

# Integrating GeoGebra into Space Geometry in College

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**Abstract:** Pre-service mathematics teacher students often find geometrical concepts that are difficult to understand. This results in a decrease in interest in geometry. The purpose of this study was to examine the impact of using 'GeoGebra' on the mathematics achievement of pre-service mathematics teacher students in space geometry learning. The study was a quasi-experimental design. A total of 56 students were selected from the mathematics education program of Tidar University, a state university located in Magelang, Central Java, Indonesia. The experimental group (27) was taught about the slice plane in the prism and pyramid using GeoGebra while the control group (29) was taught using traditional teaching methods. The research data were obtained from a test consisting of six questions and questionnaire consists of nine items. At the end of the treatment, students' mathematics achievement was measured using a post-test. The data were then analyzed using an independent T-test. The results showed that GeoGebra was an effective tool for teaching and learning space geometry in college.

**Keywords:** *space geometry, GeoGebra, mathematics achievement, college*

## INTRODUCTION

Geometry is one of the branches of mathematics. Geometry is the study of shape and Space (Guyen & Kosa, 2008). This allows one to understand the world by comparing its shapes, objects, and connections (Gunhan, 2014). Understanding geometry is important to yourself and to understand other areas of mathematics. It contributes to logical and deductive reasoning about spatial objects and relationships (Alqahtani & Powell, 2016). Therefore, understanding the concept of geometry must be developed effectively in mathematics learning.

As with other mathematical objects, space geometry objects are also abstract. This makes much math teacher candidates will have difficulty in learning it. Such a fact encourages the need for learning media that can provide a visual representation in learning the abstract objects of geometry. Although visualizations are an important element for the teaching of geometry, especially the geometry of space, there has not been an effective tool for teaching these geometry topics. As a major consideration and the fact that more than 70% of undergraduate students Mathematics Education study program, Tidar University has achievements under 70 during the learning geometry of the field, courses before the geometry of the space.

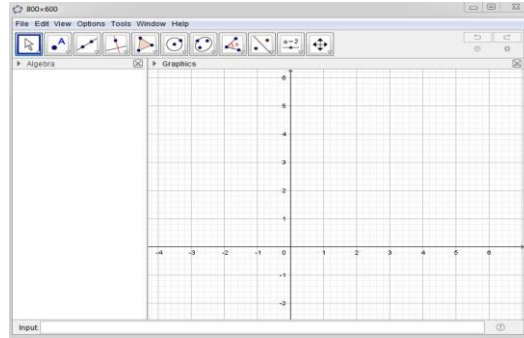
Recently, it is inevitable that technology is a major consideration in Indonesia developing every aspect of human life, including how it can make great acceleration in setting up a more student learning environment Good. Technology can provide a great opportunity for students to do an in-depth exploration of their understanding of a concept. Because of the importance of this technology in the teaching of mathematics, the National Teacher Council of Mathematics (NCTM, 2000) calls for establishing educational policies that utilize technology in teaching mathematics using smart devices and applications that Different. Thus, students receive a broad teaching program in mathematics, due to the technological ability to promote student learning through the embodiment of mathematical ideas in a visible form.

This research is done by considering the need for effective geometry learning media for student visualization. There are various types of commercial software available for teaching and learning mathematics in the open market. For example Geometer's Sketchpad, Derive, Cabri, Matlab, Autograph, and more. This mathematical software has been used in schools as well as universities around the world. In this study, we have chosen GeoGebra as a visualization tool for teaching and spatial geometry. Geogebra also encourages students to share their knowledge and creativity in mathematics (Kllogjeri & Shyti, 2010). Also, students of all levels of knowledge can encourage mathematics by using Geogebra (Mejerek, 2014). Mahmudi (2010) stated that with a varied and interesting look, GeoGebra can facilitate in manipulating various geometry objects to increase student interest in geometry learning. In accommodating the needs of increasing undergraduate students in understanding the specific concepts in geometry, and the fact that GeoGebra proved to be able to help students understand more about geometry. This research is done by noting how to integrate GeoGebra on the geometry of space at university. However, researchers limit the subject of only slices on the prism and pyramid.

