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Enhancing Students' Strategic Competence with GeoGebra and Productive Disposition: Elevating Mathematics Learning in the Digital Age

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Enhancing Students' Strategic Competence with GeoGebra and Productive Disposition: Elevating Mathematics Learning in the Digital Age

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Abstract

This research aims to explore both the individual and combined relationships between the use of GeoGebra and productive disposition with students' strategic competence. The use of GeoGebra involves teacher-led activities designed to assist students in managing and engaging with learning, serving as a tool to enhance mathematics learning outcomes. Productive disposition is a personal trait that influences how individuals think and act when solving problems. Meanwhile, strategic competence refers to students' ability to recall, comprehend, apply, analyze, and evaluate strategies for understanding, representing, and solving mathematical problems. A quantitative approach is utilized in this study, employing survey methods and correlational analysis. The research population consists of 240 tenth-grade students, from which a sample of 150 students was selected. Data collection instruments include questionnaires on GeoGebra utilization, productive disposition, and tests measuring strategic competence. The data analysis techniques encompass descriptive analysis, prerequisite testing, and hypothesis testing. The findings reveal several significant insights: (1) a positive and significant relationship exists between GeoGebra utilization and students' strategic competence; (2) productive disposition also demonstrates a positive and significant correlation with strategic competence; (3) however, there is no significant simultaneous relationship between GeoGebra utilization and productive disposition with students' strategic competence. These results highlight the need for effective integration in mathematics instruction. GeoGebra should be leveraged as a tool to foster problem-solving strategies, while productive disposition should encourage deeper exploration and reflection on problem-solving approaches.

Introduction

In the Independent Curriculum, the primary goal of mathematics education in high school is to develop students' strong conceptual understanding, critical thinking abilities, and practical problem-solving skills. Specifically, mathematics learning aims to help students master fundamental mathematical concepts, enhance their analytical skills in problem-solving, and apply mathematics across various scientific disciplines and real-life contexts. The Independent Curriculum offers a more flexible approach to learning, incorporating projects, data exploration, and digital technology to enhance student comprehension (Rizki, 2022; Das, 2019). With its tiered and differentiated learning structure, students can progress according to their readiness and interests. By integrating technology into the learning process, students are expected not only to grasp mathematical theories but also to relate them to real-world applications while fostering critical and creative thinking. Additionally, this approach enables students to develop efficient problem-solving strategies for everyday challenges.

The ability to apply effective problem-solving strategies is known as strategic competence (Rahman, 2023). In mathematics, strategic competence is crucial in helping students tackle complex problems by enhancing their problem-solving abilities, critical thinking, and mathematical reasoning (Schulz, 2024). Students with strong strategic competence can approach mathematical challenges with confidence and efficiency, leading to a deeper understanding and mastery of mathematical concepts. Research indicates that students with high strategic competence tend to employ multiple representations—such as diagrams, algebraic notation, proportional reasoning, and fractional operations—when solving problems (Copur-Gencturk, 2021). Furthermore, they can effectively develop strategies by identifying known and unknown quantities to arrive at better solutions (Szabo, 2020). Strategic competence also improves students' problem-solving skills by enabling them to analyze, understand, and determine the most effective solutions to mathematical problems (Rahman, 2023). Beyond mathematics, it plays a role in conflict resolution, teamwork, coordination, and communication, ultimately enhancing students' ability to navigate various situations effectively.

However, observations at a senior high school in the Gowa district reveal that many students struggle to utilize their strategic competence effectively, making it difficult for them to solve mathematical problems. This limitation hinders their ability to think critically, solve problems efficiently, and develop a deep understanding of mathematical concepts. Many students face challenges in solving non-routine contextual problems due to difficulties in comprehending abstract mathematical concepts, which prevents them from connecting theory to real-world applications.

To address this issue, a more innovative teaching approach incorporating technology-based strategies in mathematics education is essential. Instead of focusing solely on theoretical explanations, instructional methods should emphasize practical skills and deep conceptual understanding. One effective approach is the use of educational tools such as GeoGebra. GeoGebra is a dynamic geometry software that enhances students' mathematical knowledge and supports problem-based learning in the 21st century (Furner, 2024). This interactive software promotes critical, creative, and innovative thinking. Teachers should be trained to integrate GeoGebra into mathematics instruction as part of ICT-based learning for 21st-century education (Kim, 2017). GeoGebra has significant potential to increase student engagement in mathematics learning and facilitate the comprehension of complex concepts, particularly in geometry.

GeoGebra enables students to explore mathematical concepts in an interactive, creative, and visual manner. It fosters the development of critical and innovative thinking while enhancing student engagement in mathematics learning by increasing motivation. The use of GeoGebra in instruction has been proven effective in helping students grasp mathematical concepts more effectively than traditional teaching methods. Research by Mensah (2023) indicates that using GeoGebra in teaching circles has yielded better results for secondary school students compared to conventional approaches. Overall, students have a positive perception of GeoGebra’s role in learning about circles (Mensah, 2023). GeoGebra enhances students' understanding by allowing them to explore concepts and formulate conjectures, ultimately leading to improved performance. The software serves as a valuable tool for strengthening students’ mathematical comprehension. Studies also show that students who use GeoGebra exhibit higher levels of engagement and motivation in learning mathematics (Schaver, 2019). By integrating GeoGebra, students become more actively involved and motivated, which directly influences their learning outcomes. The level of student engagement significantly impacts the effectiveness of GeoGebra by fostering greater interest and participation in mathematics learning.

Furthermore, research suggests that GeoGebra facilitates the visualization and comprehension of abstract mathematical concepts, making them more accessible to students (Kim, 2017). Designed to enhance students’ ability to grasp and apply abstract concepts, GeoGebra helps learners establish connections between mathematical ideas, ultimately improving their overall understanding. As a dynamic tool, the software supports the development of mathematical problem-solving skills, leading to enhanced critical and creative thinking (Kim, 2017). GeoGebra plays a crucial role in fostering strategic thinking in mathematics by stimulating students' creative and innovative reasoning.

In addition to technology integration, another key factor influencing students’ problem-solving abilities is productive disposition. Productive disposition refers to students’ recognition of the usefulness of mathematics, their enjoyment of the subject, and their motivation to apply mathematical concepts to real-world problems. This trait significantly impacts students’ problem-solving skills. It reflects a person’s attitude toward mathematics, particularly their belief in the value of mathematical thinking. According to DiNapoli (2023), productive disposition involves the habit of viewing mathematics as logical, practical, and valuable, coupled with confidence in one’s perseverance and ability to succeed. This suggests that students with a strong productive disposition see mathematics as understandable and useful and believe that consistent effort will lead to success. Similarly, Dangkulos (2025) describes productive disposition as a mindset that perceives mathematics as reasonable, beneficial, and rewarding while fostering the belief that persistent learning leads to achievement. Ultimately, students who develop a productive disposition are more likely to approach mathematics with confidence, persistence, and a strong sense of purpose, which enhances their overall learning experience and future success.

Fostering a positive attitude toward mathematics can lead to improved performance and learning outcomes (Langoban, 2023). Students with a productive disposition tend to perceive mathematics as logical, useful, and beneficial, which enhances their affective abilities in the subject (Dangkulos, 2025). Disposition is a character trait that influences an individual's approach to problem-solving. Specifically, a productive disposition is a personal trait that encourages individuals to adopt a particular mindset and behavior, enabling them to achieve meaningful outcomes (Suh, 2021). This disposition can be cultivated through character development, which helps students develop positive learning habits both in academics and in their daily lives.

Technology can play a crucial role in fostering a productive disposition by offering interactive learning platforms tailored to students' individual learning styles and preferences. Virtual simulations, gamified learning experiences, and online collaborative tools can enhance student engagement, fostering enthusiasm, confidence, perseverance, curiosity, and a willingness to collaborate in the learning process (Dangkulos, 2025). Since students have different characteristics that influence their problem-solving strategies, it is essential to explore how various factors contribute to their mathematical abilities.

Therefore, further research is needed to examine the relationship between the use of GeoGebra, the application of productive disposition, and students' strategic competencies to maximize their problem-solving skills. However, existing studies on this topic remain limited, making it a challenge for researchers. GeoGebra, which provides a visual representation of abstract mathematical concepts, has the potential to promote a positive attitude toward mathematics. Its use as an interactive and dynamic teaching tool can enhance students' strategic competencies in problem-solving. Moreover, productive disposition—characterized by a positive attitude toward mathematics and the belief that success in mathematics comes through effort—plays a vital role in developing strategic competence. Understanding the interconnections between GeoGebra, productive disposition, and strategic competence is essential for optimizing students' ability to solve mathematical problems effectively.

