Students’ Mathematical Creative Thinking through Problem Posing Learning

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Abstract. The research aims to investigate the differences in enhancement of students’ mathematical creative thinking ability of those who received problem posing approach assisted by manipulative media and students who received problem posing approach without manipulative media. This study was a quasi experimental research with non-equivalent control group design. Population of this research was third-grade students of a primary school in Bandung city in 2016/2017 academic year. Sample of this research was two classes as experiment class and control class. The instrument used is a test of mathematical creative thinking ability. Based on the results of the research, it is known that the enhancement of the students’ mathematical creative thinking ability of those who received problem posing approach with manipulative media aid is higher than the ability of those who received problem posing approach without manipulative media aid. Students who get learning problem posing learning accustomed in arranging mathematical sentence become matter of story so it can facilitate students to comprehend about story

1. Introduction
Primary school plays a very important role in education. The success of students at the primary school level is very influential on their success in high school. Therefore, school-level learning needs special attention from educators. Such learning should lead students to develop deeper student thinking skills. One of the lessons learned at school is math. Mathematics is a lesson that can help students to have the ability to plan, anticipate, decide, and solve problems in everyday life [1]. One of the abilities of mathematical thinking that needs to be developed early on is the ability to think creatively. This is in line with the objectives of mathematics learning in schools that is to train thinking and reasoning in drawing conclusions, developing creative activities involving imagination, intuition and discovery by developing divergent, original thinking, curiosity, making predictions and guessing and experimenting, developing problem-solving skills, and developing the ability to convey information and communicate ideas [2]. In the purpose of mathematics, it is emphasized that developing creative activity needs to be done on the students. However, creativity is a rarity in mathematics learning [3]. Currently, there are still teachers who place logic as a benchmark and consider creativity to be unimportant in mathematics learning. Some teachers only prioritize logic and computational skills.
Divergent thinking is selective and creative thinking that uses information not only for the benefit of thinking but also to determine the results/solutions obtained [4]. The characteristic of divergent thinking is looking at a problem from several sides, spreading in different directions to find many answers, comprehensive/global, intuitive, imaginative, independent, and unpredictable. If the students have high divergent thinking skills, then students' answers to a problem will vary.

Each student has a creative potential that can be developed in the classroom. Creative thinking does not occur in a vacuum: it needs some stimulus, some content to work on [5], which means that creative thinking or creativity of learners will arise when there is a stimulus. In line with that, student creativity can be developed when trained in exploration, discovery, and problem solving [4]. However, the focus of attention on efforts to improve the ability of creative thinking in mathematics is still rarely developed. Though the ability to think creatively is needed so that the students have the ability to acquire, manage, and utilize information to survive in an ever-changing, uncertain, and competitive [6].

Given the importance of the ability of mathematical creative thinking to be developed, it requires a special approach, method or strategy to develop the ability. Related to that, there is one approach that can be used that is problem posing. Problem posing is a foreign term as the equivalent of the term in the Indonesian "problem-shaper" or "questioning". Problem posing in mathematics has several meanings, one of which is the formulation of a simple question or a re-formulation of the problem with some changes to make it simpler and more controlled [7]. Problem posing can also be defined as filing a problem that describes a situation in which an unfinished context or problem creates an opportunity for students to involve their own meaning and interpretation to solve it [8]. In the past, mathematics education experts have pointed out that the formation of questions is an important part of the students' mathematical experience and suggests that mathematical learning emphasizes the formation of questions [9]. This is because students are rarely, if ever, given the opportunity to pose in some public way their own mathematics problems [9]. The revelation states that, students are rarely given the opportunity to pose problems in mathematics.

