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Gender Differences in Geometry Achievement: Effects of Scaffolding Instructional Strategies

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Abstract

Geometry is a critical branch of mathematics that develops spatial reasoning, logical thinking, and problem-solving skills. However, students frequently struggle with geometric concepts, resulting in poor achievement. This study investigated the effect of scaffolding instructional strategies on students' achievement in geometry, with a particular focus on gender differences. Using a quasi-experimental pre-test, post-test non-equivalent control group design, 243 senior secondary two students from four co-educational schools in Owerri, Imo State, Nigeria, were sampled. The experimental group (N = 113) was taught using scaffolding strategies, while the control group (N = 130) received conventional instruction. Data were collected via a validated Geometry Achievement Test (GAT) and analyzed using mean, standard deviation, and ANCOVA at a 0.05 significance level. Results showed that scaffolding significantly improved students' achievement compared to the conventional method. Gender, however, had no significant effect on achievement in the scaffolding group. The findings suggest that scaffolding strategies enhance geometry achievement effectively and equitably across male and female students. Implications for mathematics instruction are discussed.

Keywords: scaffolding, geometry, achievement, gender, secondary education

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Introduction

Geometry is a foundational component of mathematics education, essential for fostering logical reasoning, spatial awareness, and analytical problem-solving skills, which are critical for both academic success and real-world applications. Despite its significance, senior secondary students in many countries, including Nigeria, often encounter substantial difficulties in mastering geometric concepts, which frequently results in low achievement, poor retention, and diminished interest in mathematics (Aditi, 2017; Nwoke, 2017). Traditional instructional approaches, which remain prevalent in Nigerian classrooms, are predominantly teacher-centered. These methods emphasize rote learning and passive reception of knowledge, often limiting opportunities for active engagement, collaborative learning, and individualized support; factors that are crucial for deeper conceptual understanding in geometry.

To address these persistent challenges, scaffolding instructional strategies have beenwidely advocated. Established in Vygotsky's (1978) sociocultural theory, scaffolding emphasizes the provision of structured, contextually informed support tailored to a learner's Zone of Proximal Development (ZPD). The ZPD represents the range between what learners can achieve independently and what they can achieve with guidance. By offering strategic assistance that is gradually withdrawn as learners gain competence, scaffolding fosters autonomy, enhances understanding, and promotes long-term retention of concepts (Van de Pol, Volman, Oort, & Baishuzen, 2015). The theoretical underpinning aligns with constructivist perspectives, emphasizing that learning is socially mediated and that cognitive development is significantly shaped through interaction with more knowledgeable others (MKO).The More Knowledgeable Other (MKO) refers to an individual, often the teacher, who demonstrates a higher level of understanding, skill, or experience in a specific task or concept than the learner and provides the necessary guidance to facilitate learning within the learner's Zone of Proximal Development (ZPD).

Empirical research has consistently highlighted the efficacy of scaffolding across diverse educational contexts. For instance, Nwoke (2017) found that scaffolding significantly improved mathematics achievement among Nigerian secondary school students, suggesting its potential to address persistent learning gaps. Globally, several studies have supported this assertion. Aditi (2017) reported that scaffolding enhanced both achievement and attitudes toward science among high school students in India, while Stahr (2008) underscored its positive effects on web-based evaluation outcomes among US high school learners. In Iran, Ahangari, Hejazi, and Razmjou (2014) observed improved content retention among post-elementary EFL learners, and Van de Pol et al. (2015) noted increased engagement and task completion in Dutch social studies classrooms. Similarly, Casem (2013) highlighted improved mathematics performance and more positive learning attitudes among students in the Philippines. More recent studies (Nguyen, 2021; Alabi & Ogunleye, 2022; Kim & Lee, 2023) have emphasized scaffolding's role in promoting balanced learning opportunities, including mitigating gender disparities in mathematics outcomes.

Despite the robust evidence supporting scaffolding's effectiveness internationally, there remains a critical gap in the Nigerian context. In particular, the divergent impact of scaffolding on male and female students' geometry achievement at the senior secondary level has not been scientifically examined. This gap is significant given the persistent gender-based achievement disparities observed in mathematics in Nigeria and other developing contexts. Addressing this lacuna is essential not only for advancing theoretical understanding of scaffolding within

culturally specific educational contexts but also for informing practical strategies to enhance fairness and learning outcomes in mathematics classrooms.

Accordingly, this study seeks to examine the effect of scaffolding instructional strategies on the achievement of male and female students in geometry among senior secondary schools in Imo State, Nigeria. The study is guided by the following research questions and hypotheses:

Research Questions:

RQ1: What are the mean achievement scores of students taught geometry using scaffolding instructional strategy and those taught with the conventional method?

RQ2: What is the impact of gender on the mean achievement scores of students taught geometry using scaffolding instructional strategy?

Hypotheses:

HO1: There is no significant difference between the mean achievement scores of students taught geometry using scaffolding instructional strategy and those taught using the conventional approach.

HO2: There is no significant difference between the mean achievement scores of male and female students taught using scaffolding instructional strategy.

Methodology

A quasi-experimental pre-test, post-test non-equivalent control group design was adopted. The study population consisted of 29,613 Senior Secondary II (SS2) students from 65 government secondary schools in Owerri Educational Zone I, Imo State, Nigeria. A total of 243 students were selected via stratified random sampling and purposive sampling. The experimental group (N = 113) received scaffolding instruction, including questioning, reading strategies, modeling, and collaborative learning, while the control group (N = 130) received conventional teaching. The Geometry Achievement Test (GAT), a validated 25-item multiple-choice instrument with KR-20 reliability of 0.87, was used for data collection.

