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Mathematical conceptual understanding under geogebra-assisted MASTER learning: The role of students' self-efficacy

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Mathematical conceptual understanding under geogebra-assisted MASTER learning: The role of students' self-efficacy

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ABSTRAK

This study examines differences in students' mathematical conceptual understanding across instructional conditions, the role of self-efficacy in mathematical conceptual understanding, and the interaction between the GeoGebra assisted MASTER learning model and self-efficacy. The study used a quantitative, quasi-experimental design. The study population is all grade VIII students of Public Junior High School (SMP Negeri) 1 Bukit Kemuning. The sample comprised two experimental classes and one control class selected through cluster random sampling. Data were obtained using a mathematical conceptual understanding test and a self-efficacy questionnaire. The mathematical topic was circles. The intervention was conducted for five sessions in each class, with each session lasting 2×45 minutes. The data were first examined for normality and homogeneity before testing the hypotheses using two-way ANOVA in a 3×3 factorial design. The findings showed significant differences in students' mathematical conceptual understanding across instructional conditions ($p < .001$). Self-efficacy was also significantly related to students' mathematical conceptual understanding ($p < .001$). However, the interaction between the learning model and self-efficacy was not statistically significant ($p = .170$). Thus, the GeoGebra-assisted MASTER learning model may serve as an alternative instructional approach to support students' mathematical conceptual understanding.

Keywords: GeoGebra, MASTER Learning, Mathematical Conceptual Understanding, Self Efficacy

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INTRODUCTION

Mathematics education contributes significantly to the development of students' logical, critical, systematic, and creative thinking abilities, which are essential for addressing problems in daily life and adapting to advances in science and technology (Kaustsari et al., 2024). A key objective of mathematics instruction is to foster students' conceptual understanding, allowing them to identify relationships between mathematical concepts, interpret mathematical ideas, and apply them appropriately when solving different types of problems (Safitri et al., 2023). Conceptual understanding is not limited to memorizing formulas; students are expected to restate concepts, classify objects according to conceptual criteria, apply concepts algorithmically, represent concepts in various mathematical forms, and connect different mathematical concepts (Khairunnisa et al., 2022). Therefore, conceptual understanding needs

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to be developed through learning that actively engages students in constructing, exploring, representing, and reflecting on mathematical knowledge (Rahmadhani et al., 2024).

However, students in Indonesia continue to demonstrate relatively limited mathematical conceptual understanding. Students commonly experience difficulties identifying relevant information, connecting mathematical concepts, selecting appropriate procedures, and representing concepts mathematically (Martika et al., 2025). These difficulties can cause students to rely on memorizing formulas rather than understanding the meaning and relationships among concepts, making it difficult for them to solve unfamiliar or contextual problems (Martika et al., 2025). This condition indicates the need for learning that offers students opportunities to actively develop and investigate mathematical concepts instead of simply receiving information from the teacher (Fadila et al., 2024).

Conceptual understanding is also related to affective factors, particularly self-efficacy. Bandura (1997) describes an individual’s belief in their ability to organize and carry out the actions necessary to achieve particular levels of performance. In mathematics learning, students with strong self-efficacy generally show greater confidence and persistence and are more willing to try alternative strategies when facing challenging problems. Conversely, students with weaker self-efficacy are more likely to avoid difficult tasks and give up when faced with challenges (Kaustsari et al., 2024). Thus, differences in students’ self-efficacy may influence how actively they engage in learning activities and how effectively they develop mathematical conceptual understanding.

The MASTER learning model accommodates active knowledge construction. The original MASTER framework proposed by Rose & Nicholl (1997) consists of six stages: Motivating your mind, Acquire information, Search out meaning, Trigger memory, Exhibit what you know, and Reflect how you have learned. The model emphasizes active learning through preparation and motivation, information acquisition, meaning exploration, memory activation, demonstration of understanding, and reflection. These stages are theoretically relevant to developing conceptual understanding because students are encouraged to process information, explore relationships, demonstrate understanding, and evaluate their learning rather than memorize mathematical procedures.

Integrating GeoGebra can strengthen this learning process by providing dynamic visual representations of mathematical objects and relationships. GeoGebra allows students to manipulate mathematical representations directly, observe changes, investigate patterns, and connect symbolic, graphical, and geometric representations. Consequently, GeoGebra can support the exploratory and reflective activities embedded in the MASTER stages and provide students with opportunities to construct more meaningful conceptual understanding (D. Juandi et al., 2021). Earlier studies have indicated that the MASTER model can positively contribute to students’ mathematical literacy and learning motivation (Sabirin et al., 2022),while its application viewed from self-efficacy has also been associated with students’ mathematical connection abilities (Ardiani et al., 2021). Furthermore, previous findings suggest that integrating GeoGebra into the MASTER learning model can support students’ mathematical conceptual understanding (Maharani et al., 2023).