Problem posing is a very important approach in learning mathematics. Learning with posing problems is one of the central themes in mathematics education that has been suggested as the main method for improving learners' understanding [10; 11]. The suggestion of the use of problem posing in the mathematics curriculum has been conveyed by some experts. Some figures in mathematics education, such as Freudenthal and Polya have identified problem posing as an important part of the student's mathematical experience. They promote pedagogical curriculum and innovation in mathematics education to improve the use of classroom posing problems [7]. For example NCTM Curriculum and Evaluation Standards for School Mathematics [12] encourages teachers to increase students' opportunities in investigating and formulating questions from given situations. Problem posing includes self-designed activities by students and stimulates all students' abilities, resulting in better understanding. This is in line with the opinion which explains that the posing problem is important in the mathematics curriculum because it contains the essence of mathematical activity, including the activity in which the students build their own problems [13]. In addition, problem posing is one of the important foundations in mathematics education and the realization of the importance of problem posing has led to many studies on various aspects of learning activities with problem solving [14].
Primary students (7-12 years) are included in the concrete operational thinking stage so that to understand a student concept should be given some learning activities which are related to events and real objects that are acceptable to their minds [15]. This is in line with the theory which says that students learn mathematical concepts through three stages: the enactive, iconic, and symbolic stages [16]. An enactive stage is a learning stage by manipulating objects or concrete objects, the stage of the learning phase iconic by using images, and the symbolic stage of learning phase by using symbols or symbols. Therefore, the use of instructional media is very important to assist students in constructing abstract mathematical concepts so that learning can be more easily understood by students. Manipulative media is one of the learning media that can be used in learning mathematics. Through the use of manipulative media such as beads, rocks, grains can help students to understand math become more concrete. Learning with problem posing will also be linked to real life, so students can practice examples of such events with manipulative media used during learning. Therefore, learning will be more meaningful for students.

There are a great number of research of the use of problem posing approach, one of them is research on students conducted by Irwan [17]. In his research, he explained that the use of problem posing approach can improve the ability of creative thinking. The results of the study show that problem posing can improve mathematical habits in learning such as exploring and formulating mathematical ideas on the given situation. Problem posing activities are full of activities that demand creativity in problem solving. Based on the above description, the researcher is interested in conducting the research with the aim to describe the data of improvement of the mathematical creative thinking ability of the students who are treated with the problem posing learning with manipulative media aid is higher than the ability improvement of the students who get problem posing learning without the aid of manipulative media.

2. Experimental Method
This research is a quasi experimental research with non-equivalent group design. This selection is based on the consideration that the subject of research has been grouped into existing classes and it is not possible to group students randomly. In this research, two classes were taken as sample. There was experimental class 1 which was given treatment in the form of learning with problem posing approach with manipulative media aid and experimental class-2 which was treated with problem posing approach without the aid of manipulative media.

The population in this study are all students of class III of 2015-2016 academic year in one elementary school in Bandung consisting of three classes. From the population, researchers took samples for the study. Sampling is done by purposive sampling technique that is sample determination technique with certain consideration. Two classes were chosen as the sample of research. The reason for choosing the classes is because the two classes have almost the same number of students. The class that is used as experimental class-1 amounted to 30 students. Meanwhile, the class that is used as experiment-2 class amounted to 29 students.

3. Result and Discussion

3.1. Result
The research was conducted on the application of problem posing approach on mathematics learning about number concept. The implementation of the study was conducted during six meetings. In this study, data analyzed is the data of students’ mathematical creative thinking ability which is obtained from pretest score and posttest scores. The data was calculated by the N-Gain value of mathematical creative thinking in both classes. The Table 1 in the following are descriptive statistics of pretest, posttest, and N-gain scores in the experimental-1 and experimental-2 class.

| Table 1. Descriptive Statistic of Mathematical Creative Thinking Ability |
|-----------------------------------------------------------|
| Experiment-1 Class                                      | Experiment-2 Class |
|-----------------------------------------------------------|-------------------|

