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Cabri 3D - assisted collaborative learning to enhance junior high school students' spatial ability

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Abstract. The main purpose of this quasi-experimental study was to determine the enhancement of spatial ability of junior high school students who learned through Cabri-3D assisted collaborative learning. The methodology of this study was the nonequivalent group that was conducted to students of the eighth grade in a junior high school as a population. Samples consisted one class of the experimental group who studied with Cabri-3D assisted collaborative learning and one class as a control group who got regular learning activity. The instrument used in this study was a spatial ability test. Analyzing normalized gain of students' spatial ability based on mathematical prior knowledge (MPK) and its interactions was tested by two-way ANOVA at a significance level of 5% then continued with using Post Hoc Scheffe test. The research results showed that there was significant difference in enhancement of the spatial ability between students who learnt with Cabri 3D assisted collaborative learning and students who got regular learning, there was significant difference in enhancement of the spatial ability between students who learnt with cabri 3D assisted collaborative learning and students who got regular learning in terms of MPK and there is no significant interaction between learning (Cabri-3D assisted collaborative learning and regular learning) with students' MPK (high, medium, and low) toward the enhancement of students' spatial abilities. From the above findings, it can be seen that cabri-3D assisted collaborative learning could enhance spatial ability of junior high school students .

1. Introduction

There are many ways to facilitate mankind acquire knowledge. One of the most common ways is through education. Through education, learners are expected to be personally ready and to compete properly and optimally in the global world. Mathematics is a subject that can address the challenges of the global world because it is a universal science that underlies the development of modern technology, have an important role in a variety of disciplines, and develop the power of human thought through the purpose of studying mathematics that show attitude logical, critical, analytical, meticulous and thorough, to be responsible, responsive, and not quitter in solving problem. Have a sense of want to know, spirit continuous learning, confidence, and interest in mathematics. Have confidence on power and usability mathematics, formed through learning experience, Have an attitude open, objective in interaction groups or daily activities [1].

Mathematics teaches us how to be able to think logically and systematically. It also teaches us to be more disciplined, obey rules and follow agreements. Besides, mathematics is also one of the subjects that have been taught at every level of education systems and has a very important role in the



development of students' abilities. This is in line with the goal of learning mathematics formulated by National Council of Teachers of Mathematics (NCTM) which are: "(1) mathematical communication; (2) mathematical reasoning; (3) mathematical problem solving; (4) mathematical connection and; (5) mathematical representation" [2].

Since there are many benefits of mathematics for life, mathematics should be the important subject to be taught in schools, and also should be one of the most favorite subjects for the students. However, it turns out that mathematics is not the students' favorite subject after all. The results of a preliminary study by interviewing a few Junior High students, some students think that mathematics is an appalling subject, hard to understand, and taught in monotony. They believe that studying mathematics was boring.

Geometry is a part of mathematics which deals with the shape and size of an object that has regularity. The purpose of learning geometry at school as reported by Thomas [3], such (a) to develop spatial awareness, intuition and the ability to visualize geometry; (b) To provide the breadth of experience both in the geometry of two-dimensional space and 3-dimensional; (c) To develop knowledge and understanding and the ability to use the properties and geometry theorem; (d) to encourage the development and use of conjecture, deductive reasoning and evidence; (e) To develop the application of geometry skills through modeling and problem solving in the real world; (f) to develop the use of ICT skills in the context of geometry; (g) to ensure a positive attitude towards mathematics and; (h) to develop an awareness of the historical and cultural heritage of geometry in society and contemporary applications of geometry. However some testimony from the field showed that the results of learning geometry in Indonesia remain low because there are many students who have difficulty in learning geometry, ranging from elementary to university level [4] while Syahputra's [5] statement that students find many difficulties to understand object or image of geometry.

The purpose of learning geometry is that the students will gain confidence in their math ability, be a good problem solver, can communicate mathematically, and think mathematically. Meanwhile, according to Budiarto stated that "the purpose of learning geometry is to develop the ability to think logically, develop spatial intuition, imparting knowledge to support other materials, and able to read and interpret mathematical arguments" [4]. Therefore, developing the students' spatial ability is important because it is one of the goals of learning geometry.

Wardhani and Rumiati [6] in their research revealed that "the analysis of the results of the PISA study, there are still many Indonesian students who have difficulty in solving these problems. Only 33.4% of the participants (Indonesian students) were able to answer correctly and the rest answered incorrectly". This condition illustrates that the level of spatial ability of the Indonesian students is still low, especially at 15 years old teenager. Furthermore, Faradhila, Sujadi and Kuswardi [7] in their research found "at the junior level, in the daily test of the students in grade VIII about solid geometry is very unsatisfactory and far below the minimum completeness criteria". It is because of the students' disability in interpreting the images in a visual form for their low learning achievement.

