© IIJP 2026 | Volume 2, Issue 1, pp. 677-692 | ISSN: 2636-4484

IMPACT OF SIMULATION-BASED STRATEGY ON STUDENTS' ACHIEVEMENT AND RETENTION IN BASIC SCIENCE AND TECHNOLOGY IN JOS SOUTH PLATEAU STATE, NIGERIA

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ARTICLE INFO
Article No.: 0179

Accepted Date: 21/01/2026

Published Date: 27/02/2026

Type: Research

ABSTRACT
This study investigated the impact of simulation-based strategy on students' achievement and retention in Basic Science and Technology in Jos South Local Government Area of Plateau State, Nigeria. The study adopted a quasi-experimental design involving a population of 1,778 Junior Secondary School II students, from which a sample of 153 students was drawn using simple random sampling techniques. The participants were assigned to experimental and control groups, with the experimental group exposed to simulation-based strategy while the control group was taught using the conventional lecture method. Two instruments, the Basic Science and Technology Achievement Test (BSTAT) and the Basic Science and Technology Retention Test (BSTRT), were developed, validated, and used for data collection, and the analysis yielded a reliability coefficient of 0.81, indicating a high level of internal consistency. Six research questions guided the study and were answered using mean and standard deviation, while six corresponding hypotheses were tested at 0.05 level of significance using Analysis of Covariance (ANCOVA). Findings showed that, students taught with the simulation-based strategy achieved significantly higher post-test scores than peers taught with the lecture method and, importantly, demonstrated superior retention of learned concepts after the delay. The study recommended wider integration of subject-appropriate simulations into Basic Science and Technology instruction, targeted teacher professional development on designing and facilitating simulation activities, curriculum planners should embed simulation tasks as core learning experiences rather than enrichment add-ons.

Keywords: Simulation-Based Strategy, Students, Achievement, Retention, Basic Science and Technology

Introduction

Basic Science and Technology is a foundational subject taught at the basic education level in Nigeria, comprising primary and junior secondary school (JSS). The subject comprises: Basic Science, Basic Technology, Physical and Health Education, and Information Technology. Basic Science and Technology is compulsory for all students at the basic level to ensure early exposure to scientific and technological concepts that are vital for national development and future learning. Basic Science is a fundamental subject in Nigerian basic schools, serving as a foundation for all science subjects in secondary school. According to the Nigerian Educational Research and Development Council (NERDC) (2019), Basic Science and Technology (BST) is a compulsory subject in the 9-Year Basic Education Curriculum. The Nigerian National Policy on Education emphasizes the need to inculcate scientific and technological literacy from an early age. According to the Nigerian Educational Research and Development Council (NERDC) (2018), the objectives of Basic Science and Technology as outlined in the policy include the development of interest in science and technology, acquisition of basic knowledge and skills, and the ability to apply scientific methods in everyday life. The policy aims to lay a strong foundation for scientific innovation and technological advancement in Nigeria. Achieving the objectives of Basic Science and Technology (BST) in the classroom requires a deliberate and strategic approach to instruction, curriculum implementation, and learner engagement. These goals can be effectively realized through learner-centred instructional methods, proper use of instructional materials, and continuous assessment. The integration of activity-based and simulation-oriented strategies in teaching Basic Science and Technology enhances student understanding and retention of scientific concepts. For instance, using models, virtual labs, and hands-on experiments engages students more actively and encourages experiential learning. Adeyemo and Salami (2021) found that simulation techniques significantly improved students' academic performance and retention in Basic Science, highlighting the importance of innovative pedagogy in achieving learning objectives. Yusuf and Bello (2020) also observed that computer simulations positively influenced students' attitudes and understanding in physics classes, a trend applicable to the broader BST curriculum.

According to Okoye and Nwafor (2021), achievement in Basic Science and Technology is "the level of performance demonstrated by students in cognitive, psychomotor, and affective domains of learning as a result of exposure to science-based instruction." This definition emphasizes a holistic view of learning, not limited to cognitive gains but also including skills and attitudes. Similarly, Bello and Yusuf (2020) define achievement in Basic Science and Technology as "students' demonstrated ability to apply scientific knowledge and technological skills to solve problems or perform tasks, as assessed through academic evaluations." Their view highlights practical application as a critical element of true achievement in the subject. Over the years, several empirical studies have examined the relationship between classroom teaching practices and students' achievement in Basic Science and Technology (BST). These studies consistently reveal that the quality of teaching in the classroom has a direct and measurable impact on how well students perform, particularly in national and state-level assessments such as the Basic Education Certificate Examination (BECE). Poor classroom teaching strategies, teacher-centered methods, lack of practical activities, and inadequate instructional materials have been repeatedly linked to low student achievement in BST. