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Application of the GeoGebra Graphing Calculator in Mathematics Learning to Improve Students' Mathematical Competence

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ABSTRACT

One concrete step in improving students' mathematical competencies in modern education is through the application of interactive digital learning media. The GeoGebra Graphing Calculator application is an interactive and user-friendly digital learning tool. This research uses classroom action research. The subjects of this study were 20 students from class XI at MA Tarbiyatus Shibyan Lamongan. The classroom action research was conducted in two cycles. In each cycle, students were given worksheets on the topic of linear programming. In Cycle I, students completed the worksheets manually, while in Cycle II, students were introduced to the learning media and used the GeoGebra Graphing Calculator in completing the worksheets. The results obtained from this study using the T-Test (Paired Samples Statistics) show a p-value of), indicating that the application of the GeoGebra Graphing Calculator in mathematics learning has an impact on improving students' mathematical competencies. Based on the average scores in each cycle, it is also evident that the use of the GeoGebra Graphing Calculator has an effect, as students' competencies improved from a moderate level with an average of 73.75% to a high level with an average of 89.06% after the application of the GeoGebra Graphing Calculator.0.001 ($p < 0.05$

Keywords: *GeoGebra Graphing Calculator; learning media; mathematical competencies .*

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INTRODUCTION

In the context of modern education, students' mathematical abilities are not only measured by their ability to calculate, but also conceptual understanding, problem-solving abilities, and critical thinking skills.(Sholihah et al., 2024, Malik et al., 2024, Dewi et al., 2024). However, the reality on the ground shows that many people still have difficulty understanding complex mathematical concepts.(Manurung et al., 2024). Conceptual Understanding Gap Mathematics is often considered an abstract and difficult subject to understand.(Novianto et al., 2024). Many students have difficulty transforming mathematical concepts.(Khaeroni & Nopriyani, 2018). This shows that there are still many

students who have difficulty in understanding mathematical concepts because of their abstract and complex nature. Therefore, there needs to be concrete steps in developing mathematics education in the modern era.

To face the 21st century, mathematics education faces the challenge of developing students' mathematical competence more effectively and innovatively.(Setiawati et al., 2024). The development of information and communication technology provides new opportunities in the mathematics learning process, one of which is through the use of interactive and easy-to-use digital media.(Fitriani, 2021). The use of digital learning platforms also facilitates more personalized and adaptive learning according to the needs and abilities of each student.(Fadillah et al., 2024). In this context, teachers are required to continue to develop digital competencies and be able to integrate technology effectively in mathematics learning to create meaningful and relevant learning experiences to today's needs.(Azmi et al., 2024).

Media is defined as graphics, photographs, or electronic devices for capturing, processing, and rearranging visual or verbal information.(Ediyani et al., 2020). Learning media in the current era has increasingly developed and advanced. One of the reasons is the rapid development of technology. Digital media can have the potential to support learning(Degner et al., 2022). If used properly, the use of technology in teaching and learning activities can help teachers in managing their learning.(Maryam et al., 2019).

By using electronic media, the learning process can be carried out interactively and more interestingly to increase students' interest and enthusiasm for learning.(Yaniwati et al., 2020), so that mathematics learning in class will be more effective(De Porte in Chotimah, Bernard, & Wulandari, 2018)and students can participate in education(Lee et al., 2019). As a result, it can improve students' mathematical abilities.(Zhang et al., 2020). Therefore, teachers must adapt technology in learning so that learning feels more interesting.(Rufiana et al., 2021).

In today's digital era, mobile phones can be a part of learning. Because handheld devices such as mobile phones have become a part of everyday life.(Ziatdinov & Valles Jr, 2022). Therefore, mobile phones can be used as a learning medium.(Kularbphettong et al., 2015). One of the Android-based technology products that can be used as a learning medium is the GeoGebra Graphing Calculator application.(Ziatdinov & Valles Jr, 2022).GeoGebra Graphing Calculator application can help in understanding mathematics(Machromah et al., 2019).

Previous studies have shown that the use of technology in mathematics learning can improve students' learning motivation, conceptual understanding, and academic achievement.(Nurhayati et al., 2020,2018, Diva et al., 2023). However, the implementation of technology use is still not fully optimized in many educational institutions. Especially, the GeoGebra Graphing Calculator application. This shows that there is still a gap between the potential of technology and teaching practices in the classroom.