The study of Syahputra [5] revealed that the low spatial ability of the students is caused by the teachers' pressure of learning geometry by giving and forcefully memorizing mechanical terms (e.g. to determine the ribs, the field side area, and the volume of the cubes) without adequate emphasis on the geometry spatial aspects they have studied. It is important for the teacher to design a lesson that stimulates the students to become more active in the classroom by having the group discussion or class discussion so that students' thinking skills and communication skills can be formed. An alternative solution to improve the spatial and mathematical communication ability of students is collaborative learning.

Besides designing an appropriate learning in order to get the maximum learning outcomes, the infrastructure also has a significant role. A learning process is also expected to visualize mathematical ideas clearly in order to help the students understand mathematics, especially in geometry. The visual demonstration has a very important role in learning geometry. Both teacher's demonstration and through technologies demonstration (e.g. software designed to convey geometry concepts) are surely

helpful. The learning that combines face-to-face with teacher and technology is very effective. According to Syahputra [5], a dynamic mathematics software that can be used in geometry is Cabri-3D. This program will assist the teacher in explaining geometry. Cabri-3D will help the students to visualize two-dimensional and three-dimensional geometric shapes. It will help them to uncover the geometric shapes easily and it surely will help them to understand the concept of geometry and to train their spatial skills. With Cabri-3D students can explore, observe, and see the geometry shapes in detail. This application is expected to help the students to visualize geometry concept clearly.

Based on the description that has been presented about the importance of the efficiency and effectiveness of mathematics learning, the authors propose a research study of mathematics, especially in geometry by using Cabri-3D to improve spatial skills of the Junior High students.

The specific purposes of this research are:

1. figure out the differences in the spatial abilities of the student learning with collaborative learning assisted by Cabri-3D and the students who get regular learning;
2. figure out the differences of the spatial abilities of the student learning with collaborative learning assisted by Cabri-3D and the students who get regular learning in terms of the students' prior knowledge in math IMK (High, Medium, Low);
3. To figure out the effects of the interaction between learning model and the students' prior knowledge of mathematics to increase their spatial abilities.

The definition of spatial ability in this research is the ability of the students to visualize, compare, suspect, determine the suitable object, construct, present and find information from visual stimuli in the spatial context, which is the indicators as follows:

- 1) The ability to visualize the position of a geometric object after it undergoes rotation, reflection, or dilation.
- 2) The ability to compare the logical interrelationships of the elements of 3D shapes.
- 3) The ability to accurately guess the actual shape of the geometric shape that is seen from a certain perspective.
- 4) The ability to determine the suitable object in a certain position of the 3D geometric object.
- 5) The ability to construct a model of an object associated with the 3D shapes.
- 6) The ability to specify a simple object embedded in a more complex image.

12 Methods

This research is a quasi-experimental research with the nonequivalent control group design form. In this design, the subjects of study are grouped into two, namely the experimental group and the control group. The experimental group was treated by Cabri-3D assisted collaborative learning and the control group was treated by regular learning, in addition to the two classes grouped based on mathematical prior knowledge (MPK) into three groups: high, medium, and low.

The data were obtained using a test instrument types; a test for spatial ability. It was given before treatment (pretest) and after treatment (posttest). The test was conceived and developed by the researchers based on the procedure of preparation instrument properly.

The analysis of the data used in this study is called quantitative data analysis. The steps in the analysis of spatial ability test instruments are as follows:

- a. Give the score to the students' answers according to the answer key and scoring guidelines.
- b. Make the pretest and posttest tables scores of the students of experimental group and the control group.
- c. Examine the similarities mean of the pretest from both groups.
- d. Grouping the data of samples in the experimental and control class based on the classification of the MPK.
- e. Determine the spatial ability with N-gain formula.

After the increasing data obtained, the next step is to do a statistical test. Before the statistical test, data were checked with normality and homogeneity of variance test as a condition for the use of parametric statistics called the two-way ANOVA test.

3. Results and Discussion

To answer the formulation problem proposed, the spatial ability of students were analyzed based on spatial ability pretest and posttest are given. Pretest data were analyzed to see whether the two groups have the common mean and then based on data pretest and posttest analyzed whether there is an increase or not. Furthermore, do the calculation of the N-gain. N-gain data are then analyzed to test the hypothesis by the previous normality and homogeneity test as a condition for using parametric statistics.

Other data values for the mean and standard deviation score data pretest, posttest, the gain and the normalization gain of spatial ability of students based on prior knowledge of mathematical categories are : The average value obtained an increase in spatial ability to both classes, the group of high MIK students obtained higher average than the control class for 0.87 and 0.79, with a variation of the spread of a more balanced spread also in the experimental class which can be seen from differences in the two classes, for standard deviation of 0.10 and 0.08. Similarly, the increase in spatial ability for groups of students MIK scores were obtained for the experimental class higher than the control class is 0.72 and 0.58 with a similar deployment on 0.13 and 0.11. The same result is also increasing the ability of lower MIK spatial student group class experiment is still superior to the control class for 0.68 and 0.39. With a more diverse spread of scores well in class experiments, standard deviation obtained from the experimental class larger than the control class for 1.12 and 0.65. Total mean score of the increasing of spatial abilities in experimental class is certainly higher than the control class. Note that the average N-gain experimental class is 0.74 (High), and the average N-gain control class is 0.58 (middle). To see the description of an increase in the spatial ability of students by the prior mathematical knowledge of students, presented by the following diagram.