Method

The research conducted aims to determine the relationship between the use of GeoGebra media and students' productive dispositions together or partially with strategic competence in learning mathematics. The research used is quantitative with survey methods and correlational techniques with the aim of describing the relationship between the variables studied and the relationship between variables indicated by the correlation coefficient value. The contribution model between variables in this study is as follows.

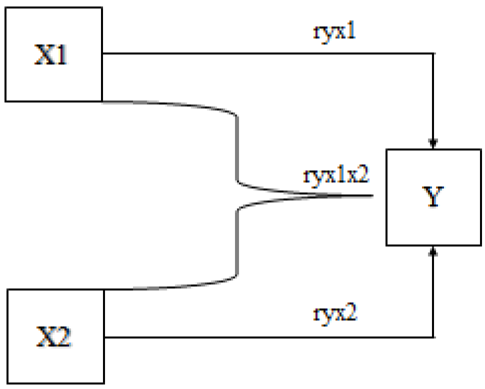

Figure 1. Research Design

Description:

X1 = Utilization of GeoGebra media

X2 = Productive Disposition

Y = Strategic Competence

The population in this study were all students at SMA Negeri 22 Gowa, totaling 240 students. The researcher used a random sampling technique, namely a sample drawn randomly from the population. The calculation of the minimum number of students included in the research sample refers to the Slovin formula, as follows:

$$\text{Slovin Formula : } n = \frac{N}{1+Ne^2}$$

Description:

n: Number of Samples

N: Population Size

e: Error Rate (0.01, 0.02, 0.03, etc.)

Based on the formula above, the minimum number of samples required for this study is: n = 240/1.6 = 150 Thus, the total number of students included in the research sample is 150. The instruments used for data collection include 1) A questionnaire on the use of GeoGebra media, 2) A questionnaire on productive disposition, 3) A strategic competency test. The strategic competency test measures a student's ability to recall, understand, apply, analyze, and evaluate strategies for comprehending, representing, and solving mathematical problems. This competency is assessed through essay questions, which are classified as non-routine problems. The GeoGebra media utilization questionnaire is a Likert-scale questionnaire (ranging from 1 to 5) designed to assess teachers' activities in implementing and managing learning using GeoGebra as a tool to enhance mathematics learning outcomes. The productive disposition questionnaire evaluates an individual's characteristic tendencies to think and act in a particular way when solving problems. This is measured using a questionnaire consisting of 30 statements, rated on a Likert scale from 1 to 5. The indicators used in this study refer to Rahman's research (2022) and are as follows:

Table 1. Productive Disposition Indicator

Disposition Productive Indicator	Sub Indicator
usefulness of mathematics	having knowledge related to the usefulness of mathematics in everyday life
	having knowledge related to the usefulness of mathematics in the world of work
motivation	having a desire to learn mathematics
	having environmental support for learning mathematics
enjoying	having a feeling of pleasure in learning mathematics
	enjoying the process of learning mathematics

The data analysis techniques used in this study include descriptive analysis, prerequisite test analysis, and hypothesis test analysis. Descriptive analysis is conducted to provide an overall summary of the research results, including measures such as the mean (average), median (middle value), mode (most frequent value), standard deviation, and data presentation in tabular form. The prerequisite test analysis includes normality and linearity tests: The normality test is conducted using the Kolmogorov-Smirnov test to determine whether the data follows a normal distribution. The linearity test is performed by deriving the regression equation between the independent and dependent variables. Based on the regression equation, the significance of the regression coefficient and its linearity are then tested.The hypothesis testing analysis is conducted using simple and multiple linear regression analysis, which involves calculating the coefficient of determination, simultaneous tests, and partial tests.

Results

The results of this study provide data related to the utilization of GeoGebra (X1), productive disposition (X2) and strategic competence (Y) of students. Table 2 shows descriptive data that has been obtained.

