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Effects of 7E's Model on Misconceptions and Achievement in Algebraic concept among Secondary School Students' in Sokoto State, Nigeria

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Abstract

This study investigated the Effects of 7E's Model on Misconceptions and Achievement in Algebraic concept among Secondary School Students' in Sokoto State, Nigeria. The study employed a non-randomized control group, pretest-posttest quasi-experimental design, with the population of 22,173 SSII students from all public senior secondary schools in Sokoto Education Zones excluding gwaranyo and gwadabawa education zones due to security concern. From these, a sample of 378 SSII students drawn from four public senior secondary schools in Sokoto Education Zones (Sokoto North, Sokoto South, Bodinga, and Yabo) through stratified random sampling. Simple random sampling technique was used to select one school from each zone. Students Algebraic Achievement Test (SAAT; Validity = 0.93, reliability = 0.71) and the 5-Tier Students' Algebraic Misconception Test (SAMT; Validity = 0.97, reliability = 0.92) were used for data collection. Mean, Standard deviation, percentages, and frequencies were used to answer research questions, while the One-way ANOVA was used to analyze hypothesis at a 0.05 significance level. Findings revealed that students taught using the 7E's Model demonstrated significantly greater improvement in achievement and reduction of misconceptions compared to those in the Peer Tutoring and Demonstration method groups. 7E's Model is the most effective of the three approaches and recommends its regular integration into algebra instruction to foster deeper conceptual understanding and minimize misconceptions. Future research should be extended to different states in Nigeria and over longer instructional periods to test the generalizability and long-term effects of the 7E's Model and Peer Tutoring.

Keywords: Achievement, Misconceptions, Instructional Modules, 7E's Model, peer tutoring.

Introduction

Algebra is a central component of mathematics that supports logical reasoning, abstract thinking, and problem-solving (Kaput, 2017). It is globally recognized as a gateway to advanced mathematical knowledge and a foundational requirement for careers in science, technology, engineering, and mathematics (STEM) (Alam & Mohanty, 2024). Through algebra, students learn to develop generalizations, recognize patterns, and make transitions from concrete arithmetic operations to more complex and abstract mathematical representations (Demonty, Vlassis & Fagnant, 2018). Beyond the academic domain, algebra also enhances critical thinking and decision-making abilities, which are essential in everyday situations involving budgeting, planning, and data interpretation (Asekun, 2023). In today's rapidly evolving global workforce, proficiency in algebra is increasingly seen as a prerequisite for innovation and digital literacy, forming the backbone of computational thinking in the 21st century (Sarmasági, Rumbus, Pluhár & Margitay-Brecht, 2023). In view of this, Nigeria considers Algebra as one of the component of mathematics curriculum. Learning algebra in spiral in nature as it cut across all the levels of education from basic level to senior secondary school (NERDC), as well as Science related areas. In spite



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of all, many Nigerian students specifically Sokoto State students still struggle with learning Algebraic content, largely due to persistent misconceptions in solving algebraic problems and dominance of teacher-centered instructional methods (Sezuni, 2022; Ray, 2024). Such pedagogical limitations have led to persistent misconceptions and poor performance in algebra. Literature indicates the problem of rote learning; use of traditional approach (Ginga & Zakariya, 2020). WAEC Chief Examiners' Reports (2020–2024) affirmed these difficulties are linked to the lack of basic algebra skills, rote memorization, and ineffective teaching strategies. Moreover, misconceptions are faulty understandings about algebraic concepts, such as seeing the equal sign only as a signal for calculation, mistaking variables for labels, or wrongly applying arithmetic rules in algebra. For instance, students may treat $3a + 4$ as $7a$ or incorrectly cancel terms in expressions. These errors hinder abstract reasoning and generalization, blocking deeper understanding of algebra. Research emphasizes that overcoming such challenges requires targeted teaching approaches that foster conceptual understanding and help students confront and correct their misconceptions. Effective strategies include the 7E's model and Peer Tutoring.

The 7E's model (Elicit, Engage, Explore, Explain, Elaborate, Evaluate, and Extend) is a constructivist-based instructional framework that promotes active learning and inquiry. It enables learners to build new knowledge from their prior understanding and experiences (Sewanu, 2022). Similarly, peer Tutoring a strategy in which students work together in pairs or small groups to support each other's learning (Topping, Buchs, Duran & Van Keer, 2017). In peer tutoring, the "tutor" explains concepts, solves problems with the "tutee," and provides feedback, while the tutee asks questions, clarifies doubts, and attempts similar problems (Abdurrahman, Abdullah, Osman, Ali, Samah, Jumaat & Kohar, 2019; Abdurrahman, 2021). This study was designed to address gaps in teaching Algebraic content. The 7E's Model and Peer Tutoring served as experimental strategies, while the Demonstration Method represented the traditional classroom approach. The study draws on relevant literature and is guided by three key theories: Vygotsky's Social Constructivism Theory, which stresses social interaction, scaffolding, and cultural context; Bandura's Social Learning Theory, which highlights observation, imitation, and peer influence; and Kolb's Experiential Learning Theory, which emphasizes learning through experience, reflection, and experimentation. The findings are expected to benefit students, mathematics teachers, and other educational stakeholders. Therefore, the present study used the 7E's Model, Peer Tutoring, and the Demonstration Method to alleviate students' misconceptions and improve their achievement in learning algebra.

Research Objectives

This research aims to examine the Effect 7E's model as alternatives to the traditional Demonstration Method, to alleviate misconceptions and enhance achievement in algebra among Senior Secondary School students in Sokoto State.

The specific objectives are to:

1. Find out the misconceptions of students in solving algebraic problems after using the three independent instructional strategies (7E's, Peer tutoring, and Demonstration method) among senior secondary school students in Sokoto State.
2. Find out the difference in the mean achievement scores of students taught using the three independent instructional strategies (7E's, Peer tutoring, and Demonstration method) among senior secondary school students in Sokoto State.

Research Questions

Based on the stated objectives, the study raised the following questions and hypotheses;

1. What are the misconceptions of students in solving algebraic problems after using the three independent instructional strategies (7E's, Peer tutoring, and Demonstration method) among senior secondary school students in Sokoto State?
2. Is there any difference in the mean achievement scores of students taught using the three independent instructional strategies (7E's, Peer tutoring, and Demonstration method) among senior secondary school students in Sokoto State?

Research Hypothesis

The null hypothesis was formulated and tested at $\alpha = 0.05$ level of significance.

H₀₁: There is no significant difference in the mean achievement scores of students taught using the three independent instructional strategies (7E's, Peer tutoring, and Demonstration method) among senior secondary school students in Sokoto State.

Methodology

This study employed a non-randomized control group, pretest–posttest quasi-experimental design. The population comprised all Senior Secondary School Two (SSII) students in public schools across Sokoto State Education Zones.



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However, due to security concerns, Goronyo and Gwadabawa Education Zones were excluded, leaving a study population of 22,173 students across 92 schools in four zones: Sokoto North, Sokoto South, Bodinga, and Yabo. A stratified random sampling technique was used to ensure fair representation from each education zone. The sample was proportionally distributed across the zones in Table 1.

Table 1 Sample of the Study

S/N	Zones	Name of School	No. of Students
1	Sokoto North	School A (EXP2)	90
2	Sokoto South	School B (EXP1)	169
3	Bodinga	School C (CONT)	56
4	Yabo	School D (CONT)	63
Total			378

Source: (Krejcie and Morgan, 1970)

From each zone, one school was randomly selected. The selected schools were then randomly assigned to two experimental groups and one control group. Within each school, SSII intact classes were randomly chosen to participate in the study, thereby preserving the natural classroom setting and minimizing disruptions. Two instruments were used for data collection in this study: the Students Algebraic Achievement Test (SAAT) and the 5-Tier Students Algebraic Misconception Test (SAMT). The SAAT was used to measure students' achievement in algebraic processes. It consisted of 35 objective test items adopted from past examination questions (WAEC and NECO) as well as recommended mathematics textbooks. Each item had four options (A–D), with one correct answer carrying one mark, giving a maximum score of 35 marks. While, the SAMT was a five-tier diagnostic test adapted to explore students' deeper understanding of algebraic concepts and identify common misconceptions. It assessed students across multiple dimensions, including correctness of answers, confidence level, and conceptual reasoning. This enabled a comprehensive diagnosis of learning difficulties beyond surface-level performance. To establish validity and reliability, both instruments were reviewed by experts in mathematics education and subjected to a pilot study with 40 students. The analysis yielded (Validity=0.93; Reliability=0.71 for SAAT and Validity=0.97; Reliability=0.92 for SAMT), confirming their suitability for the main study. A pretest was administered to determine the equivalence of groups before treatment. The treatment lasted for six weeks, after which a posttest was conducted using the same instruments to evaluate the effectiveness of the instructional strategies. After marking session, the scores obtained from the study were subjected to analysis using SPSS package. Descriptive statistics of (mean, standard deviation, percentages and frequencies) to answer research questions, while One-way ANOVA was used to test the null hypothesis at $\alpha = 0,05$ level of significance.

Research Question 1

What are the misconceptions of students in solving algebraic problems after using the three independent instructional strategies (7E's, Peer tutoring, and Demonstration method) among senior secondary school students in Sokoto State? The result of the analysis is presented in table 3, 4, 5 and 6 respectively.

Table 3: Levels of Misconception among Students Taught Using the 7E's Instructional Model

S/N	Decision	Frequency	Percentages
1	AC	124	73%
2	AAC	19	11%
3	LC	3	2%
4	LK	5	3%
5	MC	6	4%
6	HNC	12	7%
Total		169	100%

Source: (Field work/SPSS output, 2025)

Table 3 shows that among the 169 students taught using the 7E's instructional model, only a few exhibited misconceptions: 6 (4%) had misconceptions (MC), 5 (3%) showed lack of knowledge (LK), 3 (2%) lacked confidence (LC), and 12 (7%) had no conception (HNC). In contrast, 124 students (73%) demonstrated no misconceptions, while 19 (11%) showed only minor errors. This indicates that the 7E's instructional model was highly effective in reducing algebra-related misconceptions and enhancing students' understanding of algebraic concepts, as further illustrated in Figure 1.

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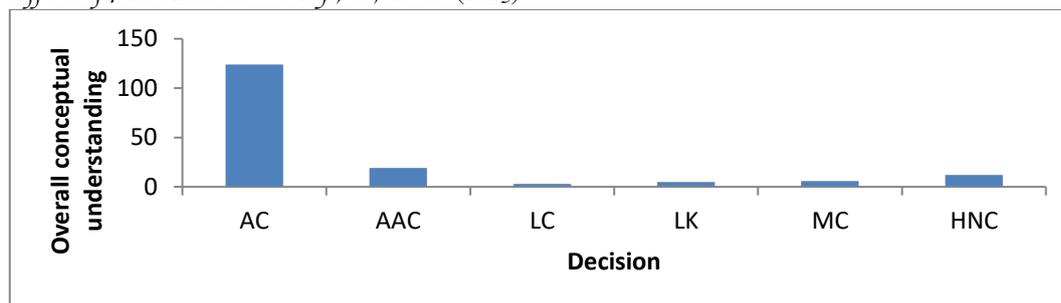


Figure 1: Students taught using the 7E's Model Levels of Misconception in Algebraic processes

Table 4: Levels of Misconception among Students Taught Using Peer Tutoring Instructional Strategy

S/N	Decision	Frequency	Percentages
1	AC	20	22%
2	AAC	16	18%
3	LC	6	7%
4	LK	7	8%
5	MC	19	21%
6	HNC	22	24%
Total		90	100%

Source: (Field work/SPSS output, 2025)

Table 4 show that only a small portion of students (22%) taught with the Peer Tutoring Instructional Strategy had no algebra-related misconceptions, meaning they clearly understood the concepts. Another 18% had minor misconceptions, showing partial understanding. However, a large number of students (21%) demonstrated clear misconceptions in their reasoning, while 24% had no meaningful understanding of algebra at all. Others lacked confidence (7%) or basic knowledge (8%) to solve problems accurately. These results indicate that while Peer Tutoring helped some students reduce their misconceptions, it was not equally effective for all. The method may need better structure or support to help students tackle more complex algebraic ideas.

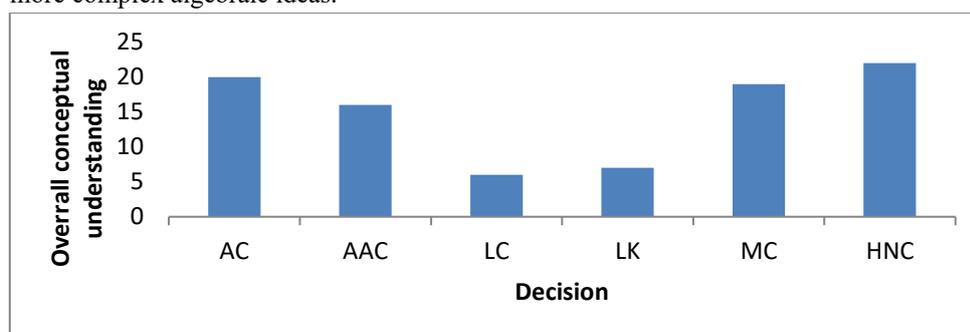


Figure 2: Misconception Levels among Students Taught with Peer Tutoring

Table 5: Levels of Misconception among Students Taught Using the Demonstration Method

S/N	Decision	Frequency	Percentages
1	AC	6	5%
2	AAC	10	8%
3	LC	10	8%
4	LK	21	18%
5	MC	32	27%
6	HNC	40	34%
Total		119	100%

Source: (Field work/SPSS output, 2025)

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Table 5 shows the levels of algebra-related misconceptions among students taught using the Demonstration Method (Control Group). Only 6 students (5%) had no misconception, meaning they fully understood the algebraic concepts. A small portion (8%) showed minor misconceptions. However, a large number of students struggled significantly: 32 students (27%) demonstrated clear misconceptions in their reasoning, and 40 students (34%) had no conception at all indicating a serious lack of understanding. Additionally, 21 students (18%) lacked the necessary foundational knowledge, and 10 students (8%) showed a lack of confidence in applying what they learned. These results reveal that the Demonstration Method was the least effective in minimizing algebra misconceptions.

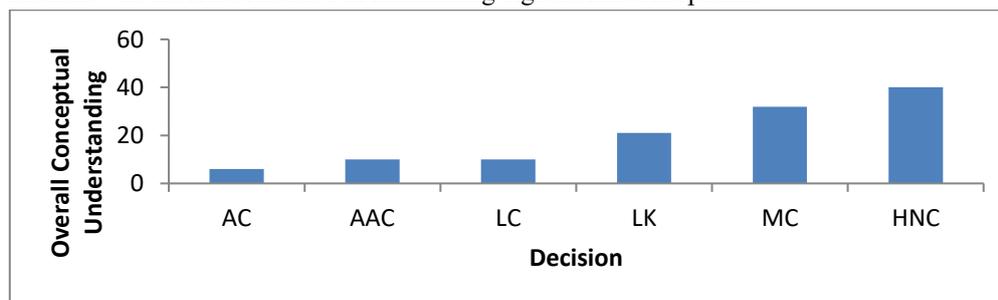


Figure 3: Misconception Levels among Students Taught with the Demonstration Method

Table 6: Summary of Students' Misconceptions across the Three Instructional Strategies

S/N	Decision	7E's		Peer Tutoring		Demonstration	
		Frequency	%	Frequency	%	Frequency	%
1	AC	124	73%	20	22%	6	5%
2	AAC	19	11%	16	18%	10	8%
3	LC	3	2%	6	7%	10	8%
4	LK	5	3%	7	8%	21	18%
5	MC	6	4%	19	21%	32	27%
6	HNC	12	7%	22	24%	40	34%
	Total	169	100%	90	100%	119	100%

Source: (Field work/SPSS output, 2025)

Table 6 presents students' levels of misconceptions across the three instructional strategies: 7E's Model, Peer Tutoring, and Demonstration Method. The 7E's Model produced the fewest misconceptions, with only 4% of students showing clear misconceptions and 7% lacking understanding, indicating its strong effectiveness in promoting accurate algebraic reasoning. Peer Tutoring showed moderate success, with 21% demonstrating misconceptions and 24% lacking understanding, suggesting that while it supported peer interaction, some students still faced conceptual challenges. The Demonstration Method recorded the highest misconceptions (27%) and lack of understanding (34%), reflecting the weaknesses of teacher-centered instruction in addressing learning difficulties. Figure 4 visually confirms the clear advantage of the 7E's Model over the other teaching methods.