Therefore, this study aims to explore the impact of implementing the GeoGebra Graphing Calculator application on students' mathematical competence. The main focus of the study is to analyze how the use of this application can improve students' mathematical competence, namely the ability to understand concepts, problem solving, mathematical communication, and student learning outcomes.

Thus, this research is expected to provide theoretical and practical contributions in the development of more innovative, interactive, and meaningful mathematics learning strategies in today's digital era.

METHOD

This study uses an analytical quantitative method with a classroom action approach (CAR). The subjects of this study were 20 students of MA Tarbiyatus Shibyan Lamongan. This classroom action research was conducted in two cycles. Each cycle consists of 4 stages, namely: (1) planning, (2) implementation, (3) observation, and (4) reflection. Each cycle is carried out in 1 face-to-face meeting. In cycle I, learning is carried out without using the GeoGebra Graphing Calculator application. While in cycle II, students are introduced to the GeoGebra Graphing Calculator application, and learning is carried out using the GeoGebra Graphing Calculator application.

Data on students' mathematical competence in the learning process were obtained by observing students in each cycle. The characteristics of students' mathematical competence are arranged as shown in Table 1 below.

Table 1. Characteristics of Students' Mathematical Competence

No.	Characteristics	Indicator
1.	Understanding mathematical concepts	Able to explain the relationship between concepts and imply concepts or algorithms, flexibly, accurately, efficiently and precisely in problem solving.
2.	Using reasoning	Able to manipulate mathematics in making generalizations, constructing evidence, or explaining mathematical ideas and knowledge.
3.	Problem solving skills	Able to design mathematical models, solve models, and interpret the solutions obtained.
4.	Mathematical Communication	Able to communicate ideas with symbols, tables, diagrams, or other media to clarify a situation or problem.
5.	Appreciating the usefulness of mathematics	Have curiosity, attention, and interest in studying mathematics, as well as a persistent and confident attitude in problem solving.

To determine students' mathematical competence, in addition to observations in the learning process, researchers also provide students with Student Worksheets (LKPD) in each cycle. In cycle I, students work on LKPD without using the GeoGebra Graphing Calculator application. While in cycle II, students work on LKPD using the GeoGebra Graphing Calculator application. From the scores obtained by each student, the scores obtained are then matched with Table 2.

Table 2. Students' Mathematical Competence Level

No.	Score Range	Level
1.	$0 < \bar{X} \leq 65$	Low
2.	$65 < \bar{X} \leq 75$	Currently
3.	$75 < \bar{X} \leq 85$	Tall
4.	$85 < \bar{X} \leq 100$	Very high

RESULTS AND DISCUSSION

In this study, data were obtained from the results of observations in cycle I and cycle II. In both cycles, both cycle I and cycle II, students were givenStudent Worksheet (LKPD) on linear programming material. In cycle I, students work on LKPD without using the GeoGebra Graphing Calculator application. While in cycle II students are introduced to the GeoGebra Graphing Calculator application and work on LKPD using the GeoGebra Graphing Calculator application.

From the data obtainedIn cycle I and cycle II, the data was analyzed using SPSS for Windows (IBM SPSS Statistics) computer calculations. First, the results of the frequency distribution of students in cycle I will be presented, which are shown in Table 3.

Table 3. Frequency Distribution of Students in Cycle I

Competency Level	Frequency	Percentage (%)
Low	4	20
Currently	9	45
Tall	5	25
Very high	2	10
Total	20	100

Based on Table 3shows that the results of students' mathematical competency scores in cycle I almost half of the students have a moderate level of mathematical competency, namely 9 out of 20 students or exactly 45% of all students. While the level of competency with the least frequency is a very high level of mathematical competency, namely only 2 students.

Next, the results of the frequency distribution of students in Cycle II will be presented, which are shown in Table 4.

Table 4. Frequency Distribution of Students in Cycle II

Competency Level	Frequency	Percentage (%)
Low	1	5
Currently	3	15
Tall	9	45
Very high	7	35
Total	20	100

Based on Table 4shows that the results of students' mathematical competency scores in cycle II almost half of the students have a high level of mathematical competency, namely 9 out of 20 students or exactly 45% of all students. While the level of competency with the least frequency is the low level of mathematical competency, namely only 1 student.

