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Utilizing GeoGebra-assisted model-eliciting activities (MEAs) in mathematics instruction enhances students' comprehension of concepts and improves their problem-solving abilities

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Abstract

A key goal of teaching math is for students to develop a deep understanding of concepts. This understanding is the foundation for all future learning in math. The purpose of this study was to improve students' conceptual understanding and problem-solving skills in GeoGebra-assisted mathematics learning with Model Eliciting Activities (MEAs). The quantitative method with a nonequivalent (pre-test and post-test) group design was used to answer the hypothesis. The instruments used were pre-test and post-test in the form of descriptions consisting of 5 questions. The participants in this study were 26 junior high school students. Data analysis used Paired Sample T-tests (t-test) to determine the level of conceptual understanding and problem-solving ability of students. The results of data analysis obtained that the application of Model Eliciting Activities (MEAs) assisted by GeoGebra is effective in increasing student' understanding of mathematical concepts and student problem-solving skills. So, it is concluded that learning with the Eliciting Activities Model (MEAs) assisted by GeoGebra can improve students' conceptual understanding and problem-solving skills. In the future teachers are recommended to use Model Eliciting Activities (MEAs) assisted by GeoGebra in learning mathematics.

Keywords: Geogebra; Mathematics Concept Understanding; Model Eliciting Activities (MEAs); Problem Solving Ability.

INTRODUCTION

The interconnection of concepts in mathematics constitutes an integral aspect of the discipline, indivisible and interdependent (Sari, 2022). Mathematics, with its multifaceted roles, positions itself as a highly utilitarian field, one of which entails serving as a cognitive tool to facilitate students' understanding of mathematical concepts under study (Illahi & Pujiastuti, 2019). Understanding mathematical

concepts stands as a pivotal objective in education, as it forms the foundation for achieving subsequent learning goals in mathematics (Kastira & Irwan, 2019).

In mathematics, comprehension of concepts supersedes mere rote memorization of formulas to evade confusion and enable the derivation of pertinent formulas (Setyani & Suhendar, 2022). Proficiency in understanding mathematical concepts empowers students to easily recollect, utilize, and rearrange learned concepts, thus navigating through various mathematical problem scenarios (Hadi & Kasum, 2015). Conceptual understanding holds immense significance, as mastery of concepts facilitates students' ease in learning mathematics (Adliani et al., 2020).

Challenging problems necessitate specific procedural steps for resolution (Jumadi, 2017). Mathematical problem-solving prowess entails amalgamating previously acquired concepts and rules to overcome encountered difficulties, thereby achieving the goal of finding solutions (Osuna & Munson, 2024; Sumirattana et al., 2017; Nusantari, 2016). Proficiency in problem-solving is imperative for students, as it equips them with the skills to tackle both mathematical and everyday problems (Zulfitri, 2019).

Students tend to resort to rote memorization of presented material rather than comprehending the underlying concepts (Novitasari et al., 2021). At times, students may be able to respond to posed mathematical questions, yet exhibit carelessness in their calculations (Sulistyaningsih, 2017). A significant portion of students lacks the ability to understand problems, process data, and present issues mathematically in various forms, choose approaches and problem-solving methods, generate and interpret mathematical models, and complete problems (Thoyyibah et al., 2018).

Several factors influencing students' learning outcomes at SMPN 1 Lingsar include the less varied teaching methods employed by teachers, who often resort to conventional teaching by delivering content followed by giving exercises and tasks, students' high levels of self-doubt, and insufficient teacher-student interaction (Hirzi, 2015). Consequently, students merely accept what teachers convey, leading to diminished understanding of the material. It is often observed in schools that teachers' ability to employ varied teaching methods is low, teachers predominantly focus on solving problems, teachers tend to use ineffective teaching methods, and they rely more on exclusive teaching methods without comprehensively considering students' affective, cognitive, and psychomotor aspects (Yulianty, 2019).

Model Eliciting Activities (MEAs) serve as a mathematical learning model aimed at understanding, explaining, and communicating mathematical concepts embedded in a problem through mathematical modeling (Juniantari, 2019). MEAs are student-centered learning activities (Meisya et al., 2018). In Model Eliciting Activities (MEAs), the most crucial problem-solving iteration involves proposing, testing, and revisiting models to solve a problem (Junaidi, 2019). In MEAs instruction, students are presented with meaningful and relevant problems related to their daily lives (Budiman & Syayyidah, 2018).

