The implementation of problem-based learning viewed from mathematical connection ability

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Abstract. The mathematical connection ability is very important for students. The mathematical connection ability includes (1) connection between mathematical topics, (2) connection with other disciplines, (3) relationships in everyday life. The aims of this research was to describe the effect of problem-based learning on mathematical connection ability of the 8th grade students (age 13-14). This research was a quasi-experiment with one group pretest-posttest designed. The research samples consisted of one class taken randomly from 4 classes in the population. The data was collected from the mathematical connection ability test‘ achievement or scores that had been declared valid by the expert team. The data analysis used one sample t-test. The criteria of being considered effective were: 1) the posttest score was higher than the pretest score and 2) the proportion of the students that passed the mathematical connection criteria was more than 75%. Based on the result of one sample t-test, the significance value was 0,000, it could be concluded that the problem-based learning approach was effective in terms of the students' mathematical connection ability. The effectiveness of the mathematics learning with problem-based learning approach reached 87.55%.

1. Introduction
One of the objectives of the mathematics learning implementation is to develop the mathematical skills and the affective aspects in the learning. Mathematical ability, here, means the standard of the mathematical ability that must be owned by the students. Mathematical abilities consist of problem-solving ability, reasoning and proof ability, mathematical communication ability, mathematical connection ability, and mathematical representation capability [1]. One of the skills developed in mathematics learning is the ability of mathematical connections. Mathematical connection is a linking activity in mathematics that is the relationship of representation of concepts and procedures, connecting mathematics with other fields of study, and using the relationship [2]. Mathematical connections are classified into three [1], namely: (1) connection between mathematical topics, (2) connection with other disciplines, (3) connection in everyday life.

The ability of the mathematical connections is very important because this ability can guide the students to find mathematics in the real world, the linkages both between mathematical topics, and between mathematics and other subjects. Mathematical connection is the core of learning to understand
the concept of mathematics [3]. Correct connections can build conceptual understanding [4]. A person will acquire and build a new understanding through relevance to the previous concept. Students with good mathematical connections, they are able [1] to recognize and exploit the relationships of the ideas in mathematics and to understand how the ideas in mathematics interconnect and underlie each other to produce a coherent need, as well as recognizing and applying mathematics in the contexts outside mathematics.

However some studies show that the students' mathematical connection ability is still low. This is in the accordance with a research conducted by Sugiman [5]. Based on the results of the research, it can be seen that the level of mathematical connection ability of junior high school students only reaches an average of 53.8% [5]. The average percentages of the aspects of the connection mastery are 63% for the connection on mathematics topics, 42% for the inter mathematics topics connection, 56% for the connection between mathematics and other lessons, and 55% for the relationship of mathematics with the daily life. The ability of mathematical connections is very important in the mathematics learning so that there should be efforts to improve it.

One effort to improve the ability of mathematical connections is by the way teachers strive organizing a learning that varies. The effective mathematical learning can be done by involving guided discovery, meaningful application and problem solving [6]. The approach of problem-based learning is effective viewed from the ability of mathematical connections [7-9]. The problem-based learning approach emphasizes meaningful application and problem solving learning. Mathematics learning with problem based learning approach is one of the alternatives that can be selected by the teacher. The characteristic of the problem-based learning [10] is it is seen as an interdisciplinary perspective where the students explore a number of perspectives and draw conclusions from several disciplines. It shows that problem-based learning has an effect on the student's mathematical connection ability. The statement is supported by the results of a research [11-15], that the problem-based learning approach is effectively improving in terms of the students' mathematical connection ability. The results of the research conducted in a senior high school [10] shows that the mathematics learning with problem-based learning approach is effective regarding to the achievement test, mathematical connection test, and self-esteem questionnaire.

Based on the description above, the question arises, whether the learning of mathematics with problem-based learning approach is effective in terms of the mathematical connections ability of the 8th grade junior high school students (13-14 years old). To answer this question, the authors conducted a study with the title of "The Implementation of Problem-based Learning Viewed from Mathematical Connection Ability".