Table 2 Descriptive Data from Research Results

		X1	X2	Y
N	Valid[a]	120	120	120
	Missing	0	0	0
Mean		67.1417	70.3250	84.2500
Std. Error of Mean		0.66160	0.31158	0.37447
Median		67.5000	70.0000	84.0000
Mode		71.00	73.00	85.00
Std. Deviation		7.24748	3.41318	4.10216
Variance		52.526	11.650	16.828
Range		29.00	15.00	18.00
Minimum		51.00	63.00	76.00
Maximum		80.00	78.00	94.00

a. Multiple modes exist. The smallest value is shown

The results of the GeoGebra utilization questionnaire indicate an average score of 67, a median of 67, a minimum score of 51, and a maximum score of 80. Similarly, the results of the productive disposition questionnaire show an average score of 70, a median of 70, a minimum score of 63, and a maximum score of 78. Meanwhile, the results of the strategic competency test reveal an average score of 84, a median of 84, a minimum score of 76, and a maximum score of 94. Furthermore, a data normality test was conducted to determine whether the collected data followed a normal distribution. The results of the normality test using SPSS are presented in Table 3.

Table 3: Normality Test Results for Variables X1, X2, and Y

		X1	X2	Y
N		120	120	120
Normal Parameters[a,b]	Mean	66.8083	66.9833	67.0000
	Std. Deviation	6.99975	7.03172	6.93184
Most Extreme Differences	Absolute	0.070	0.079	0.065
	Positive	0.057	0.056	0.048
	Negative	-0.070	-0.079	-0,065
Test Statistic[a]		0,070	0.079	0.065
Asymp. Sig. (2-tailed)		.200[c,d]	.064[c]	.200[c,d]

a. Test distribution is Normal; b. Calculated from data; c. Lilliefors Significance Correction; . d. This is a lower bound of the true significance.

Based on Table 3, it can be seen that the significant value for variable X1 is 0.200, variable X2 is 0.064, and variable Y is 0.200. This shows that all variables have significant values greater than the significance level of 0.05, so it can be concluded that the data obtained has been normally distributed. Furthermore, a linearity test is carried out by finding the equation of the regression line of the independent variable against the dependent variable. The following are the results of the linearity test for variable Y with variable X1.

Table 4 Linearity Test Y with X1

			Sum of Squares	df	Mean Square	F	Sig.
Strategic Competence * Use of GeoGebra	Between Groups	(Combined)	5121.944	27	189.702	29.280	0.000
		Linearity	4905.352	1	4905.352	757.131	0.000
		Deviation from Linearity	216.593	26	8.330	1.286	0.191
	Within Groups		596,056	92	6.479		
	Total		5718,000	119			

Based on Table 4, it is obtained that the significant value is 0.191 which is greater than the significant level (0.191>0.05) so it can be concluded that there is a significant linear relationship between variables Y and X1. The following are the results of the linearity test of Y with X2.

Table 5 Linearity Test of Y with X2

			Sum of Squares	df	Mean Square	F	Sig.
Strategic Competence * Utilization GeoGebra	Between Groups	(Combined)	5018.333	27	185.864	24.440	0.000
		Linearity	4755.992	1	4755.992	625.371	0.000
		Deviation from Linearity	262.341	26	10.090	1.327	0.164
	Within Groups		699.667	92	7.605		
	Total		5718,000	119			

Based on Table 5, it is obtained that the significant value is 0.164 which is greater than the significant level (0.191>0.05) so that it can be concluded that there is a significant linear relationship between variables Y and X2. Furthermore, hypothesis testing is carried out as follows.

The first hypothesis reads "There is a significant relationship between the use of GeoGebra and students' strategic competence". The calculation of the hypothesis test was carried out with the help of SPSS which shows the results as in the following table. Based on table 6, it can be seen that the probability value is smaller than the significant level, which is 0.000 <0.005, so H0 is rejected, so this shows that the regression direction coefficient of Y on X1 is significant at the level of 0.05, namely the simple linear regression model can be used to predict the relationship between strategic competence of high school students influenced by the use of GeoGebra.

