The improvement of mathematical communication ability of elementary school students through project-based learning using mind map technique

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Abstract. Mathematical communication is one of the important abilities for students to face the challenges in this era. The fact-based on the preliminary study conducted by researchers on students in elementary school showed that most students find difficulties in communicating mathematical ideas. The present study is aimed to describe whether the improvement of mathematical communication ability of students who learn through project-based learning using mind map technique is better than the improvement of mathematical communication ability of students who learn through project-based learning without mind map technique. This study used a quasi-experiment using a non-equivalent group design. Sixty-three students of one of the elementary schools in Bandung city were taken as subjects of this study. The instrument of this study used mathematical communication test. The data were analyzed using non-parametric statistics. The result showed that the improvement of mathematical communication ability of students who learn through project-based learning using mind map technique is better than the improvement of mathematical communication ability of students who learn through project-based learning without mind map technique.

1. Introduction
Mathematics as a universal science is an important field of science that must be mastered by students. Mathematics is not only as an abstract concept but also as a practical ability for students to face the challenges in daily life. In this era, someone who understands mathematics has a higher chance and choice to be able to prepare his future [1]. Therefore, the purpose of mathematics education, especially in elementary schools, is not limited to learning abstract concepts without developing student abilities and competencies. Mathematics learning in elementary school should provide students with various mathematical abilities. However, mathematics learning in schools in Indonesia has not reached the maximum results. This case is showed by the result of the Trends in International Mathematics and Science Study (TIMSS) in 2015 that the participants are students in elementary school grade 4th. This
test aims to measure mathematics and natural science in an international standard. The result showed that Indonesia is on the 44th level of 49 countries that participated in TIMSS [2]. This result can be caused by a lack of student mathematical abilities. It means that mathematics learning should be improved both in qualities and implementation in elementary school. Moreover, mathematics learning should provide students with some mathematical abilities.

One of the mathematical abilities which are needed by students is communication abilities. Communication is one of the crucial abilities that should be mastered by students to face the challenges in the 21st century. Mathematical communication ability is the ability of students to express and describe mathematical ideas using symbols, graphs, diagrams, and others. Communication ability is fundamental for someone to express ideas and mathematical concepts. Moreover, communication is not only crucial for learning mathematics, but it is crucial for all learning [3]. There are two reasons that mathematical communication must be the focus of mathematics learning including, 1) thinking tools, tools to find patterns, problem-solving, and tools to communicate ideas and, 2) means of communication between students and communication between teachers and students [4].

Based on the preliminary study conducted by researchers on students in elementary school, students have difficulty in communicating mathematical ideas, especially on written communication ability. This preliminary study was conducted on three indicators of mathematical communication ability. The result showed that the mathematical communication ability of students is still low. In brief, there are three difficulties of students in communicating mathematics ideas and concepts. First, students can not express ideas in writing. After understanding the questions, students are generally confused about answering these questions. Second, students generally are confused about describing the errors of the strategy. Moreover, students are not careful in understanding the question. Third, students are only able to make one sentence that describes the contents of the presented data in the mathematical problem. Students have difficulty in expressing information and ideas obtained from data using their idea and language.

Generally, after students are given a mathematical problem, students only try to solve problems and find solutions. However, they have not been able to communicate the results of these solutions so that the ideas can not be understood by others. This case in line with the opinion of Haylock and Cockburn that when a problem has been solved, the next challenge is to communicate the results of findings to others [5]. This case also supported by the results of TIMSS in 2015 which found that Indonesian students had mastered the routine, simple computational questions and measured knowledge of facts in a daily context, but Indonesian students need to strengthen their ability to integrate information, draw conclusions, and generalize their knowledge into others [6]. This is closely related to the mathematical communication ability of students. Several previous research also showed that students have difficulties in mathematical communication ability [7, 8]. Therefore, mathematical communication ability needs to be developed in elementary school students in the mathematics learning process.

The low of mathematical communication ability of students can be caused by several factors. One of them is mathematics learning in schools that do not facilitate students to develop these mathematical abilities. Mathematics learning in elementary school still tends teacher-centered learning so that students have less opportunity to explore mathematical communication ability. In learning situations, teachers tend to dominate discussions by giving lectures, asking closed questions, and giving less opportunity for students to communicate their strategies, ideas, and thoughts [9]. Based on the problem, teachers need to provide a mathematics learning process that can develop mathematical communication ability. Project-based learning is a model of learning that actively engages students through work on projects as a student learning activity and task [10, 11]. Project-based learning uses problems as a first step in collecting and integrating new knowledge through work on projects.

Some previous research showed that mathematics learning using project-based learning is better than mathematics learning using direct instruction to improve mathematical abilities [12, 13, 14]. However, the implementation of project-based learning has not been maximized. Previous research showed that in doing projects, students need a tool that can help them to organize the projects. Therefore, it needs a combination with other techniques or methods in implementing project-based learning. Mind Map technique is one of the choices to help students organize their projects and idea. In maximizing the application of project-based learning, mind map techniques are used as an alternative technique for students in designing and implementing mathematical projects. Mind Map is a learning technique by
creating mind maps that connect each mathematics concept. The mind map is a technique to summarize the learning material and project the problems faced in the form of maps or graphical techniques so that it is easier to understand [15]. Project-based learning using mind map technique is a learning model that presents projects as learning activities and uses mind map techniques as a technique to map project ideas and mathematical concepts used in completing a project. When completing a project, students can discuss and share ideas about solutions to answer any challenges given in project-based learning activities. Mind map technique is used to students to map each of their ideas in the form of mind maps. By using the mind map, student ideas can be presented in a simple form. Based on that explanation, this research aim is to describe whether the improvement of mathematical communication of students who learn using project-based learning with mind map techniques is better than the ability of mathematical communication of students who learn using project-based learning without mind map techniques.

2. Methods
This study used quantitative research. The experiment method was undertaken to answer the question of this study. In this study, there were two groups. First, the experimental class 1 was a group of students who were given the treatment of learning mathematics using a project-based learning model with mind map techniques. Second, the experimental class 2 was a group of students who were given the treatment of learning mathematics using a project-based learning model without mind map techniques. The design of the study was quasi-experiment with a non-equivalent group design. In this design, there were pretest, treatment, and posttest. Pretest and posttest were given to experimental class 1 and experimental class 2. This research design can be described in Figure 1. as follows.

\[ O \quad X_1 \quad O \]
\[ \quad ----------- \]
\[ O \quad X_2 \quad O \]

**Figure 1. Research Design**

In Figure 1, The symbol of \( X_1 \) was the treatment of mathematics learning through project-based learning using mind map techniques. The symbol of \( X_2 \) was the treatment of mathematics learning through project-based learning without mind map techniques. The meaning of O symbol was the pretest and posttest of student mathematical communication ability. Moreover, the subjects of this study were 63 students from one of the elementary schools in Bandung city. The number of class IV-B students, as an experiment class 1, is 32 people, while class IV-A, as an experimental class 2, is 31 people.

The instrument of this study used mathematical communication test. The mathematical communication ability test used was an essay test that consisted of 6 questions. The mathematical communication ability test included three indicators of mathematical communication ability. The indicators were (1) explaining mathematical ideas, situations, and relations in written communication, (2) analyzing and evaluating mathematical thinking and strategies, and (3) re-expressing a description or paragraph of mathematics using their language. This instrument was tested and analyzed by testing validity, reliability, distinguishing power, and difficulty level. The data of mathematical communication ability based on pretest and posttest results were analyzed using the normality test and Mann-Whitney U test. Moreover, N-Gain calculation was done to find out the improvement of mathematical communication ability in experimental class 1 and experimental class 2. The data of N-Gain were analyzed by descriptive statistics. Then, they were analyzed using the normality test and Mann-Whitney U test.

3. Result and Discussion

3.1. Result
In this study, the data of student mathematical communication ability were obtained based on scores of pretest and posttest of mathematical communication ability test. The pretest was aimed to obtain the
initial ability of student mathematical communication. Pretest data obtained were analyzed using the normality test and the Mann-Whitney U test. The result of the normality test of pretest data showed that the data of the initial ability of mathematical communication in experimental class 1 and experimental class 2 was not normally distributed. Based on these results, the next step was conducting the Mann-Whitney U test. The Mann-Whitney U test of pretest data showed that the significance value was 0.402, which meant that the significance value was under 0.05. The conclusion that there was no significant difference in the initial ability of student mathematical communication between the experimental group 1 given project-based learning using mind map techniques and the experimental group 2 given project-based learning without mind map techniques.

After being given treatment in experimental class 1 and experimental class 2, then the two groups are given a posttest in order to obtain the final mathematical communication abilities of students. The data of the posttest were analyzed using the normality test and the Mann-Whitney U test. Based on the normality test, both in experimental group 1 and experimental group 2 were not normally distributed. Based on that, the posttest data were analyzed using the Mann-Whitney U test. The result of the Mann-Whitney U test showed that the significance value was 0.024, which meant that there was a difference in the student ability of mathematical communication who learn using project-based learning using mind map techniques and students who learn using project-based learning without mind map techniques.

In the next step of data analysis, the N-gain test was taken to describe the improvement in student mathematical communication ability. Table 1 below is a descriptive statistical analysis of the improvement of student mathematical communication ability obtained based on the results of an increase in initial ability to the final ability of mathematical communication.

| Table 1. Descriptive Statistic of Improvement of Mathematical Communication Ability |
|-----------------|--------|---------|-------------|
| Class           | N     | Mean    | Std. Deviation |
| Experiment 1    | 32    | 0.69    | 0.226        |
| Experiment 2    | 31    | 0.49    | 0.339        |

Based on Table 1, the average improvement of mathematical communication ability in the experimental class 1 is 0.69, while the average improvement of mathematical communication ability in the experimental class 2 is 0.49. Both of those groups were categorized in the medium category of N-Gain. Furthermore, the N-Gain data were analyzed using the normality test and Mann-Whitney U test. The results of the normality test show that the significance value of improvement of mathematical communication ability in experimental class 1 was 0.037, and the significance value of improvement of mathematical communication ability of experimental class 2 was 0.021. Both of significance value of experimental class 1 and experimental class 2 were under 0.05. So it can be concluded that the improvement of mathematical communication ability in experimental class 1 and experimental class 2 is not normally distributed so that the next step is to statistic non-parametric using the Mann-Whitney U test.