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To find out the data of enhancement of mathematical creative thinking ability based on learning analyzed using N-gain of mathematical creative thinking ability in experiment-1 and experiment-2 class. The average difference test of N-gain of mathematical creative thinking ability was conducted to prove the research hypothesis that the average N-gain of the students' mathematical creative thinking ability that follows problem posing learning with manipulative media is higher than the students' that follow problem posing learning without manipulative media. Based on the statistical test, the experiment-1 data class is normally distributed, while the experimental class-2 is not normally distributed. Furthermore, Mann Whitney tests to determine the test difference in the average of both classes. In accordance with the problem formulation which is more favorable to one of the approaches, the test criterion is if the value \( p = \text{value (Sig.)} \) is greater than the value \( \alpha = 0.05 \), then H0 is accepted. The test results show the Sig. value (1-tailed) is 0.002 smaller than the significance level \( \alpha = 0.05 \), the average N-gain of the mathematical creative ability of the experimental-1 class is higher than the experimental-2 class or the enhancement of the mathematical creative thinking ability of the students that follows the problem posing learning with manipulative media is higher than the ability of those who follow problem posing learning without the manipulative media aid.

Based on the results of processing and data analysis, it is found that an increase in the students’ mathematical creative thinking ability of those who follow problem posing learning with manipulative media aid is higher than the ability of the students who follow problem posing learning without manipulative media. The enhancement of mathematical creative thinking experimental-1 proved by the N-gain of 0.67 is in the medium criteria. Meanwhile, in the experimental-2 class with N-gain of 0.32 is in the medium criteria. The result of testing of statistical test shows that the mathematical creative thinking ability of third grade students of a primary school in Bandung city who follow problem posing approach with manipulative media aid is higher than students who follow problem posing approach without the manipulative media in the number topic.

### 3.2. Discussion

In general, there is a significant difference between improving the ability of mathematical creative thinking of the students who are treated with problem posing learning with manipulative media and the ability of the students who received problem posing learning without manipulative media aid. Taking into account the average N-Gain score of the experiment-1 class and the experiment-2 class, it appears that the average N-Gain score of the experimental-1 class is greater than the average N-Gain score of the experimental class-2. This is supported by the result of statistical tests which states that the improvement of the mathematical creative thinking ability of the students who are treated with problem posing learning with manipulative media aid is higher than the ability of the students who are treated with problem posing learning without the aid of manipulative media.

The difference in the achievement of students' mathematical creative thinking ability between experiment-1 and experiment-2 class is that because the student learning activities in the experimental class-1 was optimized and also because of the help of manipulative media aid. The teaching aid is a learning medium that contains or brings out the characteristics of the concept that is being learned [16]. The main function of props is to reduce the abstractness of the concept, so that students are able to grasp the true meaning of the concept.

At the describe the content stage, the activities undertaken in the experimental-1 class are the teachers delivering and demonstrating the use of manipulative media that will be used to assist the learning process, whereas in the experimental-2 class, the students are directly assigned a problem.

|         | N   | \( x_{\text{min}} \) | \( x_{\text{max}} \) | \( \bar{x} \) | SD  | N   | \( x_{\text{min}} \) | \( x_{\text{max}} \) | \( \bar{x} \) | SD  |
|---------|-----|------------------|------------------|-----------|-----|-----|------------------|------------------|-----------|-----|
| Pretest | 30  | 7                | 23               | 14,20     | 4,50| 29  | 6                | 22               | 14,55     | 4,12|
| Posttest| 30  | 18               | 24               | 20,77     | 2,14| 29  | 13               | 24               | 18,62     | 3,53|
| N-Gain  | 30  | 0,25             | 1                | 0,67      | 0,20| 29  | 1                | 0                | 0,46      | 0,32|

Score Max Ideal = 24
posing situation and given the opportunity to provide questions that can be asked based on the situation. Thus, there are some advantages obtained by experiment-1 class. The students use manipulative media to help them in understanding the lesson material so that the process of thinking using media is understood well. This is in line with the theory that in the process of learning, children go through three stages such as the stage of enactive, iconic, and symbolic [16]. The use of manipulative media is included in the enactive stage that is directly involved in manipulating (tinkering) an object. At this stage, children learn a knowledge in which that knowledge is actively studied using concrete objects or using real situations. They will understand something from doing or doing something without the use of imagination or words. Hence, the use of manipulative media can absorb knowledge better than without the use of manipulative media. This is in accordance with the theory that knowledge is not acquired passively by a person, but through action [15]. The children's cognitive development depends on how far they actively manipulate and integrate with their environment.

