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Effect of Instructional Scaffolding on Achievement of Secondary School Students in Mathematics

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Abstract

The paper investigated the effect of instructional scaffolding on secondary school student's achievement in Mathematics. The study adopted the quasi-experimental research type involving the use of pre-test and post-test in carrying out the study. A total of 120 senior secondary school students were randomly sampled from privately owned and government owed schools. The instrument for data collection was a researcher made 20-item objective test based of trigonometry tagged "Mathematics Scaffolding Achievement Test (MSAT)". The experiment group was taught mathematics using instructional scaffolding approach while the control group was taught using a non-scaffolding method. The data generated was analyzed using mean and standard deviation to answer research questions while t-test was used to test the hypotheses at 0.05 level of significance. The result of the study revealed that instructional scaffolding is effective in enhancing senior secondary school students' achievement in mathematics, the study also revealed a significant difference between the mean score of private school students taught using the instructional scaffolding approach and public school students. Based on the result it was recommended that mathematics teachers at secondary school level should apply instructional scaffolding approach in teaching to enhance students' achievement. Also, government should facilitate workshops, seminars, and symposium to train teachers and enlighten them on the importance and use of instructional scaffolding approach in teaching mathematics.

Keywords: Achievement, Instructional scaffolding, Mathematics, Secondary school

Introduction

Mathematics has infiltrated into all parts of human undertaking including business, social and governmental issues, science and technology, education, military and so on. Hence it is a core subject at the basic and secondary levels of education in most countries of the world. Mathematics is at the core of scientific and technological innovations the world over. It is viewed as a model of reasoning, which urges students to notice, reflect and reason coherently about an issue and in conveying thoughts, making it the focal scholarly discipline and a crucial device in science, business and innovation (Nuraina and Mursalin, 2018). Mathematics is not just about calculations but a tool for understanding relationships, patterns and structures, to create answers for complex real-life problems (Niyi et al., 2024).

The teaching and learning of Mathematics continues to be a massive challenge at the basic and post basic level of education in Nigeria today. The problems associated with mathematics over the years remain unsolved as they seem to defy every possible solution. The content of the mathematics curriculum does not seem to be the problem but rather with its implementation . The teachers who execute the mathematics curriculum are very important to the success of the educational system. The low performance of mathematics learners is often attributed to ineffective instructional skills and methodologies by mathematics teachers, poor comprehension of the curriculum, poor knowledge of subject matter, ineffective assessment and poor evaluation techniques, non-use of teaching aids etc. (Arifin et al., 2020).

According to Awofala (2011) it is important that students learn mathematics through active involvement, using practical informative strategies which help the teacher inculcate the broad skills, problem-solving, reasoning, inquiry, conceptualization, and communication. The capacity of a student to learn well depends on his/her capacity to interface or coordinate past information with new ones and furthermore apply it to real life circumstances (Nzewi and Ibeneme, 2011). In other to achieve this kind of mathematics learning, there is need to adopt more learner-centered methods of learning such as instructional scaffolding. Lei et al. (2020) explored the application of instructional scaffolding in mathematics for English learners with learning disabilities. Through an exploratory case study, the authors demonstrated that scaffolding strategies, such as breaking down complex problems and using visual aids, significantly improved students' conceptual understanding and engagement. The study underscored the importance of tailoring scaffolds to the linguistic and cognitive needs of diverse learners, emphasizing that effective scaffolding not only supports academic performance but also fosters confidence and motivation.