The relationship among the MASTER stages, GeoGebra, self-efficacy, and conceptual understanding can be viewed as an integrated learning framework. In the Mind stage, students develop readiness, motivation, and confidence, which can encourage self-efficacy and willingness to engage with mathematical problems. In the Acquire information stage, students obtain relevant mathematical information and identify the characteristics of the concepts being studied. In the Search out meaning stage, students explore relationships and construct meaning through investigation; GeoGebra can facilitate this process through dynamic visualization and manipulation. These activities particularly support students in restating concepts, classifying objects according to conceptual criteria, and connecting mathematical concepts. In the Trigger

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memory stage, students relate new knowledge to previously learned concepts, supporting the ability to apply concepts algorithmically and establish connections among concepts. In the Exhibit what you know stage, students demonstrate their understanding through explanations, mathematical representations, and problem solving, directly supporting the indicators of applying concepts and presenting concepts in various mathematical representations. Finally, the Reflect how you have learned stage allows students to evaluate their strategies and understanding, strengthen conceptual connections, and recognize their own learning progress. Across these stages, self-efficacy is expected to influence students' persistence and participation, particularly when they encounter challenging exploratory and problem-solving activities (Maharani et al., 2023).

This condition is also found at Public Junior High School (SMP Negeri) 1 Bukit Kemuning. Based on preliminary research involving eighth-grade students, students' conceptual understanding was relatively low across several indicators. Table 1 reports the preliminary test results.

Table 1. Results of the Initial Test of Mathematical Conceptual Understanding

No	Concept Understanding Indicators	Class VIII 1		Class VIII 2	
		< 70	≥ 70	< 70	≥ 70
1	Restating a concept	14	18	17	15
2	Classify objects according to concept criteria	22	10	23	9
3	Applying concepts algorithmically	24	8	22	10
4	Presenting concepts in various mathematical representations	16	16	18	14
5	Connecting different mathematical concepts	27	5	28	4

Note: <70 = students who did not reach the minimum mastery criterion; ≥70 = students who reached the minimum mastery criterion.

Table 1 indicates that students performed weakest in connecting different mathematical concepts and applying concepts algorithmically. Interviews with mathematics teachers also revealed that students tended to memorize formulas rather than develop an in-depth understanding of the concepts. Conventional approaches still dominated mathematics learning, while technology-based media, including GeoGebra, had not yet been used consistently in the learning process. The teacher also reported that some students showed limited confidence when solving mathematical problems that required reasoning and exploration. These conditions indicate the need for learning that simultaneously promotes active conceptual construction, dynamic visualization, and students' confidence in solving mathematical problems.

Although previous studies have examined the MASTER model, GeoGebra, and self-efficacy in mathematics learning, studies integrating these components in a single factorial framework remain limited. Previous research has predominantly focused on mathematical literacy, mathematical connections, learning motivation, or conceptual understanding without simultaneously examining differences in self-efficacy levels and their interaction with instructional conditions (Ardiani et al., 2021). Therefore, this study extends previous research by examining mathematical conceptual understanding across three self-efficacy levels, high, medium, and low, within a 3 × 3 factorial design involving three instructional conditions. The study focuses on junior high school students learning circle material, where they can explore conceptual relationships and visual representations through GeoGebra.

Based on this framework and research gap, this study seeks to: (1) examine differences in students' mathematical conceptual understanding across instructional conditions involving the GeoGebra-assisted MASTER learning model; (2) examine differences in mathematical conceptual understanding across self-efficacy levels; and (3) investigate whether an interaction

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exists between the GeoGebra-assisted MASTER learning model and self-efficacy in relation to students' mathematical conceptual understanding.

METHODS

This research employed a quantitative approach using a quasi-experimental design. The study employed a 3 × 3 factorial design involving three instructional conditions and three levels of self-efficacy to examine differences in students' mathematical conceptual understanding and the interaction between these factors. The collected data were analyzed using two-way ANOVA with a significance level of 5% (Noferina et al., 2021).