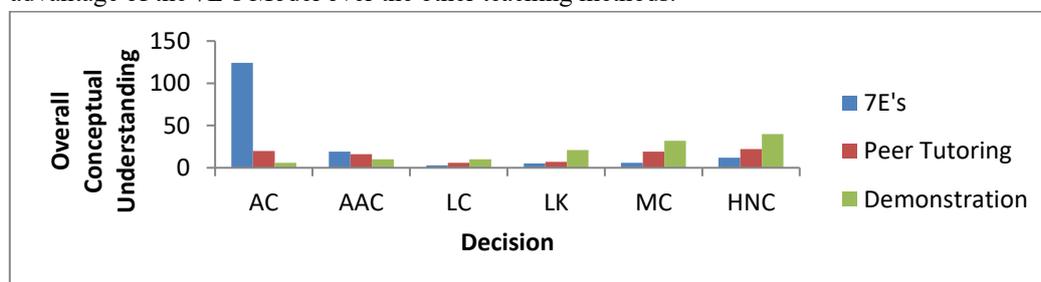


Figure 4: Comparison of Students' Misconception Levels by Instructional Strategy

Figure 4 visually compares how students across the three groups performed in terms of misconception levels. The 7E's Model produced the fewest misconceptions and highest accurate reasoning, confirming its effectiveness in promoting deep understanding. Peer tutoring showed moderate success, with noticeable improvement but still a high number of students misunderstanding algebraic concepts. The Demonstration Method had the most misconceptions, indicating that students taught through traditional lecture-based methods were more likely to misunderstand or fail to grasp the concepts.



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Research Question 2

Is there any difference in the algebraic mean achievement scores of students taught using the three independent instructional strategies (7E's, Peer tutoring, and Demonstration method) among senior secondary school students in Sokoto State? The result of the analysis is presented in Table 7.

Table 7: Means and Standard Deviation of Achievement Scores of Students taught using the Three Independent Instructional Strategies

Variable	N	Mean	SD	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
7E's Model	169	23.81	6.811	.524	22.78	24.85
Peer Tutoring	90	16.34	7.276	.767	14.82	17.87
Demonstration Method	119	10.26	5.257	.482	9.31	11.21
Total	378					

Source: (Field work/SPSS output, 2025)

The results in Table 7 show the mean scores and standard deviations of students' performance in the algebra achievement test after being taught using three different teaching methods. Students who were taught using the 7E's Model had the highest mean score ($M = 23.81$), meaning they performed better than the other two groups. This group had 169 students, and their scores were more spread out, with a standard deviation of ($SD = 6.81$). The Peer Tutoring group had a mean score of ($M = 16.34$) and a slightly higher spread of scores ($SD = 7.28$), showing more variation in how students performed. The Demonstration Method group had the lowest mean score ($M = 10.26$) and a standard deviation of ($SD = 5.26$), indicating that students in this group performed the least well overall compared to the other groups.

Null Hypothesis 1

There is no significant difference in the algebraic mean achievement scores of students taught using the three independent instructional strategies (7E's module, Peer tutoring, and Demonstration method) among senior secondary school students in Sokoto State. This null hypothesis was tested using inferential statistics of One-way ANOVA for post-test scores of the experimental and control groups. The result of the analysis is presented in Table 8.

Table 8: Summary of one-way ANOVA on Algebraic Mean Achievement Scores of Students taught using the Three Independent Instructional Strategies

Source of variance	Sum of Squares	Df	Mean Square	F	P
Between Groups	13060.326	2	6530.163	155.311	.000
Within Groups	15767.187	375	42.046		
Total	28827.513	377			

Source: (Field work/SPSS output, 2025)

Table 8 presents the results that $F(2,375) = (155.311)$ with a P-value of 0.001, which is less than the significant level of 0.05, this indicated that there is a statistically significance difference in the students achievement score among the three groups. Therefore, we reject the null hypothesis which stated that there is no significant difference in the algebraic mean achievement scores of students taught using the three independent instructional strategies (7E's module, Peer tutoring, and Demonstration method) among senior secondary school students in Sokoto State. Since a significant difference was found between the mean achievement scores of the three groups, the data was subjected to further analysis to discover where the difference exist using Scheffe's post hoc test in table 9.