The results of the frequency distribution analysis using*T Test (Paired Samples Statistics)*based on the application of the GeoGebra Graphing Calculator in improving students' mathematical competence is shown in Table 5.

Table 5. Frequency Distribution Analysis Using T Test

Competency Level	Geogebra Graphing Calculator Application Implementation	P Value

	Before (Cycle I)		After (Cycle II)		
	N	%	N	%	
Low	4	20	1	5	0.001
Currently	9	45	3	15	
Tall	5	25	9	45	
Very high	2	10	7	35	
Total	20	100	20	100	

Based on Table 5, the results of the frequency distribution analysis before (cycle I) and after (cycle II) the GeoGebra Graphing Calculator application was applied to the level of students' mathematical competence using*T Test (Paired Samples Statistics)*The obtained value shows that the value is less than the significant level, namely 0.05. Therefore, it can be concluded that$p = 0{,}001$ ($p < 0{,}05$)pThe application of the Geogebra Graphing Calculator application in mathematics learning has an influence on improving students' mathematical competence.

Table 6. Relationship between Application Implementation in Improving Mathematical Competence

	N	Correlation	Sig
Before Application Implementation and After Implementation	20	0.950	0.001

Based on Table 6, it is known that the significant value is 0.001 which shows that between before the implementation Geogebra Graphing Calculator application and after the application of Geogebra Graphing Calculator application has a relationship. Then, the correlation value is known to be 0.950 which indicates a very strong and unidirectional relationship. Therefore, it can be concluded that the application of Geogebra Graphing Calculator application in mathematics learning has a strong influence in improving student competence.

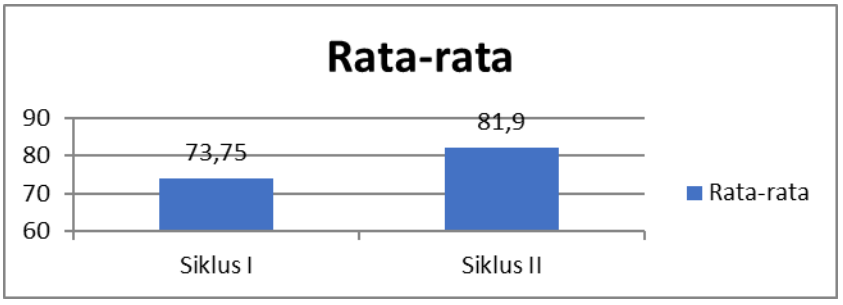

Figure 1. Average Student Competency Diagram in Cycle I and Cycle II

Based on Figure 1, the average student competency from cycle I and cycle II increased. In cycle I, namely the observation before the application was implemented.*Geogebra Graphing Calculator*, the average student competency is 73.75% which means the average student competency in the research class is classified as moderate. Then in cycle II, namely observation by implementing the Geogebra Graphing Calculator application showed an increase, namely to 89.06% which means the average student competency in the research class is classified as high.

This study found that students' mathematical competence increased when the GeoGebra Graphing Calculator application was applied in working on LKPD. Based on observations of behavior and results worked on by students, it shows that students can solve linear programming problems, students are able to apply linear programming

concepts in solving given problems, students are able to plan and apply various linear programming problem-solving strategies, students are able to operate the GeoGebra Graphing Calculator application, even students try to enter inequalities from several linear programming problems into the GeoGebra Graphing Calculator application to create graphs and find solution areas. The following is one display of the GeoGebra Graphing Calculator application when used by students in the process of understanding and working on Student Worksheets (LKPD).