The study was conducted at Public Junior High School (SMP Negeri) 1 Bukit Kemuning during the second semester of the 2025/2026 academic year. The study population included all eighth-grade students, while three classes were selected as the sample through cluster random sampling.

The study examined the GeoGebra-assisted MASTER learning model and self-efficacy as independent variables, with students' mathematical conceptual understanding as the dependent variable. Based on the questionnaire scores, students' self-efficacy was grouped into high, medium, and low categories. The research used primary data collected directly from the students. The instruments comprised a descriptive test measuring mathematical conceptual understanding and a self-efficacy questionnaire. The instruments underwent validity and reliability testing before administration.

The mathematical conceptual understanding test was developed according to the following indicators: (1) restating a concept; (2) classifying objects according to concept criteria; (3) applying concepts algorithmically; (4) presenting concepts in various mathematical representations; and (5) connecting various mathematical concepts (Nurfad et al., 2025).

Meanwhile, the questionnaire indicator is self-efficacy. It comprises three dimensions: magnitude, generality, and strength. (1) The magnitude dimension concerns students' confidence in their ability to accomplish a particular task and their motivation to take the necessary steps to complete it; (2) The generality aspect is related to the students' confidence to complete tasks in a broad and specific scope, as well as the confidence in completing various types of tasks or mathematical materials in different situations; and (3) the strength aspect is related to the students' confidence to work hard, perseverance, and persistence, as well as the ability to face obstacles and difficulties in the problem-solving process (Nu'man et al., 2025).

The instructional intervention addressed circle geometry and was implemented over five sessions in each class, with each session lasting 2 × 45 minutes. Experimental Class 1 used the GeoGebra-assisted MASTER model, Experimental Class 2 used the MASTER model without GeoGebra, and the control class followed conventional instruction. The learning materials covered the elements of circles, circumference and area of circles, and the relationship between central and inscribed angles. In Experimental Class 1, GeoGebra facilitated visualisation and exploration of circle concepts throughout the MASTER learning stages. The instructional procedures were implemented consistently across the five sessions according to the assigned learning model.

The data collection technique was carried out through tests and questionnaires. Concept comprehension data were obtained through a posttest, while self-efficacy data were obtained through questionnaires. The collected data were analyzed with SPSS. Before testing the research hypotheses, we conducted normality and homogeneity tests as prerequisite analyses. Furthermore, hypothesis testing was carried out using Two-Way ANOVA to determine the influence of each variable and the interaction between variables.

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RESULTS

Based on the data collected during the study, students' ability to understand mathematical concepts was assessed through a final test (posttest). In contrast, data regarding students' self-efficacy were gathered using questionnaires. The study involved three learning groups: experimental class I, which learned using the MASTER model assisted by the GeoGebra application; experimental class II, which learned using the MASTER model without GeoGebra; and the control class, which received conventional instruction. The following table shows descriptive statistics for students' mathematical concept understanding and self-efficacy.

Table 2. Descriptive Statistics of Students' Ability to Understand Mathematical Concepts

	Descriptive Statistics					
	N	Range	Minimum	Maximum	Mean	Std. Deviation
Experimental 1	32	31	66	97	81.03	8.612
Experimental 2	32	25	59	84	71.16	7.265
Control	32	31	44	75	59.94	9.840

Table 2 shows that Experimental Class I had a higher mean score in mathematical concept understanding than Experimental Class II and the Control Class. The mean score was 81.03 for Experimental Class I, compared with 71.16 for Experimental Class II and 59.94 for the Control Class. These findings indicate that students who received GeoGebra-assisted MASTER instruction achieved a higher level of mathematical concept understanding than those in the other classes.

Table 3. Descriptive Statistics: Self-Efficacy of Students

	Descriptive Statistics					
	N	Range	Minimum	Maximum	Mean	Std. Deviation
Experimental 1	32	21	61	82	72.44	5.168
Experimental 2	32	18	61	79	70.47	5.376
Control	32	22	56	78	67.63	5.428

Based on Table 3, the highest average self-efficacy was found in experimental class I (72.44), followed by experimental class II (70.47) and the control class (67.63). These results showed that students in the experimental classes had higher self-confidence than students in the control class. Self-efficacy was analyzed as a three-level factor consisting of low, medium, and high categories. Table 4 presents the distribution of students across the instructional groups.