In the discuss the problem stage, teachers divide the students into groups of 4-5 students who have a heterogeneous initial ability. In each group there are students with high, medium, and low ability. At this stage, the students get many benefits because they help each other in formulating and solving problems. By studying in groups, the students will be more confident to ask or express their opinions. Group discussion activities can trigger the students with relatively high mathematical ability to further strengthen their understanding, while low-ability students can gain a better understanding of the explanation of a friend who may be more easily understood. Group discussion can minimize the mistakes in the students concept because the students tend to understand a concept differently. This concept error makes students experience errors in planning solutions or mathematical problems provided by the teacher so that the answer does not match with expectation. Things that can minimize concept errors are group learning. The results obtained by students through group work are better than if they work independently and competitively [19].

Group exercises will emphasize activity and interaction among students to motivate and help each other in mastering teaching materials so as to achieve maximum performance. Social interaction will lead children to the preparation of argumentation and discussion, so that the children's point of view is questionable and they must defend and prove his point of view [20]. From these opinions, it is clear that learning to argue is very important in the process of learning mathematics. The learning activities in the experiment-1 class are also assisted by the use of manipulative media. Each group was given colored buttons and manipulative money making it easier for the students to be creative in completing the worksheets. In learning mathematics, a child needs to directly use manipulative materials [16]. Manipulative materials are concrete objects that are specially designed and can be tampered with by the students in trying to understand a mathematical concept. In addition, group learning can improve students' abilities in using abstracted information and skills to make real decisions. Learning groups can also help students in developing creativity.

This is in line with research report which says that in learning posing problems, students utilize the ability to pose problems in identifying, linking, analyzing, and evaluating the given situation. This means that cognitive ability to get the opportunity to be empowered to obtain various questions, the formulation of the problem and the resolution of each problem varied [17]. Discussions among students in one group will add to their understanding of the situation given to them. As a result they can pose problems in varying forms. Discussions conducted among students can develop creativity. Aspects of creative thinking such as fluency, flexibility, and novelty will arise in raising problems. Based on the above exposure, it is reasonable if the ability to think mathematics creatively of the students who are treated with problem posing learning with the help of manipulative media is better than the ability of the students who are treated with problem posing learning without the aid of manipulative media.

4. Conclusion
Based on the data analysis that has been presented and the discussion of research results that has been described, the following conclusions can be drawn. The improvement of the ability of mathematical creative thinking of students who received problem posing learning with manipulative media aid was higher than the ability of the students who received problem posing learning without the aid of manipulative media.

The conclusions of this study provide some implications on several things including: (1) The application of problem posing learning with manipulative media aid put students in creative thinking and cooperation situation among individual so as to contribute positively in improving the ability of creative thinking; (2) Students who get learning problem posing learning accustomed in arranging mathematical sentence become matter of story so it can facilitate students to comprehend about story; (3) Problem posing learning can be an alternative in mathematics learning for other learning materials; (4) Placement of teachers as facilitators in learning encourages teachers to understand the characteristics of each student. If it is done continuously, it will have an impact on the professionalism of teachers in managing learning.

Based on the results of the research, there are several recommendations related to this research, such as; (1) Problem posing learning with the aid of manipulative media and without the aid of manipulative media can be a learning alternative for elementary school mathematics teacher especially in improving students' mathematical creative thinking ability; (2) The application of problem posing learning is limited to the subject of original numbers. For further research, it can be used on other subjects; (3) The application of problem posing learning in this research is limited to the ability of mathematical creative thinking. For further research, it can be used on other mathematical ability.

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