Table 6 ANOVA for Linear Regression X1 and Y

Model[a]		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	4905.352	1	4905.352	712.278	.000[b]
	Residual	812.648	118	6.887		
	Total	5718.000	119			

a. Dependent Variable: Strategic Competence; b. Predictors: (Constant), Utilization GeoGebra

Based on Table 7, the linear regression equation obtained is: Y=5.721+0.917X1Y = 5.721 + 0.917X_1Y=5.721+0.917X1. This equation indicates that for every 1-unit increase in GeoGebra utilization, there is a corresponding increase of 0.917 units in strategic competence, with a constant of 5.721. Additionally, the t-count value was found to be 26.689, which is greater than the critical t-value of 1.98 (26.689 > 1.98). This result confirms that the hypothesis is accepted, indicating a significant positive relationship between GeoGebra utilization and students' strategic competence. In other words, the more effectively GeoGebra media is used in mathematics learning, the more optimally students can apply their strategic competence.

Table 7 Linear Regression Equation X1 and Y

Model[a]		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.721	2.309		2.478	0.015
	Utilization GeoGebra	0.917	0.034	0.926	26.689	0.000

a. Dependent Variable: Strategic Competence

Table 8 shows that the correlation coefficient (rxy) is 0.926, which indicates that there is a relatively strong relationship between X1 and Y. In addition, the R2 value is also seen to be 0.858, which means that 85.8% of students' strategic competence can be influenced by the use of GeoGebra.

Table 8: Significance Test of Correlation Coefficient X1 and Y

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.926[a]	0.858	0.857	2.62428

a. Predictors: (Constant), Utilization GeoGebra; b. Dependent Variable: Strategic Competence

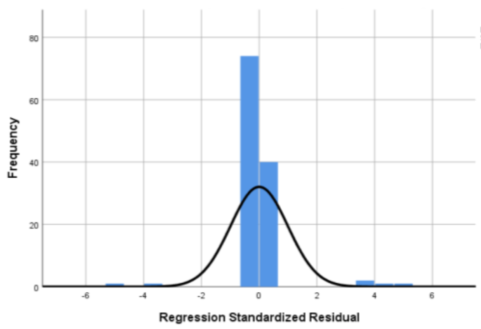

Figure 2. Histogram of the Differences in the Significance Level of α and sig. Values in the Distribution Graph

The second hypothesis states "There is a significant relationship between productive disposition and students' strategic competence". The calculation of the hypothesis test was carried out with the help of SPSS which shows the results as in the following table.

Table 9 ANOVA for Linear Regression X2 and Y

Model[a]		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	4755.992	1	4755.992	583.371	.000[b]
	Residual	962.008	118	8.153		
	Total	5718.000	119			

a. Dependent Variable: Strategic Competence; b. Predictors: (Constant), Productive Disposition

Based on Table 9, it can be seen that the probability value is smaller than the significant level, which is 0.000 <0.005, so H0 is rejected, so this shows that the regression direction coefficient of Y on X2 is significant at the level of 0.05, namely the simple linear regression model can be used to predict the relationship between strategic competence of high school students influenced by productive disposition.

Table 10 Linear Regression Equation X2 and Y

Model[a]		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	6.778	2.507		2.704	0.008
	Productive Disposition	0.899	0.037	0.912	24.153	0.000

a. Dependent Variable: Strategic Competence

Based on Table 10, it is obtained that the linear regression equation formed is Y = 6.778 + 0.899 X1, which means that for every 1 unit increase in productive disposition, it is also followed by an increase in the strategic competence value of 0.899 units with a constant of 6.778. In addition, it was also obtained that the t-count value was 24.153 which had a greater value than the t-count, which was 1.98 (26.689> 1.98), which means that the hypothesis was accepted. This shows that there is a significant positive relationship between productive disposition and strategic competence of high school students or in other words, the higher the productive disposition that students have in learning mathematics, the more optimal the application of students' strategic competence in solving problems.

Table 11 Significance Test of Correlation Coefficient X2 and Y

Model[b]	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.912[a]	0.832	0.830	2.85528

a. Predictors: (Constant), Productive Disposition; b. Dependent Variable: Strategic Competence

Table 11 shows that the correlation coefficient (rxy) is 0.912, which indicates that there is a relatively strong relationship between X2 and Y. In addition, the R2 value is also 0.832, which means that 83.2% of students' strategic competence can be influenced by productive disposition.