Table 4. Distribution of Students by Instructional Group and Self-Efficacy Category

	Descriptive Statistics			
	Low	Medium	High	Total
Experimental 1	3	19	10	32
Experimental 2	5	21	6	32
Control	8	22	2	32
Total	16	62	18	96

Based on Table 4, most students were categorized as having a moderate level of self-efficacy (62 of 96). In contrast, 16 students had a low level of self-efficacy, and 18 demonstrated a high level of self-efficacy. The number of students in each self-efficacy category varied across the three instructional groups. To further examine the descriptive pattern of mathematical conceptual understanding across the combinations of instructional group and self-efficacy level, a 3 × 3 factorial descriptive analysis was performed. Table 5 presents the findings.

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Table 5. Descriptive Statistics of Mathematical Conceptual Understanding by Instructional Group and Self-Efficacy

Descriptive Statistics

Dependent Variable: Conceptual Understanding

Learning Model	Self Efficacy	Mean	Std.Deviation	N
MASTER Assisted by GeoGebra	Low	68.00	1.732	3
	Medium	77.53	4.389	19
	High	91.60	3.098	10
	Total	81.03	8.612	32
MASTER	Low	60.60	2.191	5
	Medium	70.86	4.788	21
	High	81.00	1.897	6
	Total	71.16	7.265	32
Conventional	Low	47.38	2.504	8
	Medium	63.14	6.958	22
	High	75.00	.000	2
	Total	59.94	9.840	32
Total	Low	55.38	8.928	16
	Medium	70.16	8.045	62
	High	86.22	6.899	18
	Total	70.71	12.168	96

Based on Table 5, the mean score of mathematical conceptual understanding increased across the low, medium, and high self-efficacy categories within each instructional group. In the MASTER + GeoGebra group, the mean scores were 68.00 for students with low self-efficacy, 77.53 for students with medium self-efficacy, and 91.60 for students with high self-efficacy. In the MASTER group, the corresponding mean scores were 60.60, 70.86, and 81.00, respectively. In the conventional group, the mean scores were 47.38, 63.14, and 75.00, respectively.

Students with high self-efficacy in the MASTER + GeoGebra group had the highest mean score (M = 91.60, SD = 3.098). In contrast, students with low self-efficacy in the conventional group had the lowest mean score (M = 47.38, SD = 2.504). Although these descriptive patterns suggest differences across instructional groups and self-efficacy levels, inferential analysis was required to determine whether these differences were statistically significant.

Before hypothesis testing, the data on the ability to understand mathematical concepts were tested for normality and homogeneity as a condition for using two-way analysis of variance. Table 6 presents the normality test results.

Table 6. Results of the Normality Test of Concept Understanding

Tests of Normality

	Classes	Kolmogorov-Smirnova			Shapiro-Wilk		
		Statistic	df	Say.	Statistic	df	P
Concept Understanding	Experimental 1	.138	32	.129	.957	32	**.224**
	Experimental 2	.108	32	.200*	.952	32	**.161**
	Control	.106	32	.200*	.941	32	**.081**

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According to Table 6, the significance values from the normality test for Experimental Class I, Experimental Class II, and the Control Class were 0.224, 0.161, and 0.081, respectively. Because all significance values exceeded 0.05, the data on students' ability to understand mathematical concepts in the three groups can be considered normally distributed and therefore meet the normality assumption for subsequent analysis.

Table 7. Results of the Homogeneity Test for Concept Understanding

Test of Homogeneity of Variance					
		Levene Statistic	df1	df2	P
Concept Understanding	Based on Mean	2.326	2	93	**.103**
	Based on Median	2.094	2	93	.129
	Based on Median and with adjusted df	2.094	2	89.514	.129
	Based on trimmed mean	2.334	2	93	.103

As indicated in Table 7, the significance value based on the mean is 0.103. Since the Sig. value is greater than the P value of 0.050, the data can be regarded as homogeneous.

Hypothesis Testing

Once the data satisfied the assumptions of normality and homogeneity, hypothesis testing was performed using a two-way analysis of variance (Two-Way ANOVA). The analysis examined the influence of learning models on students' ability to understand mathematical concepts, the effect of self-efficacy on this ability, and the interaction between learning models and self-efficacy. Table 8 summarizes the hypothesis-testing results.