## LITERATURE REVIEW

Understanding geometry is important to yourself and to understand other areas of mathematics. Space geometry is one of the courses offered in the 2nd semester at the Mathematics Education Study Program, Tidar University. According to the curriculum of Mathematics Education Study Program, this course contains discussion of geometry objects (points, lines, fields) in space, relations between objects of geometry, polyhedron, pyramid, prism, cones, tubes, balls, measurements involving the objects and the geometric forms of space, the construction techniques of space drawings and the relationships between the geometry objects of space. In the prism and pyramid material, there is a field that cuts the prism and pyramid. The slices of this field can be specified in three ways, i.e. using an affinity axis, using the intersection of the diagonal field, and using an expansion of the side field.

In this study, we have chosen GeoGebra as a visualization tool for teaching and spatial geometry. GeoGebra is a free, open-source dynamic software for mathematics teaching and learning that offers geometry and algebraic features in a fully connected software environment. It's designed to incorporate dynamic geometry software features (e.g. Cabri Geometry, Geometer, Sketchpad) and computer algebraic systems (e.g. Derive, Maple) in a single, integrated, and easy-to-use system for teaching and learning mathematics, (Hohenwarter, Jarvis, & Lavicza, 2008). GeoGebra is based on the scientific criteria of mathematics. GeoGebra was designed by Mark Hohenwarter and has now been translated into 40 languages. Users around the world can freely download this software from the official GeoGebra website at <http://www.geogebra.org>. There are seven menus in GeoGebra such as File, Edit, View, Options, Tools, Window, and Help. GeoGebra also has several tools to visualize two-dimensional objects, such as points, lines, perpendicular lines, polygons, circles, ellipses, angles, reflections about lines, sliders, and moving chart views. The Menu helps us visualize geometry objects according to our purpose.



**Figure 1.** GeoGebra start page display image

Saha, Ayub & Tarmizi (2010) conducted a study aimed at identifying the impact of the use of GeoGebra in teaching geometry coordinates on a group of high school students. The results show statistically significant differences between the average post-test of the two inner groups featuring the GeoGebra group. Bhagat and Change (2015), Emaikwu, Lji & Ari (2015) show that the use of GeoGebra helps students build new knowledge and associate it with previous knowledge, which is quite consistent with a constructive learning approach. Also, it can improve the ability of students to contextualize mathematical elements, to improve learning outcomes.

## METHOD

This study used the design of quasi-experimental research divided into experimental groups and control groups. The purpose of the study was to test the impact of the use of 'GeoGebra' on the mathematical achievement of students of mathematics teachers in the course of geometry space. This study was conducted on 56 Students of Mathematics Education Study Program in 2<sup>nd</sup> semester at Tidar University in Magelang. Sampling was conducted with purposive sampling based on two groups: the experimental group ( $n = 27$ ) was taught using GeoGebra, a control group ( $n = 29$ ) was taught using conventional methods.

**Table 1.** A summary of the research procedure

	Experimental group	Control group
Phase I	Learning with GeoGebra	Learning with conventional
Phase II	Posttest	Posttest
Phase III	Answers a questionnaire	-

The data were then analyzed using an independent T-test. The collecting data in this study were the posttest of student achievement and questionnaires. Posttest is used to compare and know the difference in the treatment results given. Post-test achievements consist of six questions with a single question on the slices of a field on the prism and pyramid have given after four times the course geometry begins after the mid-semester test of even 2018/2019. The post-test was given to group experiments and control groups. Post-test achievements are used to measure students' achievements after performing lectures using GeoGebra. The validity of tests is verified by presenting the experts who are asked to give their views and suggestions to the instruments being made.

