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3D Geometry Learning Using GeoGebra on Students' Mathematical Reasoning Ability

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Pembelajaran Geometri Bangun 3D Menggunakan *GeoGebra* Terhadap Kemampuan Penalaran Matematis Mahasiswa

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ABSTRACT

Along with the development of sophisticated science and technology (IPTEK), the tools used by educators are not optimal in learning. This can be seen from the lack of student interaction during learning activities. Students do not have the opportunity to use the media that are used by educators frequently. In geometry learning on the material of building space, the understanding level of students on this material requires visualization. Students are confused about imagining the shape of the building space. Hence, the research method used by the researcher is descriptive research with a quantitative approach, which describes a situation objectively using numbers ranging from data collection, data interpretation and appearance, as well as the results. Based on the research result that has been conducted, there is an effect of the implementation of GeoGebra on 3D geometry learning space building material on the mathematical reasoning ability. In addition, the effect of GeoGebra implementation on learning geometry 3D space building material on mathematical reasoning ability is 94.9%.

Keywords: GeoGebra, 3D geometry, Mathematical reasoning ability

Seiring dengan perkembangan ilmu pengetahuan dan teknologi (IPTEK) yang semakin canggih, alat bantu yang digunakan pendidik belum optimal dalam pembelajaran. Hal ini dapat dilihat dari interaksi mahasiswa yang kurang saat pembelajaran. Mahasiswa tidak memiliki kesempatan untuk berinteraksi dengan media yang digunakan pendidik lebih lama. Pada pembelajaran geometri pada materi bangun ruang, tingkat pemahaman mahasiswa pada materi ini membutuhkan visualisasi. Mahasiswa merasa kebingungan untuk membayangkan bentuk bangun ruang. Dengan demikian, metode penelitian yang digunakan peneliti adalah penelitian deskriptif dengan pendekatan kuantitatif yang menggambarkan suatu keadaan secara objektif menggunakan angka mulai dari pengumpulan data, penafsiran terhadap data tersebut serta penampilan dan hasilnya. Dari hasil penelitian yang telah dilakukan, terdapat pengaruh implementasi *Geogebra* pada pembelajaran geometri materi bangun ruang 3D terhadap kemampuan penalaran matematis mahasiswa. Selain itu, pengaruh implementasi *Geogebra* pada pembelajaran geometri materi bangun ruang 3D terhadap kemampuan penalaran matematis sebesar 94,9%.

Kata Kunci: ***GeoGebra, geometri, kemampuan penalaran matematis***

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INTRODUCTION

Along with the times, increasingly sophisticated science and technology (IPTEK) supports the creation of new technologies. These advances affect this life and cannot be avoided. Science and technology provide many benefits and make work easier. Economic growth, social mobility, cultural expansion or expansion mark the modernity produced by technological progress (Mulyani & Haliza, 2021). 21st century learning refers to learning science and technology so that it requires human resources who are skilled in technology. In providing material, educators can take advantage of advances in science and technology so that the teaching and learning process can be carried out properly in the form of more interesting and dynamic learning media (Ariani & Festiyed, 2019). The existence of learning media makes learning more interesting, hence fostering student learning motivation, varied teaching Geogebra can reduce boredom in learning and more actively carry out learning activities.

Audio and *visual* elements are present in learning media, so it can increase interest in learning and can create a continuous learning process. There are many math software developed to help learning and teaching including GeoGebra, MATLAB, Geometer's Sketchpad, and Mathematica (Japa et al., 2017). Several studies have been conducted on GeoGebra software to study various aspects of learning. GeoGebra has become a tool that can help educators to design effective instructional lessons (Fahmi & Priwantoro, 2016). Instructional aids used by lecturers in the classroom, the quality of lecturers and classroom management affect students' attitudes towards mathematics.

The tools used by educators are not optimal in learning, this can be seen from the lack of student interaction during learning. Students do not have the opportunity to interact with the media used by educators longer. In learning geometry on the material of building space, the level of understanding of students on this material requires visualization. They feel confused to imagine the shape of the building space. Building space material, visualization problems faced by students have been much more complex. In particular, they argued that the distance between objects, the relationship between geometry objects, angles and various problems of building space becomes difficult to imagine if you just look at what is in the book alone.

