3D Grapher application: Mathematical spatial ability

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Abstract. 3D Grapher application is a user-friendly application that supports learning to three-dimensional geometry. The purpose of this study was to determine the increase of students’ mathematical spatial ability by using the 3D Grapher application. This study uses quasi-experiment method with a tutorial model conducted on class VIII students one of junior high school in Bandung City. The instruments research by test and the research data were analyzed by t-independent test. Based on the results of research that improves mathematical spatial ability of students who get 3D Grapher based tutorial learning with an average n-gain score 0.56 better than students who get conventional learning with an average n-gain score 0.44. Thus learning through the 3D Grapher application can be used as an alternative to improve the mathematical spatial abilities.

1. Introduction
Since the 1990s technology has contributed to teaching and learning, such as Cabri and Geometer's Sketchpad Software both included in the DGS Geometry System (Dynamic Geometry Software) which have a major influence in the field of teaching and learning of mathematics, especially geometry [1,2]. DGS has a "dragging" feature that makes DGS superior to other software. This feature can enable students to quickly and easily investigate the validity of certain conjectures, besides these programs facilitate exploration that promotes the conjecture process [3,4], it can have a significant effect on the understanding of its users which makes DGS widely used in schools and colleges throughout the world [5,6]. 3D Grapher is a DGS application that will be a revolutionary visualization and reasoning of previous DGS software that has many advantages. 3D Grapher is application user friendly, more practical, effective and efficient because this application is available on smartphones so it can be used anytime and anywhere [7].

3D Grapher is a renaming application of GeoGebra, where GeoGebra itself is a software that combines CAS and DGS while the 3D Grapher application has a more specific role in geometry (DGS) [7,8]. The 3D Grapher application can be used for learning to build three-dimensional spaces as recognized by its developers that this application is supported by three-dimensional features such as Surfaces, Geometric Object, Quadric and Nets. In three-dimensional space building material students are required to have spatial abilities that can imagine, compare, measure, investigate and construct an object of space building [9]. But in fact, from the results of preliminary studies conducted by researchers that resulted in students still having difficulty imagining, investigating, understanding and constructing three-dimensional building problems related to daily life, this is in line with research conducted by Siswanto who stated that students' spatial ability is still low [10]. Whereas spatial ability is a very important ability [11], closely related to many subjects in mathematics and geometry [12], it is also
related to mathematical problem solving [13] and spatial ability is also one of the abilities students must have in learning geometry [14].

Before attempting to improve spatial ability, it is important for us to know how students’ spatial skills use the 3D Grapher application in three-dimensional space building material. In this application there is a “dragging” feature so that students can construct various kinds of shapes in three-dimensional space, can investigate the elements of three-dimensional space that has been created in the application, can imagine and understand so students are helped to get the visual form of the concept building three-dimensional spaces and also students can see the shapes of three-dimensional spaces seen from various points of view, all of which help students to improve their spatial abilities. The use of the 3D Grapher application as a medium for learning mathematics is one of the positive impacts of the development of technology and information, especially the rapid number of smartphone users among productive ages [15], makes this application as an alternative learning that can make students learn and feel different sensations of learning and this application can be installed for free on Android and iOS-based smartphones.

The application in 3D Grapher mathematics learning requires a learning model that is suitable with the media and the objectives of the learning itself. There are three models of delivering material in technology-based learning and information, one of which is a tutorial learning model [16]. Researchers combine-based tutorial learning models 3D Grapher to find out whether the spatial ability of students who get 3D Grapher-based learning is better than students who get conventional learning (lecture).

2. Methods
This research is a quasi-experimental study. The populations in this research were all eighth-grade students in one of junior high school Kota Bandung, while for the sample two classes were taken through purposive sampling technique. This research was conducted by giving the initial knowledge of mathematics (PAM) was then given a pretest of spatial ability test and then given a 3D Grapher-based learning tutorial and given a posttest in the form of spatial ability questions. The data used to determine the increase in students’ mathematical spatial abilities, namely the pretest score and score posttest to determine the n-gain value, then the data is tested assumptions in the form of normality and homogeneity of variance when assumption tests are met followed by t-independent tests.