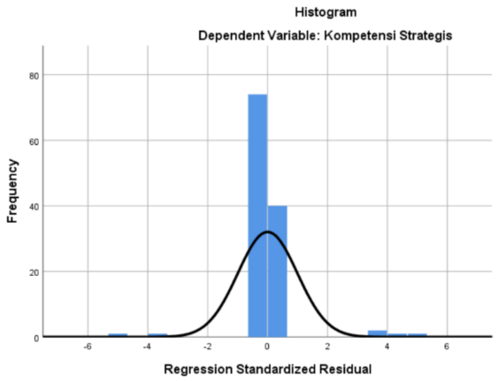

Figure 3 Histogram of the Differences in the Significance level α and sig. Values in the Distribution Graph

The third hypothesis is that there is a significant relationship between the use of GeoGebra and productive dispositions together towards students' strategic competence. The test decision uses multiple regression to determine the extent to which the utilization GeoGebra and productive dispositions together play a role in the application of strategic competence in solving problems faced by students. The results of the calculation of the linearity test and the significance of the linear regression carried out using the SPSS program are as seen in the following table.

Table 12 ANOVA for Linear Regression X1, X2 and Y

Model[a]	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	4905.800	2	2452.900	353.348	.000[b]
Residual	812.200	117	6.942		
Total	5718.000	119			

a. Dependent Variable: Strategic Competence; b. Predictors: (Constant), Utilization GeoGebra, Productive Disposition

Based on the SPSS results, it was obtained that the probability value was smaller than the significance level, namely 0.000 <0.005, so H0 was rejected. Therefore, it can be said that there is a linear effect of the use of GeoGebra and productive disposition on students' strategic competence. The multiple regression equation can be seen in the following table.

Table 13 Multiple Linear Equations and Significance Tests of Regression Equation Coefficients Y, X1 and X2

		Unstandardized Coefficients		Standardized Coefficients		
Model[a]		B	Std. Error	Beta	t	Sig.
1	(Constant)	5.763	2.324		2.480	0.015
	Productive Disposition	-0.053	0.208	-0.054	-0.254	0.800
	Utilization GeoGebra	0.970	0.209	0.979	4.645	0.000

a. Dependent Variable: Strategic Competence

Based on Table 13, the constant value is 5.763, the coefficient of X1 is 0.970, and the coefficient of X2 is -0.053.

Therefore, the multiple linear regression equation can be expressed as Y=5.763+0.970X1−0.053X2Y = 5.763 + 0.970X1 - 0.053X2Y=5.763+0.970X1−0.053X2. This indicates that X1 has a positive influence, while X2 has a negative influence. Specifically, if X1 increases by 0.970 units, X2 will decrease by 0.053 units, with a constant value of 5.763 units. The table also shows that the significance value of X1 is 0.000, which is smaller than the significance level (0.05), whereas X2 has a significance value of 0.800, which is greater than 0.05. This finding is further supported by the t-count values, where X1 has a t-count of 4.645, which is greater than the t-table value (1.98), while X2 has a t-count of -0.254, which is smaller than the t-table value (1.98). Based on these results, it can be concluded that H_0 is accepted, or in other words, the third hypothesis is rejected. This means that there is no significant combined relationship between the use of GeoGebra and productive disposition with students' strategic competence.

Discussion

The results of the study indicate a positive and significant relationship between the use of GeoGebra and students' strategic competence in mathematics learning. The more frequently GeoGebra is utilized in the learning process, the more effectively students apply their strategic competence in problem-solving. As a dynamic mathematical software, GeoGebra enables students to explore concepts visually and interactively, enhancing their understanding of patterns, relationships, and problem-solving strategies. This finding aligns with previous research, which suggests that integrating GeoGebra into mathematics learning enhances students' conceptual understanding and problem-solving abilities (Suratno, 2023).

Furthermore, other studies have demonstrated that GeoGebra is effective in mathematics learning at both the secondary and higher education levels, positively impacting students' conceptual comprehension, critical thinking skills, and independent learning (Yohannes, 2023). Strategic competence in mathematics encompasses students' ability to design solutions, connect concepts, and select appropriate strategies for problem-solving. The integration of GeoGebra into learning facilitates a deeper understanding of mathematical concepts and enhances students' problem-solving skills.