GeoGebra is recognized as a computer program utilized in mathematics education, particularly in the realms of geometry and algebra (Baye et al., 2021; Jelatu &

Sariyasa, 2018; Arbain & Shukor, 2015). Moreover, Wijayanti (2013) defines GeoGebra as software designed for studying and teaching geometry, algebra, and calculus from elementary to university levels. GeoGebra serves as a mathematical learning tool emphasizing visual and solution-oriented approaches in solving mathematical problems (Mandailina et al., 2018). Students can employ GeoGebra to visualize their ideas through graphical illustrations (Nam, 2022). The application serves three primary purposes: as a mathematics learning medium, a tool for generating mathematics teaching materials, and a means to solve mathematical problems (Yanti et al., 2019). The combination of MEAs and GeoGebra fosters a more engaging, profound, and relevant mathematical learning experience, aiding students in understanding mathematical concepts interactively and within a more realistic context.

GeoGebra's widespread recognition has led to its frequent utilization by millions worldwide, including students, teachers, professors, and other stakeholders (Farida, 2021). The integration of GeoGebra into mathematics education offers benefits to students, facilitating enhanced conceptual understanding and mathematical problem-solving (Mukarramah et al., 2022). Students' mathematical conceptual understanding through the use of GeoGebra assists in observing the relationship between visual and symbolic representations (Nulhakim et al., 2022).

Previous research by Savitri et al (2021) concluded that GeoGebra as a learning media for solid geometry topics can be effectively employed in classroom instruction, enhancing students' conceptual understanding. Additionally, MEAs assisted by GeoGebra positively influence students' conceptual understanding and mathematical disposition. Statistical analysis yielded a significant F value of 5.656 with a significance level of 0.023, leading to the rejection of the null hypothesis. Thus, the research results indicate that MEAs assisted by GeoGebra positively affect students' conceptual understanding and mathematical disposition. However, further investigation is needed to determine whether MEAs assisted by GeoGebra positively impact students' mathematical problem-solving abilities. Moreover, research conducted by Dewi et al., (2019) demonstrated an increase in students' conceptual understanding scores across cycles, with improvement in mastery learning rates from 38.24% to 67.65%.

Based on the relevant research findings above, there has been no prior exploration into students' conceptual understanding and problem-solving abilities through the combination of Model Eliciting Activities (MEAs) and GeoGebra. Hence, the aim of this study is to enhance students' mathematical conceptual understanding and problem-solving abilities in GeoGebra-assisted mathematics instruction with Model Eliciting Activities (MEAs).

METHODS

The research employed a quantitative method utilizing a nonequivalent (pre-test and post-test) group design. The participants comprised 26 eighth-grade junior high school students. The research phases can be delineated through the flowchart presented in Figure 1.

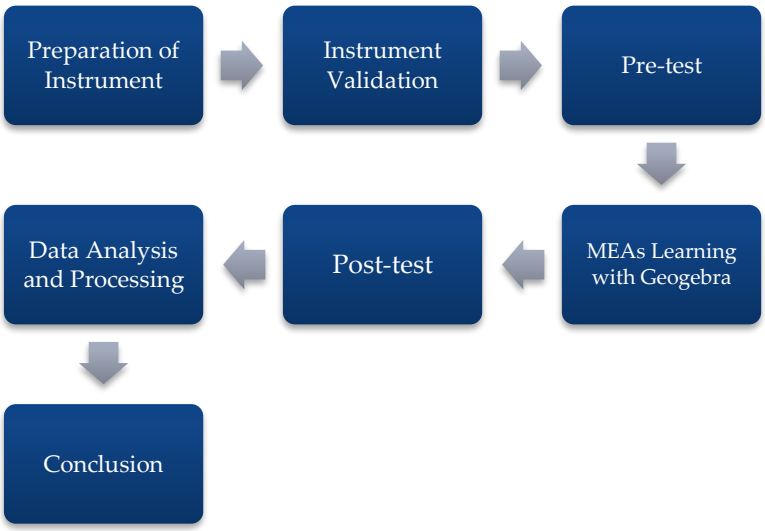

Figure 1. Research phases

In Figure 1, several stages of research are illustrated, such as instrument development. The instrument utilized in this research employs a test format consisting of 5 essay items for both pre-test and post-test to capture variables related to mathematical concept comprehension and problem-solving abilities. Subsequently, instrument validity is assessed by language and subject matter experts. Data collection involves a single sample drawn from a junior high school.
Prior to intervention, participants undergo a pre-test to gauge their initial abilities. This is followed by the implementation of the Model Eliciting Activities (MEAs) instructional approach aided by GeoGebra software, focusing on the topic of two-dimensional shapes and the surface area of cubes and rectangular prisms. To assess mathematical concept comprehension and problem-solving abilities, a final test, referred to as the post-test, is administered. The hypotheses under scrutiny are as follows:
H_a: There exists a significant difference in mathematical concept comprehension and problem-solving abilities among junior high school students following instruction employing the Model Eliciting Activities (MEAs) approach.
H_0:There is no significant difference in mathematical concept comprehension and problem-solving abilities among junior high school students following instruction employing the Model Eliciting Activities (MEAs) approach.
The data analysis process utilized SPSS version 24 software and hypothesis testing was conducted using the Paired Sample T-test. Prior to hypothesis testing, the normality of the data was assessed using the Shapiro-Wilk test. Finally, conclusions were drawn regarding the influence of implementing Model Eliciting Activities (MEAs) assisted by GeoGebra on mathematical concept comprehension and problem-solving abilities, with a significance level of 5%, employing the formula outlined (Nuryadi at al., 2017) as the formula (1).

