The Effectiveness of Using Geogebra Media in Pythagoras Learning on Students' Mathematical Communication Skills

Amelia Rizky Zalsabillah[a], Agustiany Dumeva Putri[b], Liana Septy[c*]
[a,b,c]Universitas Islam Negeri Raden Fatah, Palembang, Indonesia
*Corresponding: lianasepti_uin@radenfatah.ac.id

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Abstract

The purpose of this study is to provide an overview of the effect of using Geogebra Media on learning the Pythagorean Theorem on mathematical communication quantitatively. This study is an experimental study conducted at SMP Negeri 9 Palembang with a sample of 70 students consisting of 35 students in class VIII-1 as the control class and 35 students in class VIII-3 as the experimental class. The instrument used was a mathematical communication ability test. The results showed that $tcount > ttable$ which is 5.477 > 1.99, then $H0$ is rejected and $H1$ is accepted, so there is an effect of using Geogebra Media on learning the Pythagorean Theorem on students' mathematical communication.

Keywords

Geogebra, Pythagorean Theorem, Mathematical Communication

INTRODUCTION

Communication is one of the mathematical abilities that serves as a standard principle in mathematics learning (Mundy, 2000; NCTM, 2020). This ability emphasizes how students can communicate the results of their thinking, both in written and oral forms, so that the ideas conveyed can convince and elicit responses from others. How students comprehend readings, listen to instructions, ask questions, express opinions, or write down their thoughts can provide information about their mathematical communication (NCTM, 2020; Vale & Barbosa, 2017; Weaver, 1949). By having good communication skills, students are expected to be able to convey what they understand clearly and coherently.

While it might seem that communication is solely about speaking ability, in reality, it's not just judged by how fluently students speak. The fact, many students struggle to convey their thoughts (Vale & Barbosa, 2017). One difficulty students face in grasping what their peers are trying to communicate stems from varying abilities to visualize ideas presented by others (C. E. Shannon, 1948; Claude E. Shannon, 1964; Vale & Barbosa, 2017). Besides the imprecise terminology used when expressing ideas, a lack of supportive visual media that helps communicate one's thoughts also contributes to these communication challenges (Vale & Barbosa, 2017). Halawati & Laelasari (2022) also highlighted this, noting that students find it difficult to communicate their ideas, which prevents them from representing concepts correctly. Therefore, using media that supports mathematical visualization becomes a valuable alternative for students to communicate their ideas to others.

Many media have been implemented to support mathematical visualization for students, and these are believed to help students communicate their ideas effectively. Several media options assist students in visualizing their ideas, such as comic media (Yulian, 2018), constructivist-based SMARTbooks (Argarini et al., 2020), interactive media using Articulate Storyline 3 (Harun et al., 2021), MathML (Miner, 2005), and GeoGebra (Kusumah et al., 2022; Maryono et al., 2021; Saha et al., 2010; Yuliardi & Nurjanah, 2017; Zetriuslita et al., 2019). Looking at the widespread use of media for visualization to help students express their ideas, GeoGebra stands out as a frequently used tool, especially concerning measurement and geometry topics. In Indonesia, a bibliometric analysis indicates that GeoGebra has the highest frequency of use compared to other applications or media (Maulidiya et al., 2023; Sari et al., 2022; Supriyadi et al., 2022). This confirms that GeoGebra remains a strong favorite for both educators and researchers as a visualization tool for communicating ideas.

GeoGebra is dynamic software created by Markus Hohenwarter in 2001 at the University of Salzburg, Austria (Subiono, 2021). This application provides visualization for topics in geometry, algebra, graphing, statistics, and calculus, all presented in a worksheet format as an online platform. GeoGebra is considered an application with easy accessibility. This is because, according to Sangwin (2007), GeoGebra can be freely downloaded and installed on PCs, and it can also be accessed directly via web browsers, which means there are rarely any obstacles to its use. Additionally, as dynamic software, GeoGebra offers several features that enable students to engage in the process of mathematical communication, both individually and collaboratively, conducted online (Achuthan et al., 2016). With the various conveniences it offers, it's no surprise that GeoGebra is widely used as a learning medium, particularly in mathematics (Harisuddin, 2019; Sangwin, 2007). Thus, it's truly accurate that GeoGebra has become a favorite and user-friendly application.

Given how frequently and easily GeoGebra is used in learning, its effectiveness would naturally be more accurately validated by testing it directly with students. This would confirm that using GeoGebra has a positive impact on students' communication skills. Consequently, the use of GeoGebra could then be recommended to educators in schools.

METHOD

This quantitative research employs an experimental method using a non-equivalent control group design of the posttest-only control group type. The population for this study consisted of all eighth-grade students at a junior high school in Palembang, with a sample size of 70 students divided into a control group and an experimental group. The data comprised the posttest results of mathematical communication skills, obtained through a test administered to the sample. The posttest questions were designed to assess mathematical communication based on the indicators of written text, mathematical expression, and technical expression. According to Weng & Jankvist (2018): 1) Written text relates to how students can express a problem mathematically in written form; 2) Mathematical expression focuses on how students can represent data into other representative forms such as graphs, tables, or diagrams, and vice versa. 3) Technical expression concerns how students can provide various forms of problemsolving procedurally.