Then, in the experiment group was given a questionnaire about student reflections during the use of GeoGebra in the geometry of space classes. This questionnaire consists of nine items with a Likert scale, 1-very disagree, 2-disagree, 3-enough agree, 4-agree, and 5-very agree. The

study used a modified questionnaire from the research of Shadaan and Leong (2013). This questionnaire is reliable with Cronbach's Alpha value  $\alpha = 0.774$  with consistent good criteria.

The difference between pretest and posttest determines whether GeoGebra software affects student achievement in learning the slices of the field on prism and pyramid.

## RESULTS AND DISCUSSION

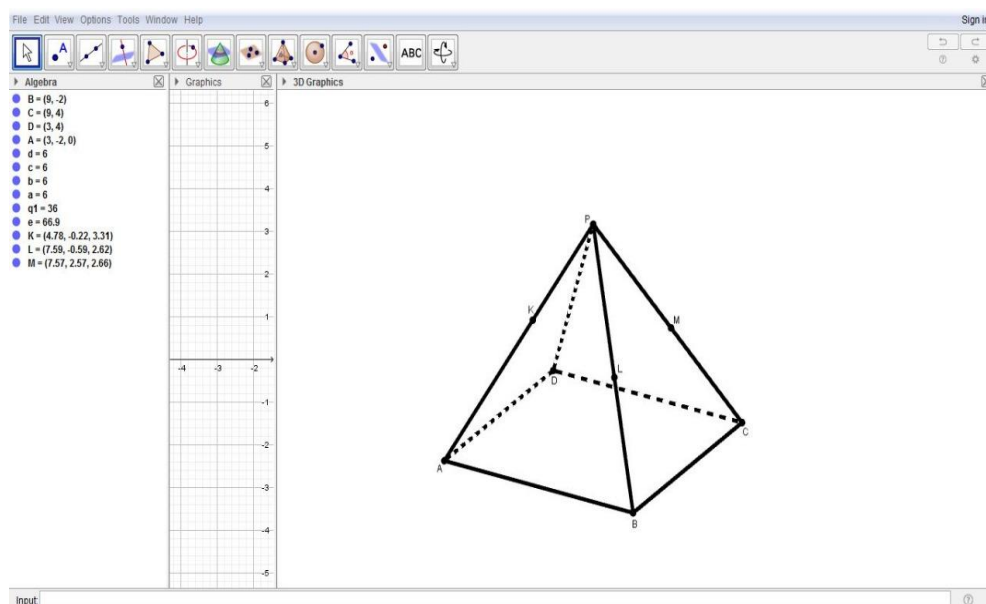
In this study, the influence of GeoGebra integration in space geometry was examined using a quasi-experimental design. With the development of information and communication technology currently in the field of education, this research seeks to test the effectiveness of using GeoGebra as a tool in teaching and learning geometry. The results showed that there were significant differences between the achievement of the control group, taught by conventional teaching methods, and experimental groups, which were taught using GeoGebra.

The following table illustrates the average control group with conventional learning and experimental groups taught with Geogebra. Independent-T test results comparing the results of a second post-test group indicate that there is a significant difference between the average score of the control group ( $M = 73,45$ ) compared to the experimental group ( $M = 88,11$ ,  $p = 0,000 < 0,05$ ). The difference between the averages is 14,66 points at a test of 100 points. These findings suggest that students of mathematics teachers who use GeoGebra in their geometry are fantastic in mathematical learning achievements than students with conventional learning. It shows that GeoGebra software enhances student achievement of mathematics teacher candidates.

**Table 2.** Result independent t-test from the final Test control group and experiment group

Group	N	Mean	Std Deviation	t	df	Sig. (2-tailed)
Control	29	73.45	7.35132	-8.204	54	0.000
Experiment	27	88.11	5.87912			

In the following figure, students are required to specify a slice of the field by using an affinity axis on a pyramid and prism that is through several known points (K, L, and M on the pyramid, P, Q, and R on prism).