The experimental procedure began with a pre-test assessment to determine students' initial understanding, followed by a five-week teaching intervention. After the intervention, a post-test was administered to measure students' achievement. Data were analyzed using mean, standard deviation, and Analysis of Covariance (ANCOVA) at the 0.05 level of significance.

Data Analysis and Discussion

RQ1: Mean Achievement Scores of Scaffolding vs. Conventional Groups

Table 1: Mean Achievement Scores at Pre-Test and Post-Test

Teaching Method	N	Pre-Test (ẍ)	S	Post-Test (ẍ)	S	Mean Gain	Diff. in Mean Gain
Scaffolding (A)	113	24.21	3.90	62.43	2.77	38.22	35.16
Conventional (B)	130	23.97	3.52	27.03	4.26	3.06	

The scaffolding group exhibited a remarkable post-test mean of 62.43, compared to 27.03 in the conventional group. The mean gain difference of 35.16 indicates scaffolding significantly enhances achievement. The lower standard deviation in the scaffolding group (2.77) suggests consistent performance among students. This aligns with previous research demonstrating scaffolding's positive impact on mathematics achievement (Aditi, 2017; Nwoke, 2017; Alabi & Ogunleye, 2022).

HO 1: ANCOVA Analysis of Scaffolding vs Conventional Achievement

Table 2: ANCOVA F-Test Statistics for HO1

Source	Type III Sum of Squares	Df	Mean square	F	Sig.
Corrected Model	6181.427	2	3090.714	596.167	.000
Intercept	466.822	1	466.822	90.046	.000
Pre-test	.984	1	.984	.190	.664
Teaching Method	5696.260	1	5696.260	1098.749	.000
Error	409.561	240	5.184		
Total	62075.000				
Corrected Total	6590.988	242			

Interpretation: $F(1, 240) = 1098.749$, $p < .05$. Scaffolding significantly improves students' achievement; HO1 is rejected. The null-hypothesis is rejected, indicating a significant difference in post-test achievement scores between students taught using scaffolding and those taught conventionally, favoring the scaffolding group.

RQ2: Gender Impact on Achievement in Scaffolding Group

Table 3. Post-Test Mean Achievement Scores by Gender

Sex	N	Mean Score	S.D.	Diff. in Mean
Male	50	63.22	1.75	1.58
Female	63	61.64	2.23	

The results indicate that male and female students taught geometry using the scaffolding instructional strategy achieved comparable post-test mean scores (63.22 and 61.64, respectively), with an insignificant mean difference of 1.58. This suggests that gender had no significant effect on students' achievement in geometry when taught through scaffolding.

HO2: ANCOVA Analysis of Gender Impact

Table 4. ANCOVA F-Test Statistics for HO2

Source	Type III sum of Squares	Df	Mean square	F	Sig.
Corrected Model	6212.354	2	1553.089	315.841	.000
Intercept	496.743	1	496.743	101.019	.000
Pre-test	.213	1	.213	.043	.836
Teaching Method*	5721.300	0	5721.300	1163.500	.000
Gender	15.740	1	15.740	3.201	.078
Teaching Method*Gender	17.672	0	17.672	3.594	.062
Error	378.633	110	4.917		
Total	62075.000				
Corrected Total	6590.988	112			

Interpretation: F(1, 110) = 3.201, p = 0.078 > .05. Gender does not significantly affect achievement; HO2 is accepted. This supports the notion that scaffolding strategies are gender-inclusive (Nguyen, 2021; Kim & Lee, 2023).

Discussion

Clearly, the findings of this study confirm that scaffolding instructional strategies significantly enhance students' achievement in geometry compared to conventional teaching methods. The notable mean gain differences and ANCOVA results underscore scaffolding's effectiveness in promoting deeper understanding, active engagement, and improved academic performance. These results align with previous studies that demonstrated similar positive effects of scaffolding on students' learning outcomes (Aditi, 2017; Nwoke, 2017; Alabi & Ogunleye, 2022). Likewise, Simon and Klein (2017) and Alake and Ogunseemi (2013) emphasized the efficacy of scaffolding in improving learners' comprehension and achievement levels.

Consequently, the gender analysis shows minimal differences in achievement between male and female students in the scaffolding group. This suggests that scaffolding strategies provide equitable support that accommodates diverse learning needs, corroborating recent studies that emphasize gender inclusivity in mathematics education (Nguyen, 2021; Kim & Lee, 2023). This finding aligns with prior studies by Achor, Imoko, and Ajai (2010), Gbodi and Laleye (2006), Olagunju (2011), and Stahr (2008), which similarly report that gender does not influence performance when scaffolding is employed.

Conclusion and Recommendation

The study concludes that scaffolding instructional strategies significantly improve geometry achievement among senior secondary students and do so equitably across genders. Scaffolding is therefore a viable pedagogical approach to reduce achievement gaps and foster deeper understanding in mathematics. Teachers and educational authorities should integrate

scaffolding techniques into daily mathematics instruction to enhance performance and engagement. Future research could explore scaffolding effects across other mathematical domains, additional educational levels, and broader geographic locations.

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