2. Experimental method

2.1 Method

This study aimed to determine the importance of the problem-based learning on the students' mathematical connection ability. The research method was a quasi-experimental research. The selection of the research method was based on a condition that the researcher did not create a new class for the research, but by using the existing class with the assumption that the classes were the same.

2.2 Model and Design

The independent variable in this research was problem-based learning approach. While the dependent variable in this study was the ability of mathematical connections. The research design used in this research was a pretest-posttest group design as presented in the following figure 1.
Figure 1. The research design (pretest-posttest group design).

Symbol description of figure 1:

- $G_1$: Experiment class with problem-based learning approach
- $O_1$: Test before treatment
- $O_2$: Test after treatment
- $X_1$: Implementation of a problem-based learning approach

The pre-test was given to know the initial condition of the subject. In the pre-test, the research variable to be measured was the ability of the mathematical connection. It was continued by a treatment in the form of learning with a problem-based learning approach to the experimental class. Furthermore, after treatment, the post-test was given with non-routine questions to measure the ability of mathematical connections.

2.3 Subject

The population of the research was all 8th grade students. There were four classes in the population but the students who became the subject of the research were arranged into one group as the experimental class which was treated with the problem-based learning approach.

2.4 Research Location

The research was conducted at SMP Negeri 2 Plagen, Gunungkidul Regency, Yogyakarta, Indonesia. This study involved some steps from the instruments’ testing until the end of the research, which was conducted in January-March 2018. The instruments’ testing was conducted in January 2018, adjusted to the mathematics learning schedule specified by the school.

The test instrument was an open matter one which was for measuring the mathematical connection ability. The test used was in the form of essay test. There were two instrument used namely pretest and posttest. The following table 1 is a test indicator of a mathematical connection test.

| Aspect | Indicator |
|--------|-----------|
| Using the connection between mathematical concepts | Using the relationship between the concepts of a circle with the concepts of lines and angles. |
| Using the connection of mathematical concepts with daily life contexts | Using the concept of circumference of circles to solve problems in daily life |
| Using the connection of mathematical concepts with other fields of study | Using the connection between the concept of the circumference of the circle and the GLBB on physics |

3. Result and discussion

The core activities of the problem-based learning approach had been well implemented. The problem-based learning approach had been implemented for 8 meetings. The pre-test was given before treatment and the post-test was given after treatment. After obtaining the data of the students’ mathematical connection ability, the total value of each unit was categorized based on predetermined criteria [16] in table 2 below.
Table 2. Student’s mathematical connection ability criteria.

| Interval        | Category  |
|-----------------|-----------|
| \( X > 9.6 \)   | Very good |
| \( 7.2 < X \leq 9.6 \) | Good      |
| \( 4.8 < X \leq 7.2 \) | Medium    |
| \( 2.4 < X \leq 4.8 \) | Low       |
| \( X \leq 2.4 \)   | Very low  |

The result of pretest and posttest of mathematical connection is presented in table 3 below.

Table 3. Descriptive statistics of students’ mathematical connection ability.

| Description                  | Before | After |
|-----------------------------|--------|-------|
| Average                     | 6.59   | 8.81  |
| Standard Deviation          | 2.00   | 1.89  |
| Theoretical Minimum Value   | 24     | 0     |
| Minimum Value               | 2      | 5     |
| Theoretical Maximum Value   | 12     | 12    |
| Maximum Value               | 10     | 12    |
| Completeness (%)            | 34.40% | 87.5% |

Based on table 3 it can be seen that the average value of the pretest and the posttest of the mathematical connection ability were both into the "good" category. Prior to treatment, the average mathematical connections ability score was 6.59. After given treatment, the average ability score of the students' mathematical connection was 8.81. The ability of the mathematical connection after the implementation of the problem-based learning class increased 2.22 point or increased by 46.85%.

The data of the mathematical connection ability test results were then converted into some categories of very high, high, medium, low, and very low. The frequency distribution and percentage of mathematical connection capabilities before and after treatment are presented in table 4.