$$t_{hit} = \frac{\bar{D}}{\frac{SD}{\sqrt{n}}} \quad (1)$$

where:

$SD = \sqrt{var}$

$var(s^2) = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2$

t = the calculated t-value

$\bar{D}$ = the mean difference between measurements 1 and 2

SD = the standard deviation

n = the sample size

Interpretation:

If:

Sig.2-tailed $>$ α $=$ 0,05, it indicates a significant difference (acceptance of H_0).

Sig.2-tailed $<$ α $=$ 0,05, it suggests no significant difference (rejection of H_0).

RESULT AND DISCUSSION

Data Collection Result

Based on the results obtained from the essay test consisting of several indicators of concept comprehension and problem-solving abilities, the graph presented in Figure 2 was generated.

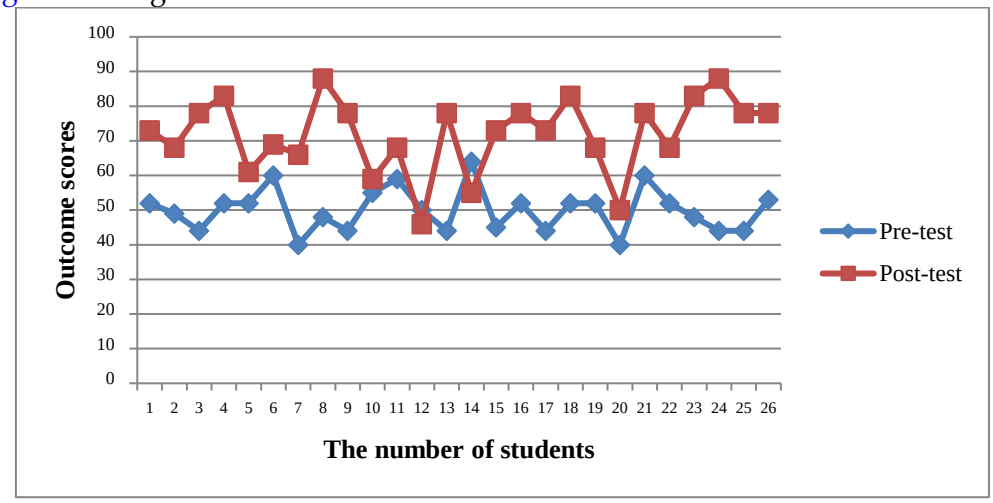

Figure 2. Student *pre-test* and *post-test* results

Figure 2 illustrates that the highest score in the post-test results of students is 88, while the lowest is 46. In contrast, the highest score in the pre-test results of students is 64, with the lowest being 40. Hence, the post-test results are higher compared to the pre-test results. A graphical comparison of the average scores of pre-test and post-test results of students can be observed in Figure 3.

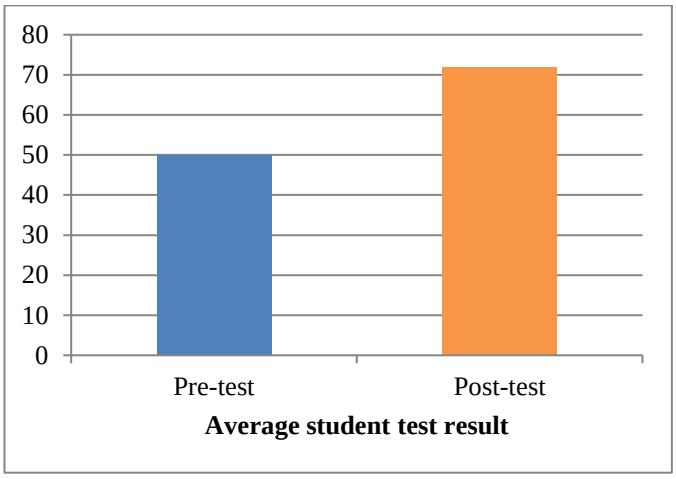

Figure 3. Comparison of average pre-test and post-test scores

In Figure 3, it is shown that the average score of the pre-test results is 50, while the average score of the post-test results is 72. This indicates an improvement following the implementation of Model Eliciting Activities (MEAs) assisted by GeoGebra.

Test of Normality

Further data analysis was conducted using inferential statistics through SPSS version 24. Before hypothesis testing a prerequisite analysis was performed, namely the normality test. To ascertain whether the data follows a normal distribution, the Shapiro-Wilk test was conducted on the pre-test and post-test results of concept comprehension and problem-solving abilities, as presented in Table 1.

Table 1. Normality test of student pre and post test results

	Shapiro-Wilk			Criteria	Conclusion
	Statistic	df	Sig.		
Pre-test	0.940	26	0.135	0,135 > 0,05	Normal
Post-tets	0.937	26	0.113	0,113 > 0,05	Normal

Table 1 presents the results of the Shapiro-Wilk test, indicating a significance value of 0.135 (Sig. > 0.05) for the pre-test data, suggesting a normal distribution. Similarly, for the post-test data, a significance value of 0.113 (Sig. > 0.05) was obtained, indicating a normal distribution as well.

Hypothesis test

Since both the pre-test and post-test data exhibit normal distributions, data analysis proceeds with the Paired Sample T-test.

Table 2. Uji hipotesis results

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Pre Test - Post Test	-21.885	13.492	2.646	-27.334	-16.435	-8.271	25	0.000

As presented in Table 2 presents the results of hypothesis testing regarding the extent of improvement in junior high school students' understanding of mathematical concepts and problem-solving abilities using the Paired Sample T-test, with a significance level of $\alpha = 0.05$. The obtained P-value (Sig.2-tailed) of 0.000 (Sig.2-tailed < 0.05) leads to the rejection of the null hypothesis H_0, indicating an enhancement in students' understanding of mathematical concepts and problem-solving abilities following instruction using Model Eliciting Activities (MEAs) assisted by GeoGebra. Based on these findings, it can be concluded that Model Eliciting Activities (MEAs) contribute to the improvement of mathematical concept comprehension and problem-solving abilities.

The results of the post-test regarding students' understanding of concepts and problem-solving abilities following instruction using Model Eliciting Activities (MEAs) assisted by GeoGebra in junior high school students indicate that the average scores obtained are higher than those of the pre-test. This suggests that instruction utilizing Model Eliciting Activities (MEAs) assisted by GeoGebra has an influence on students' understanding of concepts and problem-solving abilities.

Previous research provides insights into the significant influence of instruction utilizing Model Eliciting Activities (MEAs) on enhancing students' understanding of mathematical concepts and their problem-solving abilities, particularly when aided by GeoGebra applications, which facilitate the visualization of diagrams and graphs. The understanding of mathematical concepts taught by teachers in each topic is crucial for students, as it aids in the retention process and simplifies the solving of mathematical problems that require numerous formulas (Christou et al., 2024; Aini et al., 2020). Mathematical concept comprehension entails the ability to systematically understand and delve into mathematical ideas (Nurani et al., 2021).

Similar to previous research titled "The Influence of MEAs Approach on Problem-Solving Ability, Mathematical Communication, and Self-Confidence of Students" by (Wijayanti, 2013), it was concluded that instruction using the MEAs approach outperformed traditional approaches in terms of problem-solving abilities. Furthermore, a study by Muna et al. (2019) concluded that the implementation of Model Eliciting Activities assisted by APPEM (Assessment, Pedagogy, and Educational Management) enhanced students' conceptual understanding, as evidenced by the final research results showing a mean classical score of 78.24, indicating a good level of achievement. According to Meisya (2019), MEAs direct

students to think and reason, ultimately aiding them in understanding concepts or procedures.

In a study of Afhami, (2022), the research findings indicated that the use of the GeoGebra Classic application in instruction had a significant influence on students' understanding of mathematical concepts in the topic of geometric transformations. GeoGebra is an application that students can use in mathematics lessons to facilitate the drawing of graphs. Moreover, it can be utilized in calculus, geometry, and algebra topics (Vadya et al., 2022). GeoGebra aids students in learning mathematics because through its use, students encounter many mathematical formulas, algebraic presentations, and geometry (Mollakuqe et al., 2020). Additionally, understanding the required concepts becomes easier as GeoGebra can visualize geometric objects and depict geometric problems (Anggraeni et al., 2021).

CONCLUSION

This research found that students' understanding of mathematical concepts and problem-solving abilities significantly improved after using Model Eliciting Activities (MEAs) assisted by GeoGebra software. Higher post-test scores compared to pre-tests and a very low p-value from statistical analysis (indicating strong rejection of the idea that no improvement occurred) both support this conclusion. Incorporating MEAs with GeoGebra appears to be an effective strategy for enhancing mathematical learning.

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