Table 8. Hypothesis Test Results

Tests of Between-Subjects Effects

Dependent Variable: Pemahaman Konsep

Source	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	12070.459[a]	8	1508.807	65.785	.001
Intercept	256792.580	1	256792.580	11196.373	.001
Learning Model	2316.501	2	1158.250	50.501	**.001**
Self_Efficacy	3612.154	2	1806.077	78.746	**.001**
Learning Model * Self_Efficacy	150.812	4	37.703	1.644	**.170**
Error	1995.374	87	22.935		
Total	494034.000	96			
Corrected Total	14065.833	95			

a. R Squared = .858 (Adjusted R Squared = .845)

Based on Table 8, students' mathematical conceptual understanding differed significantly among the instructional conditions, F (2, 87) = 50.501, $p < .001$, partial $\eta^2 = .537$. Therefore, the first hypothesis was accepted.

A significant difference was also found in students' mathematical conceptual understanding across different levels of self-efficacy, F (2, 87) = 78.746, $p < .001$, partial $\eta^2 =$ .644. Thus, the second hypothesis was accepted.

However, the interaction between instructional condition and self-efficacy was not statistically significant, $F(4, 87) = 1.644$, $p = .170$. Thus, the third hypothesis was rejected.

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Overall, the results indicate significant differences in mathematical conceptual understanding across instructional conditions and self-efficacy levels, but no significant interaction between the two factors.

DISCUSSION

The Effect of the GeoGebra-Assisted MASTER Learning Model on Students' Understanding of Mathematical Concepts

The results indicate that students' understanding of mathematical concepts differed significantly across the three instructional conditions: Experimental Class 1, Experimental Class 2, and the Control Class. Experimental Class 1 was taught using the GeoGebra-assisted MASTER learning model, whereas Experimental Class 2 used the MASTER learning model without GeoGebra, and the Control Class was taught through conventional instruction. The higher posttest performance of Experimental Class 1 suggests that integrating GeoGebra into the MASTER learning model may help enhance students' understanding of mathematical concepts.

This result may be attributed to the characteristics of the MASTER learning model, which encourages students to participate actively throughout the learning process. Through the stages of motivation, acquisition, exploration, triggering, presentation, and reflection, students do not merely receive information from the teacher; they are also encouraged to explore ideas, discuss, communicate, and reflect on their understanding. (Nazilah & Amir, 2025). Incorporating GeoGebra can further support this process by allowing students to interact with and dynamically modify mathematical representations. Previous studies have likewise indicated that integrating GeoGebra into instruction can enhance students' conceptual understanding, especially when it is incorporated into activities that promote exploration and active participation (Gurmu et al., 2024).

The results of the present study are in line with the findings of Hidayat et al. (2024), who reported that GeoGebra use is related to students' conceptual understanding and engagement in learning mathematics. Likewise, Juandi et al. (2025) reported that learning supported by GeoGebra can facilitate the development of students' conceptual understanding through an approach centered on active participation and knowledge construction. These findings suggest that GeoGebra's advantages extend beyond displaying mathematical visualisations, as it also enables students to investigate relationships between different representations and develop understanding through active learning activities.

Nevertheless, interpret the results of this study with caution. This study used a quasi-experimental design involving three intact classes and did not administer a pretest to assess students' mathematical conceptual understanding. Consequently, it cannot be entirely excluded that the three classes differed in their initial levels of ability. Furthermore, factors such as classroom characteristics, interactions among students, learning habits, prior experiences, and variations in teachers' instructional practices may have influenced the posttest outcomes (Haslinda et al., 2021; Farida et al., 2025). Differences in treatment implementation may also have occurred during the five instructional sessions. Thus, the findings are better understood as evidence supporting the implementation of the GeoGebra-supported MASTER learning model under the conditions of this study, rather than as evidence that the intervention alone caused all differences in learning outcomes.

The Effect of Self-Efficacy on Students' Understanding of Mathematical Concepts

The second finding indicates that self-efficacy significantly influences students' understanding of mathematical concepts. Students with higher self-efficacy tend to have stronger beliefs in their ability to complete mathematical tasks. These beliefs may be associated with students' willingness to face challenging tasks, maintain effort when experiencing

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difficulties, and remain engaged in the learning process. A review of research on mathematics self-efficacy indicates that self-efficacy is associated with students' learning behaviour and mathematical performance (Street et al., 2024).

This finding is also supported by research that specifically examines the association between self-efficacy and students' understanding of mathematics. Rajab et al. (2024) reported an association between self-efficacy and students' abilities in understanding mathematical concepts. In addition, Wulandari et al. (2026) showed a connection between self-efficacy and students' understanding of mathematical concepts. These findings support the idea that affective aspects, such as beliefs about one's own ability, need to be considered when explaining differences in students' mathematical conceptual understanding.