Based on the aim of this study, the Mann-Whitney U test of N-gain data is aimed to test the hypothesis in this study. Conducting the Mann-Whitney U test, the following statistical hypotheses are formulated. Hypothesis (H₀) meant that the improvement of mathematical communication of students who learn using project-based learning using mind map techniques same as the ability of mathematical communication of students who learn using project-based learning without mind map techniques. Hypothesis (H₁) meant that the improvement of mathematical communication of students who learn using project-based learning using mind map techniques is better than the ability of mathematical communication of students who learn using project-based learning without mind map techniques.

Based on the results of the analysis using SPSS 21 for Windows Software, the Mann-Whitney U test results in the improvement of mathematical communication ability were showed in Table 2 below.
Table 2. The Result of Mann-Whitney U Test of Improvement of Mathematical Communication Ability

|                          | Mann-Whitney U | Z   | Asymp. Sig. (2-tailed) | Conclusion     |
|--------------------------|----------------|-----|------------------------|----------------|
| The Improvement of       |                |     |                        |                |
| Mathematical            | 331,500        | -2.266 | 0.023                  | H₀ Rejected    |
| Communication Ability    |                |     |                        |                |

The Mann-Whitney U test obtained that the Sig. (2-tailed) value is 0.023, which is divided into two. The significant result was 0.0115, which meant under 0.05. The conclusion showed that H₀ was rejected dan H₁ was approved. The result showed the improvement of mathematical communication of students who learn using project-based learning using mind map techniques is better than the ability of mathematical communication of students who learn using project-based learning without mind map techniques.

3.2. Discussion

After processing and analyzing the data, there are some findings to be discussed. Based on the analysis that has been done, research results show that the improvement of mathematical communication of students who learn using project-based learning using mind map techniques is better than the ability of mathematical communication of students who learn using project-based learning without mind map techniques. The difference in the improvement of mathematical communication ability between students in the experimental class 1 and students in the experimental class 2 is certainly supported by the use of mind map techniques in the experimental class 1. This mind map also acts as a tool for students to be able to express their mathematical ideas so that they are more comfortable for others to understand. Through the use of mind map techniques in the implementation of project-based learning, students in experimental class 1 are allowed the opportunity to map ideas and ideas in writing into mind maps.

Furthermore, The difference in the improvement of mathematical communication ability can be seen from the implementation of project-based learning. There are differences between the implementation in the experimental class 1 and experimental class 2, especially the stage of project implementation and testing the results of the project. In the project implementation stage, students in experiment class 1 use mind map to guide their project, while the students in experiment class 2 use the conventional method. In the testing stage of project results, students in experiment class 2 explore their mathematical communication skills by presenting project results in written form and presenting them to other groups of students in the class. In contrast, in the experimental class 1, there is the use of mind map techniques so that in the project testing stage, students present the results of their projects and present them using the mind maps that students have done in groups. At this stage, students exchange ideas and analyze and evaluate each other mind map of the results of the project created by each group. The advantage of the use of mind map techniques, students can see the interrelation of ideas and concepts written by each group in the form of mind maps.

The use of mind map techniques helps students map every idea contained in data information. Through mind map techniques also help students communicate their ideas systematically and have links between the ideas expressed. Mind mapping techniques prepare the mind by means that mapped information can be used logically and can create images in the brain [16]. In line with the result of other researcher that shows the ability of mathematical communication on statistical material whose learning applies the mind mapping learning method is better than the mathematical communication ability of students whose learning applies the conventional method [15]. In using communication strategies effectively, interaction in mathematics classes must be focused on three things: (1) the learning community, (2) reasoning standards, and (3) knowledge [17]. Strategies used by teachers to facilitate mathematical communication ability can be done by providing real-life context to students, using question and answer techniques, using peer teaching, and doing game activities [17]. Through project-based learning, students can practice their communication abilities by completing projects in groups. This activity provides many opportunities for students to interact with other students. In this process, there is a two-way communication process and the delivery of ideas from each student in the group.
4. Conclusion
Based on the results, this study can be concluded that the improvement of mathematical communication of students who learn using project-based learning using mind map techniques is better than the ability of mathematical communication of students who learn using project-based learning without mind map techniques. The project-based learning model with mind map techniques provides a positive contribution to improve the mathematical communication skills of elementary school students. The mind map is a means for students to write their ideas and communicate their ideas to others in writing. The use of mind map techniques can optimize the implementation of project-based learning, even though the improvements obtained in this study are still included in the medium category. For the next study, the researcher recommends that for the selection of projects to be completed by students in groups must be appropriate and consider student abilities and student time allocation. Besides, instructions for implementing project work must be presented clearly and thoroughly to facilitate students in carrying out the project.

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