Metaphorical thinking approach assisted geogebra to improve connection mathematical ability of junior high school students

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Abstract. This research is motivated by the low mathematical connection ability of students, with the aim of the study is to examine the improvement of junior high school students mathematical connection ability through learning using Geogebra software-assisted metaphorical thinking approach. The method in this study is an experimental method with a posttest-pretest control group research design. The research test instrument consisted of 5 test questions of mathematical connection ability. The population of this study was all junior high school students in Kabupaten Bandung Barat, while the sample was one of junior high school at Kabupaten Bandung Barat. The experimental class obtained learning with the Geogebra software-assisted metaphorical thinking approach, and the control class gained regular learning. The data obtained from the results of the normalized gain test, which were processed through normality tests, and Mann-Whitney test using IBM SPSS 23. The results of the study showed that the achievement of the two classes was still in the moderate category, although the increase in mathematical connection ability between students get learning using the GeoGebra software assisted metaphorical thinking approach is significantly better than students who get regular learning.

1. Introduction

The aim of mathematics education states that students must be able to understand mathematical concepts, can also explain the relationship between concepts and apply concepts or algorithms flexibly, accurately, efficiently and precisely in solving problems [1]. In connection with the concept and applying the concept, a connection is needed so that each concept can be connected. This shows that the initial stage of the ability that must be mastered by students is the ability to connect concepts mathematically which in the end this mathematical connection ability is a prerequisite for students to master other higher abilities.

The mathematical connection ability is mathematics as a connection between mathematical topics, connections with other scientific disciplines, and used in everyday life [2]. This is in line with what was stated by Lestari that mathematical connection ability is the ability of students to connect mathematical concepts both between mathematical concepts themselves and connect mathematical concepts with other fields [3]. Then Saminanto & Kartono suggested that mathematical connection ability is the ability to connect concepts that exist in mathematics as well as relationships with fields outside mathematics [4]. And also Latipah & Afriansyah say that mathematical connection is an ability to connect mathematics with everyday life and other fields of science, this ability is important to have...
so that it makes it easier for students to solve problems related to other fields of study and daily life [5].

Indicators of mathematical connection ability according to Hendriana & Soemarmo include, (1) understanding equivalent representations either concepts, mathematical processes or procedures, (2) looking for relationships from various representations equivalent to concepts, processes or mathematical procedures, (3) understanding relationships Antarctic mathematics, (4) applying mathematics in other fields or in everyday life, (5) looking for the relationship of one procedure with other procedures in equivalent representation, (6) applying relationships between mathematical topics between mathematical topics and other disciplinary topics[6]. In addition, mathematical connection indicators according to Ni'mah, Setiawani, & Oktavianingtyas, namely writing down the mathematical concepts underlying the answers, writing down the relationship between objects and mathematical concepts and understanding the problems of daily life in the form of mathematical models[7].

From the various kinds of mathematical connection indicators that are presented, the research will be examined more deeply in the indicators (a) applying mathematics in other fields or in daily life, (b) applying relationships between mathematical topics and between mathematical topics and outside topics mathematics, and (c) understanding the relationship between mathematical topics because the subject of this study is the cognitive stage junior high school students transitioning from concrete thinking to formal and in line with the metaphorical thinking approach that will be used so that it is expected to hone mathematical connection skills through the indicators mentioned earlier.

But it turns out that junior high school mathematical connection ability is still low. This can be seen from the research conducted by Saminanto & Kartono which also shows that the average mathematical connection ability of middle school students is still low, which is only at 34%, so it can be concluded that the mathematical connection ability is not in the good category[4]. Likewise, the research conducted by Danaryanti & Tanaffasa which examined the mathematical connection ability in class VIII SMP which resulted in the achievement of the average mathematical connection ability of junior high school students only 63.3%[8]. This is in line with the research results of Sudirman, Cahyono, & Kadir, the average achievement of students’ mathematical connection skills is only 36%, this indicates that students’ mathematical connection ability is still not good[9].

To achieve mathematical connection skills of students, it must be emphasized again in solving the concept of connecting mathematical ideas and concepts of everyday life. In directing students to complete the concept of connecting mathematical ideas and concepts of everyday life, the teacher can direct students to find concepts, find concepts, and apply concepts in solving problems in the problem.

Carreira in Affrilianto argues metaphorical thinking is a concept in thinking that connects a mathematical idea with phenomena that are around it[10].

Then Sunito, Sukardjo, Syukur, & Latifah suggested that metaphorical thinking is an approach that uses metaphors to find or explain a concept[11]. The metaphor used in this approach is the process of transferring new meanings and associations from one object or abstract idea to another object or idea that is better known. Through the process of memorizing students are trained to connect the relationships between knowledge (concepts) that have been studied previously with the knowledge (concepts) that will be learned and students are trained to connect mathematical concepts with real things that exist in everyday life. This is in accordance with the mathematical connection capabilities that want to be built, namely understanding the relationship between mathematical topics and applying mathematics in other fields or in everyday life.