Complementing this perspective, Obafemi et al. (2024) investigated the impact of scaffolding on pupils' academic performance in mathematics in primary education. Their findings highlighted the positive effects of scaffolding on student achievement, particularly in building foundational skills. The study revealed that scaffolding helps mitigate learning gaps, enabling pupils to tackle mathematical problems more effectively. Notably, the authors emphasized the role of teacher-student interaction in the scaffolding process, suggesting that personalized guidance is crucial for maximizing its benefits. The role of scaffolding in science education is equally compelling. Chen and Wang (2022) examined how scaffolding influenced students' conceptual understanding and problem-solving skills in physics. Their study demonstrated that scaffolding, such as guided questioning and structured problem-solving frameworks, enhanced students' ability to connect theoretical concepts with practical applications. The authors argued that scaffolding fosters deeper cognitive engagement, enabling students to overcome common misconceptions in science. Additionally, the gradual removal of scaffolds encouraged students to develop independent problem-solving skills, a critical competency in science education. Yang and Looi (2023) extended the discussion on scaffolding to the domain of collaborative problem-solving in computer science education. Their research highlighted how scaffolding facilitates effective teamwork by providing students with structured guidelines, prompts, and feedback. The study demonstrated that scaffolding not only improved individual learning outcomes but also enhanced group dynamics and collaborative problem-solving skills. Furthermore, the integration of digital tools into scaffolding strategies allowed for real-time feedback and adaptive support, making the scaffolding process more efficient and dynamic.

The reviewed studies collectively illustrate the versatility and effectiveness of instructional scaffolding across diverse educational settings with following key themes;

1. **Customization and Adaptability:** Scaffolding must be tailored to the specific needs of learners, considering their prior knowledge, cognitive abilities, and learning contexts.

2. **Role of Interaction:** Teacher-student and peer-to-peer interactions play a vital role in the scaffolding process, ensuring that learners receive timely and contextually relevant support.

3. **Integration with Technology:** Digital tools enhance the scaffolding process by enabling adaptive support and real-time feedback, particularly in collaborative and STEM-related learning environments.

Conceptual Framework

Instructional scaffolding is a teaching strategy that helps learners to gradually acquire new skills and knowledge by providing guidance and support. In mathematics education, instructional scaffolding has been found to be particularly effective in promoting conceptual understanding, problem-solving skills, and higher-order thinking. According Faiza (2022), scaffolding means providing the necessary guidance and advice to students to improve their knowledge and abilities and approach the targeted mastery level.

Instructional scaffolding in mathematics is based on the principles of Vygotsky's sociocultural theory (1978), which emphasizes the importance of social interactions and cultural context in learning. According to Vygotsky, learning occurs through interaction with more knowledgeable others, such as teachers or peers, who provide guidance and support to learners. Instructional scaffolding in mathematics involves providing learners with the necessary support and guidance to help them reach the next level of understanding (Obialor & Chukwuagu, 2022 and Akani, 2015).

Instructional scaffolding in mathematics is also guided by the zone of proximal development (ZPD) (Vygotsky, 1978), which refers to the difference between what learners can do independently and what they can do with guidance and support. The goal of instructional scaffolding in mathematics is to move learners into their ZPD, where they can make progress and acquire new skills and knowledge. Instructional scaffolding in mathematics has been shown to be effective in promoting student learning and achievement. For example, studies have found that instructional scaffolding can improve students' problem-solving skills (Arifin, 2020), enhance their conceptual understanding of mathematical concepts and improve their attitudes toward mathematics.

Instructional scaffolding is a powerful teaching strategy in mathematics education that can help learners acquire new skills and knowledge by providing guidance and support. Based on the principles of Vygotsky's sociocultural theory, instructional scaffolding involves providing learners with explicit instruction, breaking tasks into smaller steps, providing feedback, encouraging collaboration, and using visual aids. By moving learners into their zone of proximal development, instructional scaffolding in mathematics can promote student learning and achievement.

Statement of the Problems

The persistent poor achievement of students in mathematics has remained a great concern to researchers, parents, learners and other stake holders in the educational sector in Nigeria (Niyi, et.al., 2024; Olulonye & Ihendinihu, 2013). A common problem identified by most authors is the method of instruction employed by the teacher and according to Dorgu (2015) incorporating different teaching strategies would make teaching more effective and help in the attainment of the curriculum objectives. Many students struggle to understand and apply mathematical concepts because the traditional lecture-based approach to teaching mathematics often does not provide students with the necessary support and guidance to overcome these challenges (Arifin et al., 2020**)**. Thus, there is the need to explore effective instructional scaffolding strategies that can support student's mathematical learning and improve the academic achievement in mathematics and ensure that they develop a deep understanding of mathematics concepts. It is on this premise this study sought to investigate the effects of instructional scaffolding on academic achievement of secondary students in mathematics in Kontagora local government (Niger state), Nigeria. To the best of the knowledge of the researchers, no such study has been conducted in Kontagora local government (Niger state) Nigeria and the researchers hope to fill this gap in research and literature.