Table 9: Scheffe's post hoc test

(I) treatment group	(J) Comparison group	Mean Difference (I-J)	F	P
7E's Model	Peer Tutoring	7.466*	155.311	.000
	Demonstration Method	13.550*		
Peer Tutoring	7E's Model	-7.466*		.000
	Demonstration Method	6.084*		
Demonstration Method	7E's Model	-13.550*		.000
	Peer Tutoring	-6.084*		

Source: (Field work/SPSS output, 2025)

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Table 9 presents the results of Scheffé's post hoc analysis conducted to identify where the specific differences occurred in students' mean achievement scores across the three instructional strategies: the 7E's Instructional Model, Peer Tutoring, and the Demonstration Method. The test followed a significant one-way ANOVA result. The comparison between the 7E's Model and Peer Tutoring showed a mean difference (MD) of 7.466, $F = 155.311$, and $p = .001$, indicating a significant difference in favour of the 7E's Model. Similarly, the comparison between the 7E's Model and the Demonstration Method revealed a mean difference of 13.550, also significant at $p = .001$, confirming that the 7E's Model was more effective. Lastly, the Peer Tutoring group outperformed the Demonstration Method group with a mean difference of 6.084, $p = .001$. Therefore, both the 7E's Model and Peer Tutoring were significantly more effective than the Demonstration Method in enhancing students' achievement in algebra. The 7E's Model produced the best results overall, confirming the superiority of constructivist and student-centered instructional approaches over traditional, teacher-centered methods. Consequently, the null hypothesis of no significant difference was rejected.

Summary of the Major Findings

This section presents a concise overview of the key findings derived from the research questions and hypotheses that guided the study;

1. Students taught using the 7E's Model showed the fewest misconceptions in algebra, indicating a stronger and clearer understanding of algebraic processes.
2. Students taught using the 7E's Instructional Model significantly demonstrate a better achievement in algebra.

Discussion of Findings

The findings from Research Question One revealed that students taught using the 7E's instructional model had the fewest misconceptions in algebra, indicating that this strategy effectively enhanced understanding and minimized common errors. In contrast, students taught through the Demonstration Method recorded the highest level of misconceptions, showing that the traditional, teacher-centered approach was less effective. Students in the Peer Tutoring group displayed a moderate level of misconceptions, meaning the method was beneficial but less impactful than the 7E's Model. This result aligns with previous research. For instance, Sule, Imoko, and Chianson (2024) found that students taught with the 7E's model performed better and had fewer misconceptions in algebra compared to those taught traditionally, likely due to its activity-based and student-centered nature. Similarly, Abdurrahman, Abdullah, and Osman (2020) observed that Peer Tutoring improved understanding as students clarified concepts to one another, while Anwer (2019) confirmed that activity-based learning enhances students' reasoning and problem-solving abilities. However, some studies contradict this finding. Nzekwe (2018) reported no significant difference between Peer Tutoring and the Demonstration Method, possibly due to poor implementation or inadequate student participation. Likewise, Cheron (2021) noted that the 7E's Model may be less effective when teachers lack proper training or when class sizes are large. These discrepancies could stem from variations in teacher competence, duration of treatment, or learning environments.

The findings revealed that students taught using the 7E's Model achieved the highest mean scores in algebra, followed by those taught through Peer Tutoring, while the Demonstration Method produced the lowest scores. This indicates that student-centered approaches enhance understanding and performance better than teacher-centered methods. The 7E's Model promotes active engagement and deeper conceptual learning through its structured phases, while Peer Tutoring supports learning through collaboration and feedback. These results align with studies by Likita (2023), Sule, Imoko, and Chianson (2023), and Wilujeng (2017), which found the 7E's Model to significantly improve students' achievement in mathematics. Similarly, Awofala and Agbolade (2022) reported that Peer Tutoring was more effective than traditional methods. However, contrary findings by Gurmu, Tuge, and Hunde (2024) and Adeagbo (2022) showed Peer Tutoring outperforming teacher-guided instruction, suggesting that its success depends on students' participation and group dynamics.

Conclusion

This study concludes that the 7E's instructional model is the most effective among the three instructional strategies (7E's Model, Peer Tutoring, and Demonstration Method) for improving students' achievement and reducing misconceptions in solving algebraic problems among senior secondary school students in Sokoto State. The 7E's model significantly outperformed the Peer Tutoring and Demonstration methods, promoting greater student engagement and a clearer



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understanding of algebraic concepts. These findings underscore the value of adopting learner-centered, inquiry-based instructional approaches over traditional teaching methods (such as demonstration) in addressing persistent learning difficulties in algebra.

Recommendations

1. Mathematics teachers should be trained and encouraged to regularly use the 7E's instructional model in teaching algebra, as it has been shown to improve student performance and deepen understanding. This can be achieved through well-organized workshops, seminars, and in-service training programs that equip teachers with the necessary skills for effective classroom implementation
2. School authorities and governments should provide necessary instructional materials and planning time to enable teachers to implement the 7E's model effectively.

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