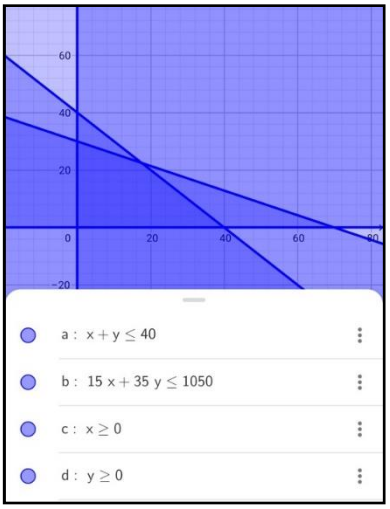

Figure 2. GeoGebra Graphing Calculator Application Display

Based on the explanation above, students' mathematical competence is in the moderate category before the implementation of the GeoGebra Graphing Calculator application. This is indicated by students' ability to understand the concept of linear programming which is still limited. The results of field observations show that students tend to have difficulty in visualizing graphic forms, understanding transformations, analyzing graphs, and finding solution areas. This is due to conventional learning methods that only rely on blackboards and textbooks. This learning approach is no longer interesting and tends to be theoretical(Fauziyah & Hermanto, 2025)As a result, students feel bored and do not understand the material presented.(AK Dewi et al., 2024). This causes students to lack visual and interactive experience in understanding abstract mathematical concepts.(Lukman et al., 2020).

After implementing the GeoGebra Graphing Calculator application in learning, students' mathematical competence increased significantly to reach the high category. Even in the very high category, which in cycle I there were only 2 students, in cycle II there were 7 students who had very high mathematical competence. This increase occurred because the GeoGebra Graphing Calculator application was able to present dynamic and interactive visualizations that helped students understand mathematical concepts.(Gunčaga & Majherová, 2012). With features such as manipulating geometric objects and visualizing function graphs, students can construct understanding through observation and experimentation.(Sulistiawati et al., 2021). So that it allows students to explore and experiment independently. The dynamic and colorful visual display of the GeoGebra Graphing Calculator application makes abstract mathematical concepts easier to understand. This helps students build a stronger understanding between various mathematical concepts, so that students' understanding becomes deeper.(Siregar et al., 2024).

The implementation of the GeoGebra Graphing Calculator application has succeeded in creating a more interesting and interactive learning atmosphere. The quality

of the learning process also increases when using learning media, especially helping students in learning.(Mayer, 2017). Because with learning media, the message conveyed by educators to students can be conveyed more easily.(Han & Jiang, 2013). The existence of learning media also makes students feel happy and not bored with learning.(Hallal et al., 2016). So as to arouse students' interest and enthusiasm in studying mathematics.(Nurhaliza et al., 2022).

Students' ability to visualize and manipulate mathematical objects directly through the GeoGebra Graphing Calculator application makes students more confident in solving mathematical problems. Students' self-confidence is shown by the increasing independence of students in learning and solving problems.(Nuritha & Tsurayya, 2021). This is evident from the significant increase in student learning outcomes, where students are not only able to understand concepts better but can also apply that understanding in solving various math problems. The use of the GeoGebra Graphing Calculator application also encourages more collaborative learning.(Choirudin et al., 2021). This is demonstrated by the students' ability to discuss and share findings with classmates. creating a more dynamic and effective learning environment(Wati et al., 2024).

Application implementation*GeoGebra Graphing Calculator*asMathematics learning media provides many positive impacts. Some of these impacts include:improving conceptual understanding(Siregar et al., 2024), skills in problem solving(Simamora et al., 2022), mathematical communication skills(Siregar et al., 2024), and improve student learning outcomes(Lubis et al., 2024).In addition, the implementationGeoGebra Graphing Calculator application can improve students' creative thinking skills(Septian et al., 2020).

The advantage of the GeoGebra Graphing Calculator application is that it is flexible and easy to use(Hallal et al., 2016). This is because the GeoGebra Graphing Calculator application can be used directly using each student's mobile phone. By using the GeoGebra Graphing Calculator application, it can train students' flexibility in solving the problems given. Students can also elaborate on how mathematical equations, graphs, images, and change or shift graphs or points on the application, so that students can easily find solutions and understand.

CONCLUSION

Based on the results of the analysis and discussion, it can be concluded that learning mathematics by implementing the GeoGebra Graphing Calculator application can improve students' mathematical competence. This study found that the average percentage of students' mathematical competence in cycle I, namely learning without implementing the Geogebra Graphing Calculator application, was 73.75%, which means that the average student competence in the research class was classified as moderate. Then in cycle II, namely learning by implementing the Geogebra Graphing Calculator application, there was an increase to 89.06%, which means that students' mathematical competence was classified as high. This study also found that the implementation of the Geogebra Graphing Calculator application in mathematics learning had a strong influence on improving student competence.

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