Research Question

The following research questions were formulated to guide this research;

1. How does instructional scaffolding influence secondary school students' achievement in mathematics?
2. How does school type affect the achievement of students in mathematics?

Research Hypothesis

The following null hypotheses were tested;

H_{01}: There is no significant difference between the mean achievement score of students taught using instructional scaffolding and those taught using non scaffolding method.

H_{02}: There is no significant difference on mean achievement scores in mathematics based on school type.

Methodology

The study adopted a quasi-experimental research design. The target population comprised of the senior secondary School students in Kontagora L.G.A Niger State. Simple random sampling method was used to sample 120 students from four (4) schools in Kontagora Niger state comprising of 60 students from private schools and 60 from public schools. The experimental group has 60 students comprising of 15 students in each of the four (4) schools while the control group have 60 students comprising of 15 students from each of the schools. The instrument used for data collection was Mathematics Scaffolding Achievement Test (MSAT). MSAT was made up of twenty (20) multiple choice objective questions on trigonometry.

The face and content validity of the instrument was determined by two mathematics lecturers in the Department of Mathematics, Federal University of Education Kontagora, Niger state who evaluated and guided the structuring of the instrument where necessary. Reliability of the instrument was determined by test-retest method administered on 16 students outside the study sample and school but with the same characteristics. The data generated was analyzed using spearman rank correlation coefficient formula which gave a reliability coefficient of 0.86.

Both experiment and control groups were given a pre-test at the beginning of the study. After that, the experimental group was taught using a lesson plan made by the researcher based on instructional scaffolding approach to teach the experiment group. During the learning process the teacher provided learning supports which included; videos, PowerPoint presentations, and quiz cards for the experimental group. The control groups also taught the same concept with a lesson plan that drawn based on the traditional approach by their regular mathematics teacher. The entire process last for 4 weeks after which a post-test was administered. The generated data was analyzed using means and standard deviation for the research questions while *t-test* at 0.05 level of significance was used for the hypotheses.

Results

Research question 1: How does instructional scaffolding influence secondary school students' achievement in mathematics?

Table 1: Descriptive statistics of mean gain of students in achievement test.

Group	Number	Test	Mean	S.D	Gain
Experimental group	60	Pretest	5.62	2.50	
	60	Posttest	12.13	2.20	6.51 (115%)
Control group	60	Pretest	5.15	2.36	
	60	Posttest	8.17	2.02	3.02 (59%)

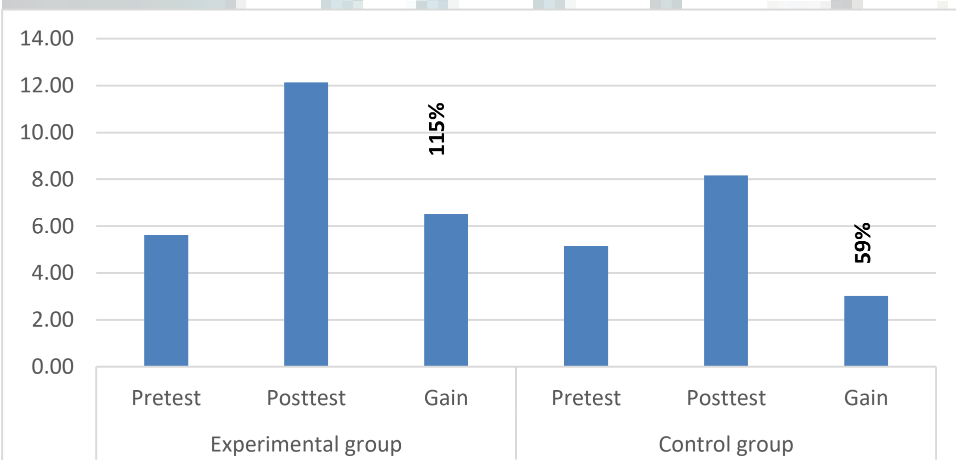

Chart 1:

Table 1 one shows that the experiment group has a mean score of 5.62 in the pretest and a mean score of 12.13 in the posttest indicating an average gain of 6.51 which translates to 115% gain. While the control group had a mean score of 5.15 in the pretest and a mean score of 8.17 in the posttest indicating an average gain of 3.02 which translates to 59% gain.

The use of instructional scaffolding resulted in the average score of the pupils more than doubling in the posttest. This implies that instructional scaffolding has a positive effect on the students' mathematics achievement.

Research question 2: How does school type affect the achievement of students in mathematics?

Table 2: Mean score of private and public schools.

Group	No	Test	Mean	SD	Gain
Private school	Pretest	30	6.17	2.32	
	Posttest	30	12.8	2.35	6.63 (107%)
Public school	Pretest	30	5.07	2.06	
	Posttest	30	11.47	1.83	6.4 (126%)

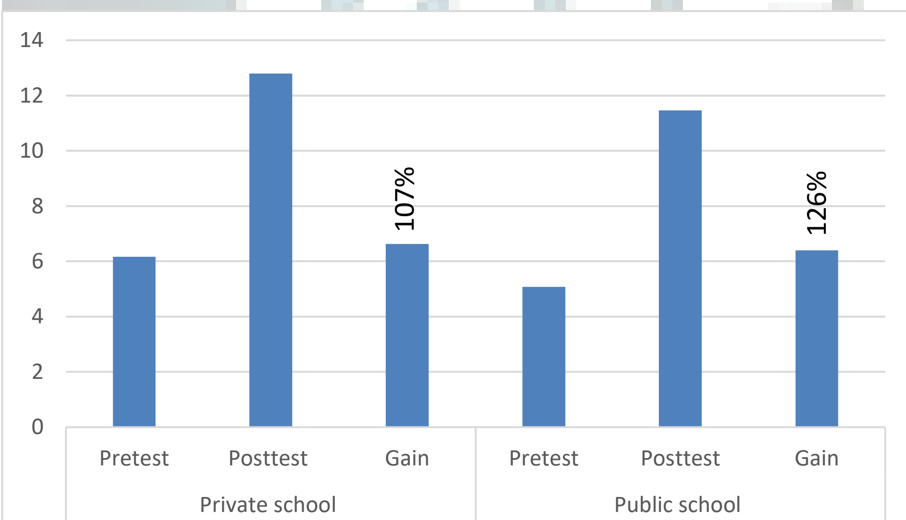

Chart 2

The descriptive analysis in the Table 2 gives results of the private school in the experimental group had a mean posttest score of 12.8 as against a mean score of 6.17 in the pretest. The result shows a percentage improvement of 107%. For the public schools, the experimental group had a mean posttest score of 11.47 as against a mean score of 5.07 in the pretest which shows a 126% improvement in the achievement test score.

H_{01}: There is no significant difference between the mean achievement score of students taught using instructional scaffolding and those taught using non scaffolding method.

Table 3: Independent t-test comparison of experimental and control group

Variables	Sum	Mean (*M*)	SD	DF	*t*-score	*p*-value	α-value
Control	60	8.17	2.02	118	10.28	0 .0001	0.05
Experimental	60	12.13	2.20				

From Table 3, the result from the control group taught using the conventional approach ($M = 8.17, SD = 2.02$) compared to the experimental group taught using the instructional scaffolding approach ($M = 12.13, SD = 2.20$) demonstrated a significantly better achievement better mean score for the experimental group ($t(118) = 10.28,\ p = 0.0001$). The null hypothesis is therefore rejected. Therefore, there is a significant difference between students taught using instructional scaffolding and those taught using the traditional method.