Productive disposition reflects students' positive attitudes toward mathematics, including an appreciation of its benefits, high motivation, and enjoyment of problem-solving challenges. This attitude plays a crucial role in enhancing students' ability to design solutions, connect concepts, and determine effective strategies for solving mathematical problems. Students with a productive disposition tend to be more persistent in exploring different problem-solving approaches, do not easily give up when facing difficulties, and are more reflective when evaluating their chosen strategies (Awofala, 2022).

Research has also shown that students with high levels of productive disposition, particularly in terms of persistence, curiosity, and reflective thinking, are better equipped to develop effective problem-solving strategies (Haji, 2019). Furthermore, studies confirm that students with positive attitudes toward mathematics and perseverance in overcoming challenges tend to develop more flexible and systematic problem-solving approaches (Rahman, 2022). Similarly, research indicates that students with a positive attitude are more open to experimenting with various problem-solving methods, ultimately enhancing their strategic competence (Dewi, 2021).

Thus, the stronger a student's productive disposition, the greater their ability to develop strategic competencies that can be applied to solve mathematical challenges in real life. Strategic competence refers to an individual's ability to design, manage, and adapt strategies to achieve specific goals. Productive disposition, on the other hand, embodies an appreciation of mathematics, a sense of enjoyment, and the motivation to actively and consistently apply acquired skills and strategies. Students with high strategic competence but lacking productive disposition may struggle to apply their abilities optimally (Al-Malky, 2020).

Conversely, a productive disposition without strategic competence may result in unfocused efforts toward problem-solving. A student with a strong productive disposition does not easily give up when encountering difficulties but instead continues to explore alternative strategies, evaluate mistakes, and learn from past experiences (Chua, 2021). This mindset also fosters curiosity and persistence in understanding mathematical concepts and encourages critical and creative thinking in problem-solving. Therefore, beyond mastering mathematical concepts and strategies, developing a productive disposition is essential for solving problems systematically, efficiently, and innovatively.

The application of GeoGebra and productive disposition does not play a significant combined role in developing strategic competence for problem-solving. This indicates that these two variables do not have a direct or strong influence on students' strategic competence in learning mathematics. The relationship between GeoGebra, productive disposition, and strategic competence may be insignificant if these factors are not optimally integrated into the learning process. This aligns with previous research findings, which suggest that although GeoGebra is highly effective for visualizing mathematical concepts, its benefits must be supported by a more interactive learning approach and a deeper conceptual understanding to yield optimal results (Badriyanto, 2022). If GeoGebra is merely used as a tool without encouraging students to think strategically, or if students' productive dispositions are not channeled into systematic problem-solving strategies, its impact on strategic competence will remain minimal.

GeoGebra is a powerful software for visualizing mathematical concepts, particularly in geometry, algebra, and calculus. However, strategic competence is not solely dependent on visualization skills; it also requires higher-order thinking skills, such as designing problem-solving strategies, generalizing concepts, and making informed decisions. Similarly, productive disposition reflects a positive attitude towards mathematics, including an appreciation of its usefulness in daily life, enjoyment in learning, and motivation to engage with mathematical concepts. However, even when students have a high productive disposition, they still require effective learning approaches to develop strategic competence. Research supports this notion, suggesting that productive disposition alone does not always have a major impact on problem-solving abilities, especially when students are not explicitly taught how to solve problems effectively (Gurmu, 2024). A high productive disposition without structured instruction on developing problem-solving strategies, reflective thinking, and analytical skills will not necessarily lead to significant improvements in strategic competence (Awofala, 2022).

This outcome may be attributed to several factors, including GeoGebra's limitations in fostering strategic thinking, the fact that productive disposition does not always directly contribute to problem-solving strategies, and the lack of effective integration between these two elements. Students' strategic competence is not only influenced by GeoGebra and productive disposition but also by several other factors, including teacher instruction, students' prior knowledge, and teaching methods. If teachers do not explicitly train students in strategic thinking or fail to connect GeoGebra usage with problem-solving strategies, its impact on strategic competence will be minimal (Firdiana, 2022). Students with a stronger conceptual understanding may find it easier to develop strategic competence compared to those who struggle with basic mathematical concepts (Vankúš, 2021). Moreover, if the instructional approach focuses more on procedural learning rather than strategic problem-solving, then even with GeoGebra integration and a positive productive disposition, students may not significantly develop their strategic competence (Septian, 2020).