GeoGebra is a computer program (*software*) for teaching mathematics, especially building space. Markus Hohenwarter in 2001 developed GeoGebra in Australia and released it as *open source* software that can be used for free and is free to develop (Suryawan & Permana, 2020). GeoGebra allows students to be active in building an understanding of geometry so that it can help educators and students in understanding the material. GeoGebra is a dynamic, free, and multiplatform math software that brings together geometry, algebra, tables, graphs, statistics and calculus into one easy and usable unit for all levels of education. Dynamic means that users can produce interactive math applications. Free means that it can be used and reproduced freely and includes opensource software so that anyone can change or improve the program. Multi-platform means GeoGebra is available for all types of computers such as Windows, Mac OS, Linux and so on (Lestari & Sundi, 2021).

Mathematics is an abstract science that needs to be assisted with tools to better understand it. Various kinds of tools that can facilitate learning mathematics, especially tools in the form of computer application programs. One of the computer application programs that can be used in learning mathematics is Geogebra. Because the Geogebra program is dynamic and can visualize or demonstrate mathematical concepts and as a tool for constructing mathematical concepts. According to (Nurdin et al., 2019), GeoGebra is a computer program for teaching mathematics, especially geometry and algebra. This program can be used freely and can be downloaded from www.geogebra.com. The GeoGebra program is very famous, so it is often visited and has been used by millions of people around the world, both by students, students, lecturers, lecturers, and those who are interested in using it. Some of the benefits of the GeoGebra program in learning mathematics are: 1) Can produce geometry paintings quickly and thoroughly, even complex ones. 2) There are animation facilities and

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manipulation movements that can provide a visual experience in understanding geometry concepts. 3) Can be used as a feedback/evaluation material to ensure that the painting geometry that has been made is correct. 4) Make it easier to investigate or show the properties that apply to a geometry object (Bedada & Machaba, 2022).

One of the courses obtained by PGSD students at Lampung University is a geometry course. Geometry is an area of mathematics that involves shape, size, space, position, direction and movement that describes and classifies the physical world around us (Yorulmaz & Çilingir Altıner, 2021). Geometry offers a different aspect of mathematical thinking so that students become familiar with shapes, structures, locations and transformations. Geometry is the understanding of the concept of various geometric shapes of flat and spatial shapes (Saputro et al., 2015). Recognize the names and characteristics of various geometric shapes and look for shapes that are the same as each of these shapes in the real world (Yulianti et al., 2020). Learning in concrete objects that are introduced makes it easier for children to understand more quickly from the differences in shape, characteristics and properties of an object.

One of the branches of mathematics is geometry which studies flat and spatial shapes. Given that PGSD students are expected to be able to teach geometry material at the primary grade level, an understanding of prospective primary grade educators is needed. According to NCTM (2000) one of the geometry skills that students must have is the ability of mathematical reasoning. *Mathematical reasoning* is a thought process that is done in a way to draw conclusions. The ability to reason makes students able to solve problems in their lives, inside and outside the classroom. Mathematical reasoning is a thought process to determine whether a mathematical argument is true or false and is also used to construct a new mathematical argument (Mumu & Tanujaya, 2019). Mathematical reasoning ability is a brain habit like any other habit that must be developed consistently using a variety of contexts, recognizing reasoning and proof are fundamental aspects in mathematics. With mathematical reasoning, students can propose conjectures then compile evidence and manipulate mathematical problems and draw conclusions correctly and precisely.

Indicators of mathematical reasoning ability in mathematics learning according to Sumarmo are as follows: 1) Draw logical conclusions. 2) Provide explanations with models, facts, properties, and relationships. 3) Estimating answers and solution processes. 4) Using patterns and relationships to analyze mathematical situations. 5) Constructing and reviewing conjectures. 6) Formulating and following rules of inference, checking the validity of arguments. 7) Checking and constructing the validity of arguments. 8) Construct direct, indirect proofs, and use mathematical induction (Putri et al., 2020). In mathematics, the ability to reason is known as mathematical reasoning ability. Activities that demonstrate mathematical reasoning skills including drawing conclusions, analogizing, generalizing, estimating models, explaining the solution of a problem, and using relationship patterns to analyze and construct conjectures are called mathematical reasoning skills (Rahmadi et al., 2015). After knowing the advantages that exist in this GeoGebra software, The objective of this research is to determine the impact of GeoGebra software on the learning of 3D Build Geometry on students' mathematical reasoning abilities.