The low mathematical connection ability of students is caused by the lack of trained students to deal with real-world problems even though they often find them in everyday life. By applying the approach to learning metaphorical thinking in the classroom, students can feel directly learning mathematics while solving problems related to everyday life. They become more aware of the benefits of learning mathematics.

Along with the development of technology, the field of mathematics also progressed. In line with this, Suryadi explains that the need to use technology develops and is influenced by facts that occur in outside communities[12]. Technological developments in the field of education are the presence of mathematical software that can be used to support learning. One of the mathematical software that can be used is GeoGebra software. GeoGebra is a dynamic mathematical software that can be used as a tool
in learning mathematics. According to Faza, the GeoGebra software was developed by Markus Hohenwater to help the learning process of mathematics at school[13].

By using the GeoGebra software assisted metaphorical thinking and approach, it is expected that during the learning process students will become meaningful and can improve their mathematical connection skills. Based on the previous explanation, the question of the researcher in this study was "What is the improvement in the mathematical connection ability of middle school students whose learning using the approach of metaphorical thinking and assisted by Geogebra software is better than the one using the usual approach?"

2. Method

This study is intended to analyze the ability of mathematical connections by using the approach of metaphorical thinking and assisted by GeoGebra software. The research method used in this research is the experiment. The research design was in the form of a Control Group Design pretest-posttest involving 81 grade VIII students from one of the junior high schools in West Bandung Regency. To obtain data in this study a test instrument was used, namely a set of test questions for mathematical connection skills. To find out how much improvement in students' mathematical connection skills before and after learning activities, a normalized gain score analysis was carried out.

Data obtained from the test results of mathematical connection abilities are converted into qualitative data with criteria that are 85-100 (very high); 69-84 (high); 53-68 (moderate); 37-52 (low); and 20-36 (very low). To prove the research hypothesis first a prerequisite test was carried out, namely the data normality test, homogeneity test and different test (t-test).

The instrument of this study is a test in the form of essays on mathematical connection skills. The sample of students' mathematical connection ability test is as follows:

1. Andi has a cuboid container with 10 m long ribs that will be filled with water through a tap. When the faucet is opened, every 2 minutes the water level in the container will rise 1 m. If Andi has a second container which is 20 m long, 10 m wide and 5 meters high and will be filled with water through the same tap. What concept is used to determine the time needed for the second container to be filled with water in full and how long does it take?

2. Mr. Doni wants to fill the water reservoir in the form of a beam. If every 1 m$^3$ of water costs Rp. 3,000. Determine the mathematical model, if the dimensions of the tub are length x m, width y m, height = 5y m. If p + l = 7m and the height of the beam is 2 times the length? How much does it take for Mr. Doni to fully fill the tub?

3. Result and Discussion

3.1. Data Analysis

After carrying out learning using the metaphorical thinking approach assisted Geogebra software in the experimental class and carrying out regular learning in the control class. Furthermore, the data processing of the research results is carried out so that it can be seen the improvement of the mathematical connection ability of junior high school students who use learning metaphorical thinking with the help of Geogebra software by using ordinary learning after the learning treatment. The table contains the values of each class as table 1.

| Class     | N | \( \bar{x} \) | %  |
|-----------|---|------------|----|
| Experiment|   |            |    |
| Pretest   | 41| 4,00       | 20.00 |
| Posttest  | 12,195| 60.98      |     |
| Gain      | 0,513| 51.30      |     |
| Control   |   |            |    |
| Pretest   | 40| 4,10       | 20.50 |
| Posttest  | 10,70| 53.50      |     |
| Gain      | 0,410| 41.00      |     |
Based on Table 1, it is known that for aspects of mathematical connection ability, the average pretest score in the experimental class is smaller than the control class. Whereas, on the average posttest score and gain of the experimental class is greater than the control class. To support the description of the increase in mathematical connection skills that have been explained, then the data analysis of the mathematical connection ability of students is carried out through statistical tests using the two-average difference test.

a. Normality Test

If Sig. > 0.05, the sample is normally distributed.

The following are the results of data processing for gain normality tests in the experimental class and the control class assisted by IBM SPSS Statistics 23 software presented in Table 2.

| Class       | Kolmogorov-Smirnov | Statistic | Df  | Sig. |
|-------------|--------------------|-----------|-----|------|
| Gain        | Experiment         | .191      | 41  | .001 |
|             | Control            | .112      | 40  | .200*|

Based on Table 2 above, it can be seen that the significance of the experimental class is 0.001 and the control class is 0.200 * the value of the experimental class does not meet the testing requirements for the data normality test, namely Sig. > 0.05. This shows that the two classes are not normally distributed. Because of this, the test will continue with the Mann-Whitney test.

b. Mann Whitney Test

H0: m1 = m2
Ha: m1 > m2

The testing criteria, namely:
If Sig. > 0.05 then H0 is accepted.