**Figure 2.** Pyramid P. ABCD with Point K on AP, L on BP, and M on CP

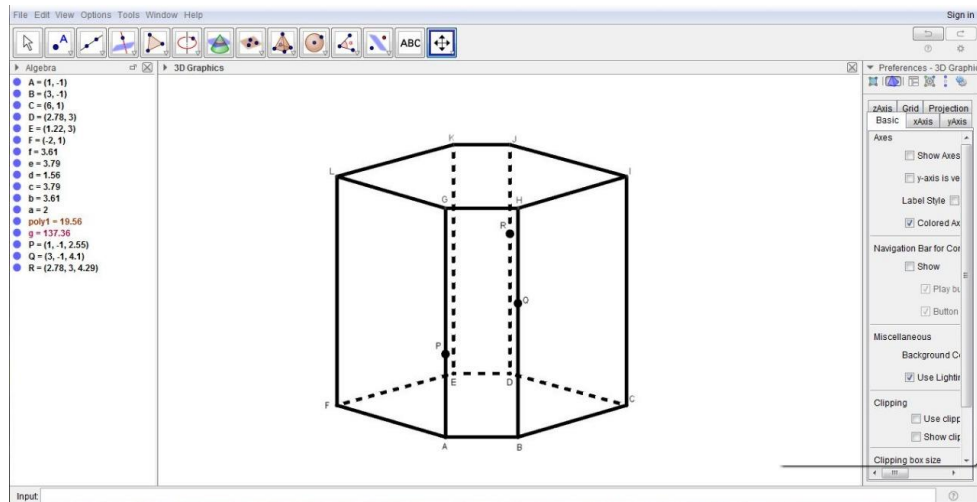


Figure 3. Prism ABCDEF.GHIJKL with Point P on AG, Q on BH, and R on DJ

Some students in many experimental groups are already able to determine the slice of the field asked. We take one example of the following student work results.