In this study, the self-efficacy questionnaire was administered before the instructional intervention. Therefore, the high, medium, and low self-efficacy categories represented students' initial conditions before receiving the treatment. This provides a stronger basis for comparing conceptual understanding according to self-efficacy levels because the measurement was not conducted after students experienced the instructional treatment. Nevertheless, a self-report questionnaire still has limitations because students' responses depend on their perceptions of their own abilities. In addition to self-efficacy, factors such as prior mathematical ability, learning motivation, and previous knowledge or learning experiences may also be associated with students' mathematical understanding and learning outcomes (Rianto et al., 2022; Mutammimah et al., 2026).

Interaction of the Learning Model with Self-Efficacy

The findings show that the interaction between instructional condition and self-efficacy was not statistically significant. This result does not mean the GeoGebra-assisted MASTER learning model is equally effective across self-efficacy categories. Rather, it indicates that the study found insufficient statistical evidence that differences in outcomes among the three instructional conditions varied significantly by students' self-efficacy levels.

Several conditions may influence the absence of a significant interaction. First, the number of students in some combinations of instructional conditions and self-efficacy categories was relatively limited, which may reduce statistical power to detect an interaction (Sommet et al., 2023). Second, dividing self-efficacy into high, medium, and low categories may reduce the information contained in the original scores (Verhulst & Neale, 2021). Third, measurement error in the questionnaire may increase variation in the data, making the interaction effect more difficult to detect (Sommet et al., 2023).

In addition to statistical factors, differences among the classes should also be considered. The study involved three different classes, meaning that class characteristics, student interactions, learning conditions, and teacher delivery may not have been the same. Differences in the implementation of the MASTER stages and the use of GeoGebra may also have produced additional variation in learning outcomes. Therefore, the non-significant interaction should not be interpreted as evidence that self-efficacy has no moderating role. Instead, it indicates that this study did not find sufficient statistical evidence of differences in the effects of the instructional conditions across self-efficacy levels.

Study Implications and Limitations

Overall, the results indicate that both instructional condition and self-efficacy were significantly related to students' understanding of mathematical concepts, whereas their interaction was not statistically significant. These results indicate that learning that combines an active instructional structure with mathematical technology can be an alternative approach for supporting conceptual understanding (Hidayat et al., 2024). However, GeoGebra should not

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be viewed as the only factor determining learning success because learning outcomes may also be influenced by student, teacher, and class characteristics (Izdahara & Irvan, 2025).

Several limitations should be considered when interpreting the results of this study. First, this study did not use a pretest of students' mathematical conceptual understanding. Therefore, differences in students' initial abilities among the three classes could not be fully determined. Second, this study involved three different classes, so possible class and teacher effects should be considered. This is because teachers' instructional practices can be related to students' mathematics learning outcomes (Viryanto & Kismiantini, 2024). Third, the treatment may not have been implemented in exactly the same way in every instructional session. Therefore, consider differences in treatment implementation when interpreting the findings (van Dijk et al., 2023). Fourth, although self-efficacy was measured before the treatment, grouping the scores into three categories may reduce the information available for detecting interactions (Williamson et al., 2022). In addition, self-report questionnaires may affect data quality because students' responses may not fully reflect their actual conditions (Chauliac et al., 2023).

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Future research should use larger samples with more balanced numbers of students in each factorial cell. Pretests of mathematical conceptual understanding and self-efficacy can also provide information about students' initial conditions. In addition, researchers should systematically monitor treatment implementation to ensure each instructional condition is applied consistently. Self-efficacy may also be analyzed as a continuous variable so that information from students' original scores is retained and its potential moderating role can be examined more effectively.

CONCLUSIONS AND SUGGESTIONS

Students in the GeoGebra-assisted MASTER class obtained the highest posttest mean, followed by students in the MASTER-only and conventional classes. The omnibus analysis indicated statistically significant differences in mathematical conceptual understanding across instructional conditions and self-efficacy categories, but no statistically significant interaction. However, the absence of a comparable baseline and the use of one class per instructional condition limit causal interpretation. Therefore, the observed differences should not be attributed solely to the instructional model.

Future studies should include comparable pretests, larger and more evenly distributed samples across the nine factorial cells, and multiple classes per instructional condition to reduce potential class effects. Researchers should also consider teacher effects and treatment fidelity, and preferably measure self-efficacy before the intervention. These improvements may provide stronger evidence regarding differences in mathematical conceptual understanding across instructional conditions and self-efficacy levels.

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