The following are the results of Mann-Whitney test data processing in the experimental class and the control class assisted by the IBM SPSS Statistics 23 software presented in Table 3.

|                      | Gain       |
|----------------------|------------|
| Mann-Whitney U       | 436.000    |
| Wilcoxon W           | 1256.00    |
| Z                    | -3.638     |
| Asymp. Sig. (2-tailed)| .000     |
| Monte Carlo Sig. (2- tailed)| .000b |
| Sig. 95% Confidence Interval | Lower Bound |
|                      | Upper Bound |
|                      | .036       |
|                      | .036       |

Monte Carlo Sig. (1- tailed) Sig. 95% Confidence Interval Lower Bound Upper Bound .000b .036 .036
Based on Table 3, it can be seen that the table sig (1-tailed) is 0.000. This value does not meet the testing criteria, namely Sig. > 0.05 then H0 is rejected. This shows an increase in the mathematical connection ability of junior high school students who use the learning of metaphorical thinking with the help of Geogebra software better than those using ordinary learning.

3.2. Discussion of Research Results

In this section, a discussion of the description of the research that has been carried out will be described. During conducting the research the researcher implemented learning using the metaphorical thinking approach with the help of Geogebra software in the experimental class. The material taught in the experimental class and the control class is to build a flat side space. Both classes received treatment in groups. In the experimental class of learning carried out using a metaphorical thinking approach assisted by Geogebra software with conceptual forms of grounding metaphors, linking metaphors, and redefinition metaphors and using GeoGebra software to present flat side space builds. While in the control class using ordinary learning.

The difference in the average acquisition of pretest scores on mathematical connection abilities in Table 1 shows the average acquisition of the experimental class 4.00 and the control class 4.10. This shows that students' initial abilities in both classes are not much different.

From Table 1 we can know that the average final test results of the experimental class are higher than the control class. This shows the level of mathematical connection ability of students who learn to use the metaphorical thinking approach assisted by Geogebra software is better than using ordinary learning. This is because in learning the metaphorical thinking approach students are trained to memorize concepts so students can build connections between abstract concepts that are being studied with real things they know.

In addition, in Table 1, the results of the average percentage of posttest experimental class results are 60.98% and the control class is 53.50%. The achievement of the two classes is still relatively moderate even though the average value of the experimental class is better than the control class. This shows that the achievement of students' mathematical connection skills has not been maximized in both the experimental and control classes. Although in terms of increasing the experimental class better than the control class seen from the results of processing the gain data using IBM SPSS Statistic 23 software presented in table 3, but both classes belong to the moderate improvement criteria when viewed from the average gain of 0.513 for the experimental class and 0.41 for the control class.

At the end of the study, students were given the final test, namely the posttest. The aim is to see the achievement and improvement of mathematical connection skills after giving different learning treatments in both classes. One example of work post both classes as follows:

**Figure 1.** Control Class Postes Answers

Figure 1 and Figure 2 show the answers to one of the posttest questions. Figure 1 shows the steps of the workmanship are incomplete even though the answer is correct. Meanwhile, Figure 2 shows the answers with the right steps accompanied by what concepts are used to solve the problem. From the two picture answers, it can be seen that the experimental class students are more master of the concept
of mathematical connections than the control class students. Table 4 shows that the increase in mathematical connection ability of junior high school students using the metaphorical thinking approach assisted by Geogebra software is better than using ordinary learning.

![Figure 2. Experiment Class Postes Answers](image)

The results of this study indicate an increase in mathematical ability because it uses a metaphorical thinking approach, besides improving mathematical connection skills, this metaphorical thinking approach can also improve mathematical reasoning abilities such as the research conducted by Nurhikmayati[14]. In line with the previous research mentioned the results that are not much different are also found in the research conducted by Roesdiana, the metaphorical thinking approach influences the achievement of mathematical reasoning abilities but not the achievement of students' mathematical communication due to students' mathematical communication skills using more metaphorical thinking approaches low is not significantly[15].

Then another study conducted by Lesmana, Hidayat, & Rohaeti showed that the increase in the ability of mathematical generalizations of students who learned using the approach of metaphorical thinking was better than students who received ordinary learning[16]. In addition, research conducted by Mardiyanti, Afrilianto, & Rohaeti shows that the approach of metaphorical thinking can improve the mathematical critical thinking skills of junior high school students in triangular material compared to ordinary learning[17].

Based on the previous explanation, it turns out that the approach of metaphorical thinking can improve some mathematical abilities, however, there are also abilities whose achievements are not higher than using ordinary learning. This can be caused by material that is not in accordance with the steps of the metaphorical thinking approach and has not yet been used to using metaphor in learning as stated by Roesdiana [15]. This can be a consideration for further research in choosing an approach that matches the material to be studied.

4. Conclusion

Based on the results of the research and discussion, the conclusions of this study are (1) There are differences in the increase in mathematical connection ability of junior high school students who use learning metaphorical thinking with the help of Geogebra software by using ordinary learning, and (2) Improving the mathematical connection ability of junior high students using learning metaphorical thinking with the help of Geogebra software is better than those that use ordinary learning.

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