3. Results and discussion
3D Grapher is an application used by researchers to be able to improve students’ mathematical spatial abilities combined with a tutorial learning model. Implementation of learning at each meeting carried out in accordance with the stages of the 3D Grapher-based tutorial learning model where there are seven stages is opening, presentation of information, question and response, assessment and response, feedback, repetition and closing. Display 3D Grapher application taken from the official website of GeoGebra and then modified as follows:

Figure 1. Display of 3D Grapher application.
Figure 1 is a display of the 3D Grapher application which consists of an initial display and examples of project projects that can be performed on the application. The first lesson discusses the building elements of cubes and beams. In the 3D Grapher application module made by researchers construct the building of cubes and beams in the 3D Grapher application according to the steps in the 3D Grapher module. After forming a cube building student are asked to answer the questions listed in the module in order to build concepts about elements of cube space. The appearance to construct the cube space in the 3D Grapher application is as follows:

Figure 2. Constructing the cube’s waking space on 3D Grapher application.

After completing the construction of the cube space, students are then asked to construct the building of beams. After a beams structure is formed in the 3D Grapher application students are then asked to answer questions about the element’s beams listed in the 3D Grapher application module. The appearance to create a beam building in 3D Grapher applications like the following.

Figure 3. Constructing beams in the 3D Grapher application.

Implementation of mathematics learning using the 3D Grapher application with a tutorial model.
Figure 4. Implementation of learning tutorials based on 3D Grapher application.

Figure 4 show that of implementation of learning tutorials based on 3D Grapher Application. Students are given a 3D Grapher tutorial module made by researchers, then students are asked to explore instructions and work on projects contained in the module. The study was conducted seven times with four learning meetings. The first learning meeting discusses the elements of building a flat sided space on the subject of cubes and beams, the second meeting discussed cube and beams nets, the third meeting discussed the surface area of cubes and beams and the last learning meeting discussed the volume of cubes and beams. Improving students' mathematical spatial ability can be trusted with the calculation of the pretest and posttest score data which is then processed with the n-gain normalized.

The results of the average score of the n-gain of the experimental class was 0.56 while the average score of the n-gain of the control class by 0.44 showed that the average score of the experimental class was better than the control class. As for the results of the assumption test normality n-gain score aided by IBM SPSS Statistics 21 produces that the value of Sig. 3D Grapher based tutorial class or experiment (0.743) > 0.05 means that data is normally distributed. For the results of normality tests in the control class or class that uses conventional learning in the form of lectures produces Sig. (0.999) > 0.05, then the data is normally distributed. From the two calculations it can be concluded that the N-Gain Score data from the 3D Grapher based learning tutorial and conventional (lecture) are normally distributed, this is in line with research conducted by Ghasemi et al [17].

The results of the assumption homogeneity test for n-gain data variance from the two classes assisted by IBM SPSS Statistics 21 produce that the Sig. 0.321 > 0.05 which means that the variance of the two data is homogeneous, this is in line with research conducted by Singh [18]. Both assumption tests have been fulfilled, then continued with t-independent test to be able to find out the differences in the improvement of students' mathematical spatial abilities between students who use 3D Grapher-based tutorial learning with students who get conventional learning in the form of lectures.

The results of the t-independence test aided by IBM SPSS Statistics 21 obtained Sig. (2-tailed), that is 0.027 < 0.05, meaning that there are differences in the improvement of mathematical spatial abilities between students who use the 3D Grapher-based tutorial learning model and students who use conventional learning models in the form of lectures. Because there are differences between the two learning and when seen from the average score of n-gain class using 3D Grapher based tutorial learning is better than the average n-gain score of students who use conventional learning in the form of lectures. This is in line with research [7,19,20], that learning mathematics using 3D software has a positive effect on spatial ability, can improve students' spatial abilities and increase mathematical spatial abilities of students who get Grapher-based 3D learning lessons better than students who get conventional learning.
4. Conclusion
Improved spatial ability of students who use 3D Grapher-based learning with an average score of n-gain 0.56 better than students who obtain conventional learning with an average score of n-gain of 0.44. 3D Grapher application can improve students' mathematical spatial abilities.

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