RESEARCH METHODS

This research was conducted at the Elementary School Teacher Education Study Program at Lampung University in the city of Metro. The time span of this research was conducted from May to August in the 2023/2024 academic year. The research design used in this research is descriptive research with a quantitative approach that describes a situation objectively using numbers starting from data collection, interpretation of the data and the appearance and results. According to Arikunto, descriptive research is not intended to test certain hypotheses, but only describes what it is about a variable. According to Arikunto, quantitative research is more required to use numbers, starting from

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collecting data, interpreting the data, and displaying the results (Ahyar et al., 2020). So it can be concluded that quantitative descriptive research in this study is to see, review and describe with numbers about the object under study as it is and draw conclusions about it according to the phenomena that appear at the time the research is conducted.

The subjects in this study were 3rd semester students of S-1 Primary School Teacher Education, University of Lampung, as many as 29 people consisting of 4 men and 25 women. The instruments used in this study were questionnaires and mathematical reasoning ability tests. The mathematical reasoning ability test instrument used there are 5 indicators, namely: 1) transductive, drawing conclusions from one special case or trait applied to other special cases, 2) giving explanations to existing models, facts, properties, relationships, or patterns, 3) estimating answers, solutions, and trends, 4) generalization, drawing general conclusions based on data that has been observed, 5) using patterns of relationships to analyze situations, and compiling conjectures. The mathematical reasoning ability test instrument is carried out validity test and reliability test with the aim of knowing the feasibility of question content, language use and how to present.

RESULTS AND DISCUSSION

The research results obtained consisted of mathematical reasoning ability test scores and questionnaires on the use of Geogebra in student 3D building learning. Researchers analyzed data on the value of mathematical reasoning ability tests from questionnaire data on the use of Geogebra students who had been summarized by researchers. The research questionnaire consists of 10 statement items that have been tested for validity through expert validation and have conducted field trials. The results of the calculation of the questionnaire data score from the research instrument for elementary school teacher education students at Lampung University can be seen in table 1 below.

Table 1. Results of Variable Correlation Calculations

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.974[a]	.949	.947	1.66269

From the table above, it can be seen that the correlation value is 0.974 with an R-square of 94.9%, which means that geogebra *software* can explain or describe 3-dimensional space buildings and has an influence of 94.9%, then 5.1% is influenced by other variables that are not studied. Further analysis can be seen in table 2 below.

Table 2. Regression Model Calculation Results

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	1396.116	1	1396.116	505.009	.000[a]
Residuals	74.643	27	2.765		
Total	1470.759	28			

Based on the data calculations above, it is known that the F value is 505.009 and the significance of regression linearity is 0.000 or *Sig.* <0.05 so that it interprets the regression model to fulfill linearity significantly.

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Table 3. Regression Equation Model

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	35.075	1.926		18.213	.000
Score_questionnaire	1.303	.058	.974	22.472	.000

From table 3 in the *Unstandardized Coefficients* column, the mathematical model of the regression equation is obtained, which is as follows:

$$Y = 35{,}075 + 1{,}303X$$

Y shows the ability of mathematical reasoning after students use Geogebra, while X shows the initial ability of students' problem reasoning before using Geogebra. Then with a *p-value* of 0.000 or *Sig*. <0.05, it is interpreted that there is an effect of Geogebra on 3D space building material on students' mathematical reasoning skills. While the positive sign on the regression coefficient means that there is a positive effect of Geogebra *software* implementation on 3D space geometry material on mathematical reasoning skills.