H_{02}: There is no significant difference on mean achievement scores in mathematics based on school type.

Table 4: Independent t-test comparison of pre-test and post-test for experimental group

Variables	Sum	Mean (*M*)	SD	DF	t-score	p-value	α-value
Pre	60	5.62	2.5	58	15.15	0 .0001	0.05
Post	60	12.13	2.20				

The t test analysis in Table 4 shows that result from the pretest ($M = 5.62,\ SD = 2.5$) compared to the posttest ($M = 12.13,\ SD = 2.20$) for students taught using the scaffolding approach demonstrated a significantly better achievement better mean score ($t(58) = 15.15,\ p = 0.0001$).

The null hypothesis is therefore rejected. Therefore, there is a significant difference between the mean pretest score and posttest score of students taught using the instructional scaffolding approach.

Table 5: t-test comparison of private and public schools taught using scaffolding approach

Variables	Sum	Mean (*M*)	SD	DF	t-score	p-value	α-value
Private	30	12.80	2.35	58	2.52	0.0176	0.05
Public	30	11.47	1.83				

The *t* test analysis from tavle 5 shows that result from the private schools ($M = 12.80,\ SD = 2.35$) compared to the public schools ($M = 11.47,\ SD = 1.83$) for students taught using the scaffolding approach demonstrated a significantly better achievement better mean score ($t(58) = 2.52,\ p = 0.0176$). The null hypothesis is therefore rejected. Therefore, there is a significant difference between the mean score of private and public students taught using the instructional scaffolding approach.

Discussions

This study highlights the significant impact of instructional scaffolding on students' academic achievement in mathematics. The experimental group, taught using scaffolding, showed a remarkable mean gain of 6.51 (115% improvement), compared to a gain of 3.02 (59% improvement) in the control group, supporting previous findings on scaffolding's effectiveness in enhancing learning outcomes (Lei et al., 2020; Obafemi et al., 2024). The significant difference in performance (t(118) = 10.28, p = 0.0001) underscores scaffolding's role in promoting better achievement. Both private and public school students benefited from scaffolding, with private schools achieving slightly higher posttest mean scores (M = 12.80) than public schools (M = 11.47). However, public schools recorded a greater percentage improvement (126%) compared to private schools (107%), suggesting contextual factors may moderate scaffolding's impact. This difference was statistically significant (t(58) = 2.52, p = 0.0176). Additionally, the experimental group's pretest and posttest comparison (t(58) = 15.15, p = 0.0001) confirmed substantial performance gains, aligning with research that recognizes scaffolding as a vital tool for improving conceptual understanding and application of mathematical knowledge (Chen & Wang, 2022).

These finding have strong implication for teaching and learning of mathematics in secondary schools in Nigeria using instructional scaffolding strategy. Major implication of these finding is that students taught with instructional scaffolding strategy perform better than those taught with non-scaffolding method.

Conclusion

The study examined the effect of instructional scaffolding on senior secondary school students' achievement in mathematics. The study concludes that instructional scaffolding is a highly effective strategy for improving students' academic performance in mathematics. The study examined the effect of instructional scaffolding on secondary school students' achievement in mathematics. The significant gains observed in the achievement of students taught using scaffolding underscores the role of the method in enhancing students' understanding, retention, and problem-solving skills.

The study highlighted the need for educators to integrate scaffolding techniques into mathematics instruction, as this approach not only improves achievement but also addresses disparities in educational outcomes across school types. Future research could explore the long-term impact of scaffolding on students' learning trajectories and its applicability to other subject areas.

Recommendations

The following recommendations are made based on the study;

1. Mathematics teachers at the secondary school level should apply instructional scaffolding approach in teaching as to enhance students' achievement.

2. Curriculum planners should adopt instructional scaffolding as an adequate teaching method to teaching mathematics.

3. The government should provide Workshops, seminars, and symposium and should be organized for teachers to enlighten them on the importance and use of instructional scaffolding approach in teaching mathematics.

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