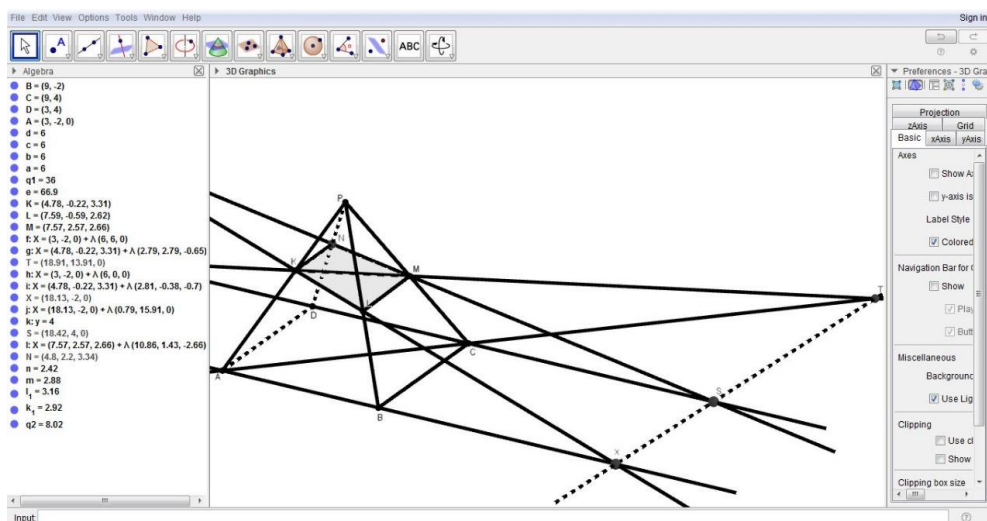


Figure 4. Test results determine the slice of the field in the pyramid

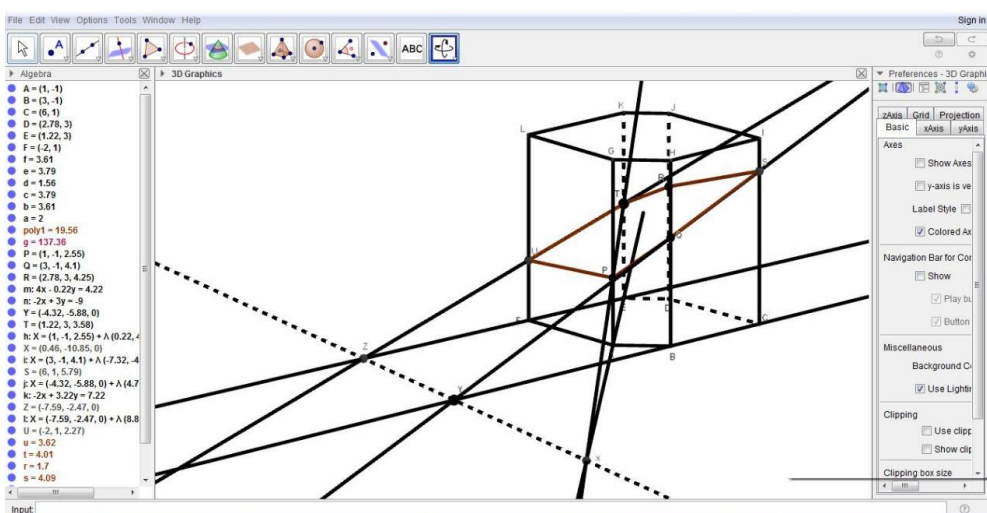


Figure 5. Test results determine the slice of the field in the prism

The study found that items in a questionnaire that had the lowest average were an item stating that students felt confident when conducting lectures using GeoGebra with a mean of 3,89. While the highest average is 4.3, it was acquired for the fourth item: 'GeoGebra can help improve my math learning performance'. Based on table 3, the overall mean is 4,086. This shows the entire student agrees with a positive statement about GeoGebra. Students also find that GeoGebra can also give a good impression when learning geometry space.

**Table 3.** Table of average questionnaires.

No.	Item	Minimum score	Maximum score	Mean
1	GeoGebra helps learn the concept of space geometry	3	5	4,11
2	I love using GeoGebra	3	5	4,04
3	I learned a lot about geometry when using GeoGebra	3	5	4,15
4	GeoGebra can help improve my math learning performance	3	5	4,3
5	I am glad if the lecturer uses GeoGebra when the learn space geometry	3	5	4,19
6	I am glad when asked to explore GeoGebra	2	5	4
7	I feel confident when doing a lecture using GeoGebra	3	5	3,89
8	I can think creatively and think critically when using GeoGebra	3	5	4
9	I prefer to learn the geometry of space with GeoGebra	2	5	4,11
	Overall Mean			4,086

Based on the above exposure, GeoGebra seems to have a positive effect on the achievement test of the geometry of learning space performed on prospective mathematics teacher students. The results were also supported by Jelatu, Sariyasa, and Ardana's (2018) studies, suggesting that the REACT-assisted GeoGebra learning resulted in higher performance on the understanding of geometry concepts when compared to students with conventional learning. Other research results show that the use of GeoGebra can help learners succeed in finding the properties of straight-line graphs with the majority of learners to understand the concept (Mudaly & Fletcher, 2019). Other studies conducted by Alkhateeb and Al-Duwairi (2019) show that the use of Sketchpad and GeoGebra facilitates students to understand the concept of geometry. Furthermore, results show that GeoGebra affects more than Sketchpad on learning mathematics. From these results, it can be concluded that the use of Geogebra can increase the exploration power, motivation, and interest of students in learning mathematics, especially learning the geometry of space.

## CONCLUSION

Learning and teaching space geometry should not be focused on theory but also a variety of approaches involving the use of teaching aids. These teaching aids are proven to help stimulate



student interest in space geometry. The mathematical Software available on the market or even online has facilitated the task of educators to provide knowledge of benefits to the students. In a very convincing manner, this research suggests that GeoGebra has a positive impact on student achievement in the geometry of the field of material space slices of prism and pyramid fields. The students also have a positive perception of GeoGebra in the interest and motivation of learning geometry space. This software should be introduced to students of mathematics teachers so that later can explore the world of mathematics more broadly and make students of prospective mathematics teachers able to think critically and creatively in learning geometry.

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