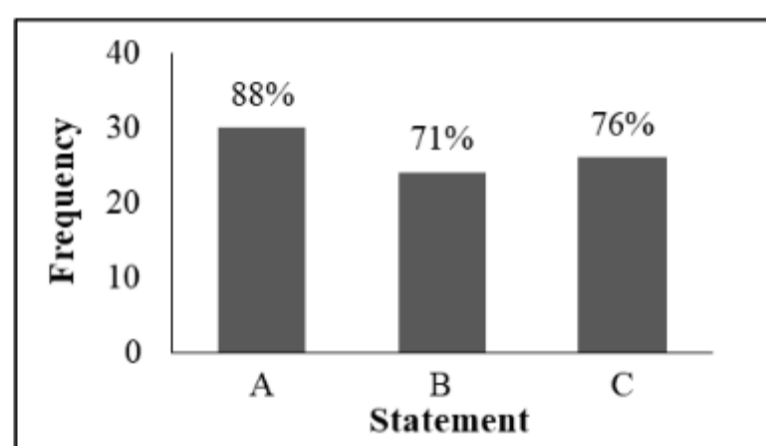


Figure 5. The statement of technology role towards creativity in solving mathematical problems.

Figure 5 shows that the questionnaire given to students was intended to find out students' responses concerning technology role that had been used to support the development of students' creativity in solving mathematical problems. Furthermore, this questionnaire also aimed to perceive students' responses concerning their expectations about the use of technology so that it could support students' creativity improvement in solving mathematical problems. In this aspect, the questionnaire statement was divided into three main elements, which were (A) technology role was expected develop creativity in concreting abstract mathematical problems; (B) technology role could help students to make various mathematical problem-solving designs; and (C) technology role could help students to find new solutions or strategies in solving mathematical problems.

Based on the results of data analysis, it was found that mathematics learning in the classroom was not maximal in utilizing the role of technology in supporting the development of students' creativity in solving mathematical problems. The utilization of technology was limited to the use of PowerPoint by teachers. Based on the results of the questionnaire, each student had a laptop, yet they did not use it maximally. On the other hand, the school in fact included Information Technology subject in the school curriculum and provided the internet connection. This was in accordance with the results of previous research which stated that the availability of appropriate facilities/materials, the flexible use of space and time, and the use of approaches based on the needs of students were important factors that could support the development of students' creativity [17]. However, the reality in the field revealed that mathematics learning done by the teachers in the classroom had not been optimizing the available facilities. Based on the interview, the reason was because the teacher had a lot of workload so that it was difficult to provide the time to utilize technology as it took time to prepare everything. In

addition, the teachers' ability to take advantage technology role in supporting the development of students' creativity in solving mathematical problems was also still lacking.

According to the results of data analysis, students' responses regarding statements about technology role expected to help develop creativity in concreting abstract mathematical problems gained 88%. This result can be categorized as good. Students were generally eager in utilizing technology to help concretize abstract mathematical problems. Technology can assist them using a program or an application providing instructions that empowered students to recognize the abstraction of mathematical operations. It could also provide graphic elements such as: images, symbols, colors, sounds, and movements [18, 19, 20].

On the aspect of students' responses, concerning making various mathematical problem-solving designs obtained 71%. Based on the results, this could be categorized as fairly good. Generally, students wanted technology usage to help them create mathematical problem-solving designs. Technology could help students through a program or an application providing instructions that were able to stimulate the emergence of intelligent ideas and initiatives and to practice more on concentration and collaboration [19, 21].

Finding new solutions or strategies in solving mathematical problems obtained 76%. It could be categorized as fairly good. Students wished to use technology to help them find new solutions or strategies in solving mathematical problems. The usage of a program or an application could be able to help students develop digital fluency in designing, creating and mixing ideas into a unique/new problem-solving solution [22].

The findings of this study had implications that the application of technology in mathematics learning provided a stimulus or an encouragement to students to become creative in producing various solutions and strategies. It could also be used as an assistance to discover new ideas in solving mathematical problems and to obtain fun experiences [21, 22]. This research showed the principles of divergent thinking to facilitate mathematics learning that could be able to encourage students to develop their creativity in mathematical problem solving [4].

4. Conclusion

Based on the results of data analysis, it was found that the creativity profile of fifth grade students in one of elementary schools in Palangkaraya was categorized as not fairly creative in solving mathematical problems. Students' responses towards the role of technology provide important information about their thoughts and expectations. The students hoped that the role of technology could help them develop creativity in concreting abstract mathematical problems, making various design solutions to problems, and finding new solutions or strategies in solving mathematical problems. Meanwhile, mathematics learning taught so far has not maximized the role of technology to support the development of students' creativity in solving mathematical problems.

Realizing that this research is only limited to a profile description of students' creativity in solving mathematical problems by considering the role of technology, then further research can be expanded by utilizing one of the appropriate technologies. The process of learning mathematics in the classroom by utilizing technology can be arranged and conditioned into learning situations. It can be done by analyzing problems and making decisions in order to produce a creative problem solving. The utilization can be done by integrating technology in the learning process of mathematics in the classroom so that students can improve mathematical creativity in solving mathematical problems.

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