Before being used, the test instruments were first assessed for validity and reliability. This was done using criteria from Guilford (1965), specifically the Pearson product-moment correlation coefficient for validity and Cronbach's Alpha for reliability. The test was administered after students in the experimental group received treatment using GeoGebra media. Meanwhile, the control group was given instruction through conventional lecture methods (students were provided with material, example problems, and exercises).

Once the data were collected, they were subsequently analyzed using a t-test, after performing normality and homogeneity tests with IBM SPSS Version 25. The hypothesis of the study was whether or not there was a difference in the average learning outcomes of students using GeoGebra-based instruction compared to conventional instruction. Broadly, this research will be discussed following the quantitative research flow outlined by Creswell (2018), as described in Figure 1.

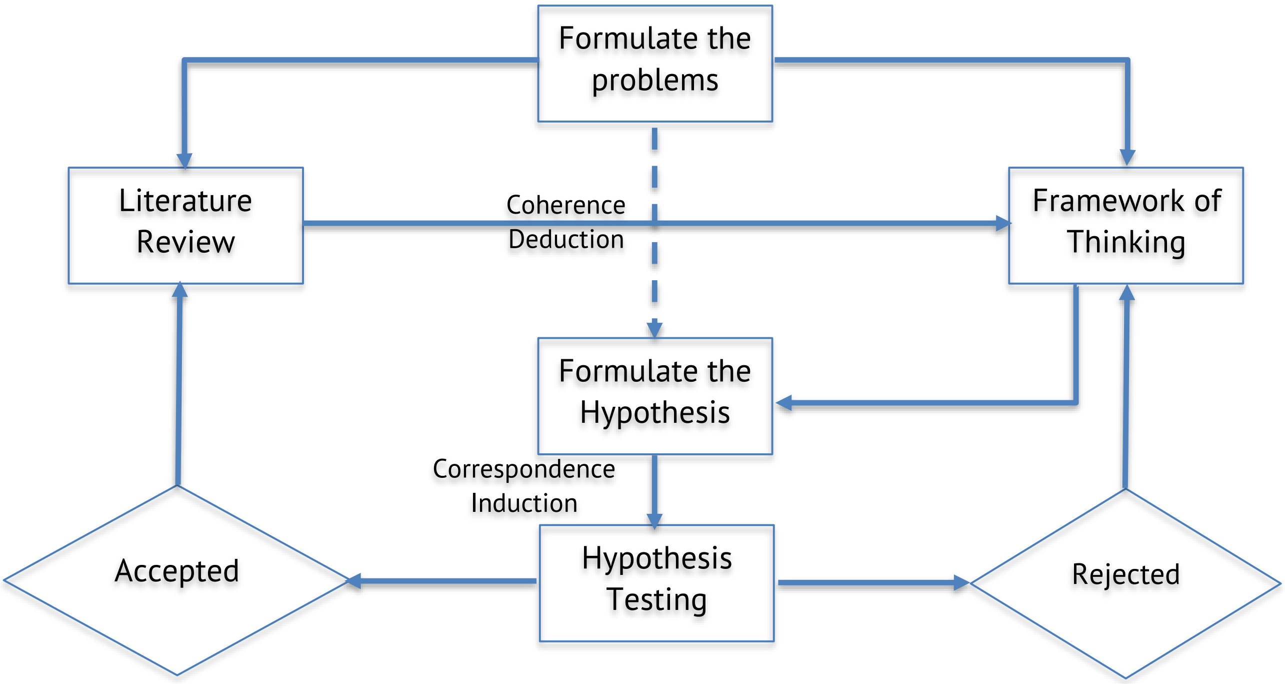

Figure 1. Quantitative Research Flow

RESULT AND DISSCUSSION

In implementing learning, considering the selection of teaching materials is a crucial aspect that needs attention. One way to aid this consideration is by determining the effectiveness of a particular learning approach in achieving desired goals. In this study, the collected data were used to examine the effectiveness of using GeoGebra media in instruction on mathematical communication skills. This was assessed in the experimental class and then compared to the control class.

The data, consisting of student learning outcomes after the treatment, were then subjected to normality and homogeneity tests. For the normality test, the significance value for the experimental class was 0.200 and for the control class was 0.127. Both values are greater than 0.05, indicating that the data are normally distributed and thus robust enough for analysis. Meanwhile, based on a Levene Statistic of 1.129 with a p-value (sig) of 0.386, which is greater than 0.05, it means the variances of each sample are homogeneous.

To test the hypothesis and draw a conclusion, the test data results will be analyzed using a Hypothesis Test with the aid of IBM SPSS Version 25. The results of the Hypothesis Test can be seen in Figure 2.