Table 4. Frequency and percentage of student's mathematical connection ability criteria.

| Interval        | Category  | Pretest F | Pretest % | Posttest f | Posttest % |
|-----------------|-----------|-----------|-----------|------------|------------|
| \( X > 9.6 \)   | Very good | 1         | 3.13      | 7          | 25         |
| \( 7.2 < X \leq 9.6 \) | Good      | 10        | 31.25     | 21         | 62.5       |
| \( 4.8 < X \leq 7.2 \) | Medium    | 17        | 53.13     | 4          | 12.5       |
| \( 2.4 < X \leq 4.8 \) | Low       | 3         | 9         | 0          | 0          |
| \( X \leq 2.4 \)   | Very low  | 1         | 3.13      | 0          | 0          |

Based on table 4 it can be seen that before being given treatment there were 3 students in the very high category, there were 2 students in the low category, and 2 students were in the very low category. After treatment, no students were in the low and very low categories. Some students in the very high category experienced an increase from 3 to 8 students.

Case-based learning was effective in terms of the students' mathematical connection ability if the minimum achieved average score was "good" or at least 7.2. The result of the calculation in the table 3 shows that the effectiveness of mathematics learning with problem-based learning approach reached 87.5%. Students with excellent mathematical connections could solve problems perfectly, as in the following figure 2.
Based on Figure 2, it shows that the students could use the relationship between the mathematical concepts and other subjects. The students could write down what was known and there was no error in the calculation to solve the problem. Although 87.5% of the students had good results, there were still problems for students with moderate and low connection skills. One of the students' answers in the medium category is presented in the following figure.

![Figure 3. Student answers with medium category math connections.](image)

Based on Figure 3, it shows that the students could not use the relationship of mathematical concepts with other subjects. The students did not understand that the distance traveled by the oil drum for 20 times was equal with 20 times of the circumference of the circle (oil drum). In Figure 3, the student actually wrote that the distance was 20 times. The initial error generated an error calculation in the next step. This shows that the ability of a mathematical connection is one of the important mathematical skills for the students to have.

Furthermore, the calculation of the students’ connection test results was measured by using SPSS. Since the sample came from a normally distributed population so we could use one sample t-test. The result of one sample t-test is presented in figure 4.
One Sample Statistics

|          | N  | Mean | Std. Deviation | Std. Error Mean |
|----------|----|------|----------------|-----------------|
| VARCO001 | 32 | 8.812| 1.88119        | .33432          |

One-Sample Test

|          | t     | df  | Sig. (2-tailed) | Mean Difference | 95% Confidence Interval of the Difference |
|----------|-------|-----|-----------------|-----------------|-----------------------------------------|
| VARCO001 | 20.30 | 31  | .000            | 8.81250          | 8.1300 to 9.4943 |

Figure 4. The result of one-sample t-test using SPSS.

Based on the results of a t-test sample, the value of significance (2-tailed) was 0.000. Because of the significance value was <0.05, the alternative null hypothesis was rejected and it could be concluded that problem-based learning was effective in terms of improving the students' mathematical connection ability. The results were in the accordance with many studies that had been done, i.e. learning approaches related to the problem which was effective in terms of the students' mathematical connection ability [7-9, 11-15].

This happened because problem-based learning steps could support the ability of the mathematical connections. Due to the problem-based learning, the students explored a number of perspectives and drew conclusions from several disciplines [10].

4. Conclusion
Based on the results of the analysis and discussion of the data, the students after obtaining treatment in the form of learning using problem-based learning have a better mathematical connection ability than the students who have not been treated using problem-based learning. Based on the result of one sample t test, the significance value is 0.000, it can be said that the problem-based learning approach is effective in terms of improving the students' mathematical connection ability. Problem-based learning approach can be used in the mathematics learning to improve the students' mathematical connection skills. In this study there are limitations that the ability of mathematical connections measured is only in the chapter of the Circle. So it is expected to open up opportunities for other researchers to conduct similar research better.

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