Discussion

The results of research conducted by researchers in Elementary School Teacher Education that there is a significant influence between the use of Geogebra in 3D building geometry material on students' mathematical reasoning skills. This shows that the use of Geogebra (Variable X) will affect the mathematical reasoning ability of students (Variable Y). In using Geogebra *software*, students still seem stiff because they have never used it in learning 3D geometry. There are still many students who make mistakes in modeling 3D shapes such as cubes and blocks manually. When drawing cubes and blocks there are still many students drawing cubes resembling blocks and vice versa. Moreover, when students draw pyramids and prisms with triangular bases there are still frequent mistakes in making these shapes. Learning using Geogebra-assisted problem-based models in online learning is more effective than using problem-based models or ordinary learning on mathematical reasoning skills of vocational students. This results in their mathematical reasoning skills being less good, the indicators of students' mathematical reasoning skills that are less good are indicators: 1) provide explanations with models, facts, properties, and relationships. 2) provide explanations with models, facts, properties, and relationships. 4) Use patterns and relationships to analyze mathematical situations. 5) Constructing and reviewing conjectures. 6) Formulating and following the rules of inference, checking the validity of arguments. 7) Checking and constructing the validity of arguments. 8) Constructing direct, indirect proofs, and using mathematical induction.

The second and fourth indicators of mathematical reasoning ability are providing explanations with models, facts, properties, and relationships and using patterns and relationships to analyze mathematical situations. At the beginning of learning, students always make mistakes in modeling 3D spaces such as cubes and blocks, then this results in students also using the wrong pattern in constructing the correct cube building. Students should draw 6 square sides facing each other but students draw rectangles and parallelograms which are wrong in making models. Then students draw cubes and blocks with Geogebra *software to* get appropriate and good results. Students better understand how to construct 3D buildings with Geogebra *software*. GeoGebra abstract geometry objects can be visualized and manipulated quickly, accurately, and efficiently (Maskar & Dewi, 2020).

The 5th and 6th ability indicators are constructing and reviewing conjectures and formulating

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and following rules of inference, checking the validity of arguments. The 5th and 6th indicators of mathematical reasoning ability are interrelated. When students are wrong in assessing the cube building earlier due to errors in drawing, this will result in students being wrong in formulating the space building. When drawing a square, the student's mistake is to draw a parallelogram and rectangle so that the formula used is not a square but a parallelogram and rectangle. Cube and beam shapes drawn using Geogebra *software* can be rotated from various sides so as to minimize student errors in determining the formula used. Geogebra is one of the interactive applications in introducing mathematical teachings (Alkhateeb & Al-Duwairi, 2019). The 7th and 8th indicators of mathematical reasoning ability are checking and compiling the validity of arguments and compiling direct, indirect proofs, and using mathematical induction. Student errors in determining the cube formula can be wrong in calculating and drawing conclusions. Meanwhile, the use of Geogebra *software* in solving problems can be checked for the correctness of the answer by using the *area* and *volume* features in Geogebra. The accuracy of student answers can be known properly and correctly. Learning mathematics with the help of Geogebra shows active interaction between lecturers and students (Zulnaidi et al., 2020).

Geogebra has several advantages, namely (1) paintings are usually produced quickly and thoroughly compared to using a pencil, ruler, or term, (2) The animation facilities and manipulation movements in the Geogebra program can provide a clearer visual experience to students in understanding mathematical concepts, (3) Can be used as feedback / evaluation to ensure that the paintings that have been made are correct, and (4) Make it easier for teachers / students to investigate or show the properties that apply to a mathematical object. Learning using Geogebra received a positive response from students. They get new experiences and knowledge that make their curiosity better, encourage them to be more active, and try to use Geogebra instead of just listening to the explanation. Geogebra makes students active in building an understanding of geometry (Yanti et al., 2019). Mathematical reasoning skills in 3D geometry material can be achieved by using Geogebra (Fajriyah et al., 2019). Students are more detailed and thorough in conjuring the space and become their evaluation tool in answering 3D geometry problems.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the study, it was found that the mathematical reasoning ability of students in the experimental class on 3D geometry learning using Geogebra can be concluded as follows: a) There is an effect of Geogebra implementation on 3D geometry learning on student mathematical reasoning ability; b) The effect of Geogebra implementation on 3D geometry learning on student mathematical reasoning ability has an influence of 94.9%. Based on the results of the above research, the researcher recommends the following: a) Geogebra in learning 3D space building is proven to have an influence to deepen student understanding so it is recommended that other researchers deepen each space building material such as cubes, beams, prisms, and pyramids; b) In this study revealed the ability of mathematical reasoning. There are still many other mathematical abilities that need to be researched such as algebraic thinking ability, critical thinking ability, mathematical problem solving ability, geometry ability, creative thinking ability, and many more.

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