If students rely solely on GeoGebra without a strong productive disposition, they may lack motivation to explore alternative problem-solving strategies (Romero Albaladejo, 2024). Conversely, students with a high productive disposition but without the support of tools like GeoGebra may struggle to grasp abstract mathematical concepts in depth. Although GeoGebra and productive disposition can be interrelated in fostering strategic competence, their relationship is not direct. If GeoGebra is used procedurally, for example, merely for drawing graphs without further analysis, it will have little impact on enhancing students' productive disposition, thereby limiting the development of strategic competence. However, when learning is structured so that students actively use GeoGebra to develop problem-solving strategies, and when this process is reinforced by a strong productive disposition, it can significantly enhance strategic competence. Effective integration occurs when GeoGebra is used to encourage strategic thinking rather than just procedural operations, and when productive disposition is directed towards exploration and reflection in problem-solving. When these elements are combined effectively, they maximize students' ability to apply strategic competence in solving mathematical problems efficiently and innovatively.

Conclusion

Strategic competence refers to students' ability to apply strategies in understanding, utilizing, and implementing mathematical concepts and skills in various situations, including real-life contexts. Productive disposition encompasses an appreciation of the benefits of mathematics, enjoyment in learning mathematics, and the motivation that drives students to think positively and actively engage in learning and problem-solving. The application of GeoGebra refers to the use of GeoGebra software in the mathematics learning process to help students understand concepts, visualize problems, and explore various solution strategies. Therefore, problem-solving outcomes can be maximized when the application of GeoGebra, productive disposition, and strategic competence are effectively interconnected.

In mathematics learning, there is a partial relationship between the use of GeoGebra and productive disposition with strategic competence. The application of GeoGebra in mathematics learning can significantly enhance students' strategic competence in problem-solving, and vice versa. When used effectively, GeoGebra helps students understand relationships between concepts, design more systematic approaches, and improve critical thinking skills in solving mathematical problems. However, if GeoGebra is not utilized optimally or is merely used procedurally without encouraging strategic thinking, its impact on students' strategic competence will be minimal, making it difficult for them to develop effective problem-solving strategies.

A positive attitude plays a crucial role in the effective implementation of problem-solving strategies. Productive disposition fosters perseverance, self-confidence, and openness to trying different approaches to problem-solving. Students with a positive attitude are more motivated to think critically, explore alternative strategies, and persist when faced with challenges. Conversely, without a positive attitude, even the best problem-solving strategies may not be implemented effectively due to a lack of motivation or fear of failure. The successful application of a good strategy can further strengthen a positive attitude, as students who systematically solve problems develop confidence and motivation to continue learning and tackling new challenges.

An inverse relationship may exist between the application of GeoGebra and productive disposition in maximizing strategic competence in problem-solving. The integration of GeoGebra and productive disposition can contribute to the development of strategic competence, but this relationship does not always occur automatically. GeoGebra serves as a visual aid that helps students explore mathematical concepts, while productive disposition fosters positive attitudes such as perseverance, curiosity, and critical reflection in problem-solving. However, if GeoGebra is only used procedurally without promoting strategic thinking, or if productive disposition is not directed toward in-depth exploration of problem-solving strategies, the relationship between these factors and strategic competence may be weak or insignificant. Therefore, effective integration in learning is essential, where GeoGebra is utilized as a tool to develop problem-solving strategies, and productive disposition is cultivated to support deeper exploration and reflection.

Recommendations

Mathematics teachers should integrate GeoGebra not only as a visualization tool but also as a means to enhance students' strategic competence through interactive and problem-based learning. Teachers should design lesson plans that encourage students to explore mathematical concepts dynamically, make conjectures, and test their ideas using GeoGebra. Additionally, it is crucial to foster a productive disposition by creating a supportive learning environment where students feel confident in exploring different problem-solving strategies without fear of failure.

Teachers can implement inquiry-based learning, guided discovery, and collaborative tasks that require students to analyze, reflect, and discuss their reasoning processes. Moreover, explicitly linking GeoGebra activities to real-world applications can help students see the relevance of mathematics, further strengthening their motivation and engagement. By integrating GeoGebra effectively with strategic learning approaches and promoting a positive attitude towards problem-solving, teachers can maximize students' mathematical competencies and critical thinking skills.

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