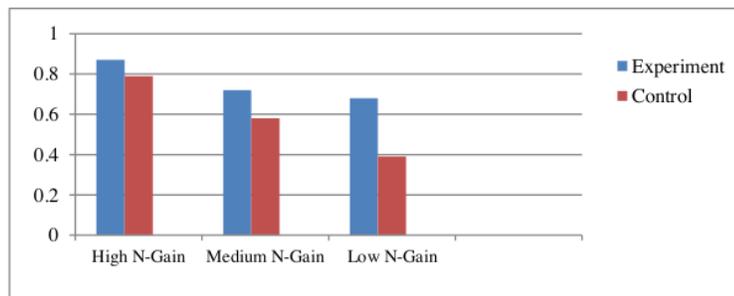


Figure 1. The mean of spatial ability of students based on MIK

The average value of the N-largest gain was the experimental class for highly capable students, amounting to 0.87. The average value of the smallest N-gain is also in the control class for low-ability students, for 0.39. Furthermore, the category of an increase in the spatial ability of students based on MIK presented in the following table:

Table 1. The Category of Increasing in Student's Spatial Ability Based on MIK

MIK	Experiment			Control		
	n	N-Gain	Category	n	N-Gain	Category
High	5	0.87	High	5	0.79	High
Medium	10	0.72	High	12	0.58	Middle
Low	5	0.68	Middle	5	0.39	Middle

Total	20	0.74	High	22	0.58	Middle
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According to Table 1 found that a group of students of high MIK and medium MIK in the experimental class gained increased spatial ability with the high category, only the low group are upgrading spatial ability in the average category. In contrast to the control group which spatial enhancement to the group of students who entered high MIK with higher categories, while the medium and low MIK have only low increase of spatial ability. It is also included in the Middle category.

The first thing to do in analyzing the improvement score of spatial ability is to do normality test. If the data are normally distributed then proceed to test the homogeneity of variance. Normality and homogeneity test scores N-gain spatial skills performed in order to determine what types of statistical tests to be used in hypothesis testing. If the data are normally distributed and the variance of data is homogeneous, then the hypothesis test performed using two-ways ANOVA. If not, then the hypothesis test is done by using Freidmann's Nonparametric Test. Data spatial enhancement of students coming from a normally distributed population, and also from the population that has a homogeneous variance, so the statistical test used was two-way ANOVA statistical test. Here is the result of N-gain two-way ANOVA test scores:

Table 2. The Result of Two-Way ANOVA of N-Gain

Factor	F	Sig.	Conclusion	Description
Class	17.467	0.000	H ₀ Rejected	There was significant difference
Category of IMK	13.997	0.000	H ₀ Rejected	There was significant difference
Class*IMK	1.87	0.169	H ₀ Accepted	There was no significant difference

Based on the Table 2, it can be seen that the value of class significance, i.e. learning model = 0.000 < 0.05 = α , so that H₀ is rejected. It means that there are differences in spatial abilities enhancement among students who learn by collaborative learning using Cabri-3D and regular learning. This indicates that the class factor is the type of learning has the significant influence on the improvement of students' spatial abilities.

Based on table 2, it can also be seen that the value of significance to MIK = 0.000 < 0.05 = α , so that H₀ is rejected. It means that there are differences in spatial abilities increase among students who received collaborative learning with Cabri-3D and regular learning in terms of MIK students. This indicates that MIK also has a significant influence on the enhancement of students' spatial abilities.

Furthermore, to determine the category of MIK which provides the significant difference, then the advanced ANOVA test, Scheffe Post Hoc test, must be done. Post Hoc test is an advanced ANOVA test which aims to determine which data group had significant differences among the six groups of data. Post Hoc test used is Scheffe Post Hoc test. Here is the results Scheffe Post Hoc test:

Then, based on Table 2 above, also found that the significance of learning approaches and MIK category to the improvement of spatial ability students = 0.169 > 0.05 = α , H₀ is accepted. It means that, there is no significant interaction between learning models and the categories of MIK to enhance students' spatial abilities. It also means that, learning models and the categories of MIK together do not have a significant influence on the enhancement of students' spatial abilities.

4. Conclusion

Based on the research and discussion, the findings of this study can be concluded such as: (1) There is a difference between the enhancement in spatial ability of students who learn by collaborative learning Cabri-3D and regular learning; (2) There is a difference between the enhancement in spatial ability of students who learn by collaborative learning Cabri-3D and regular learning in terms of MIK of the students (High, Medium, Low); and (3) There is no interaction between learning model with MIK of students to enhance students' spatial abilities.

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