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	29.841	2.827		10.554	.000
	EKSPERIMEN	-.968	.177	-.690	-5.477	.000

Figure 2. Hypothesis Test Results

Based on manual calculations, with d_f=35+35−2=68 and a significance level of 0.05, we obtained a t_{table}=1.99. Since $t_{calculated}$>t_{table} (i.e., 5.477>1.99), it can be concluded that H_0 is rejected and H_1 is accepted. This means there is a significant difference in the average learning outcomes of students in classes using GeoGebra-based instruction compared to those using conventional instruction.

In this study, the researchers measured students' mathematical communication skills using a post-test. A control group was included for comparison with the experimental group. There were differences in the test items answered by students in the experimental and control classes. The experimental class had a highest score of 87.5 and a lowest score of 37.5, with an average of 65. In contrast, the control class had a highest post-test score of 83.3 and a lowest score of 25, with an average of 59.3. The following is a recapitulation of the communication skills based on the students' post-test results. When presented graphically, the differences in the post-test scores of the students are apparent as Figure 3.

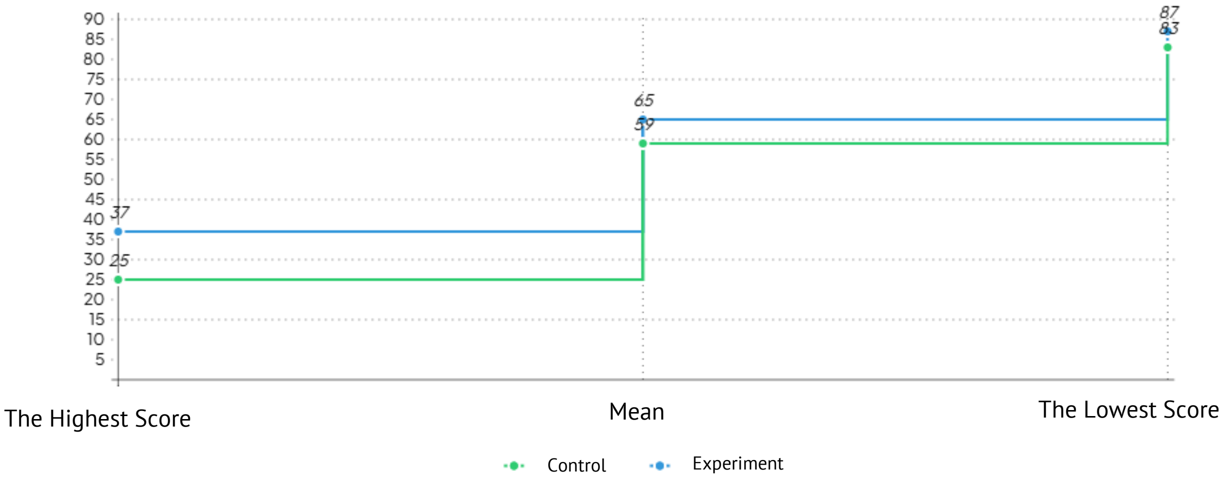

Figure 3. Graph of Differences in Student Communication Skills

Looking at the Graph in Figure 3, you can clearly see the difference in scores obtained between the control class and the experimental class. This means the distinction isn't just evident from quantitative data calculations, but also from comparing the low, high, and average scores. This difference is due to the varying treatments provided. In the experimental class, students were given GeoGebra as an assistive medium, which provided visualizations for proving the Pythagorean theorem. This made the comparisons more representative than simply writing or drawing them on conventional media. This aligns with GeoGebra's strength as a visualization application that provides precise measurements (Sangwin, 2007). Therefore, choosing this application as a teaching medium is indeed a good step for a teacher to take (Harisuddin, 2019).

Beyond just observing the overall differences in students' mathematical communication skills, it's certainly necessary to delve deeper by analyzing each question indicator. For the "written text" indicator, the average mathematical communication ability of students in the experimental class was 50%, while in the control class it was 48.2%. The difference between the two was only 1.8%, and both classes fell into the low category. However, for the "mathematical expression" indicator, the experimental class showed a superior level of mathematical communication ability at 85.48%, whereas the control class reached 76.4%. The difference between these two classes was 9.08%, placing them in the high ability category. Finally, for the "technical expression" indicator, the experimental class achieved a result of 61.2%, placing them in the medium ability category, while the control class reached 50.2%, falling into the low ability category.

This indicates that the average mathematical communication ability of students taught using GeoGebra is higher than that of students taught with conventional methods, even though the difference in scores between the two classes isn't very large. However, this can serve as an indication that GeoGebra-based instruction has a positive impact on improving students' mathematical communication skills. This, of course, can be a solution to the problem of a lack of visualization media that affects mathematical communication ability.

CONCLUSION

With the significant difference in the average mathematical communication skills between students in the experimental and control classes, it can be concluded that using GeoGebra in learning has a positive impact. This also addresses the major challenge of a lack of mathematical communication skills, which often requires a visual medium in instruction. Therefore, this finding reinforces the idea that the GeoGebra application can be an excellent choice for teaching mathematics, especially for topics in geometry, algebra, graphing, statistics, and calculus.

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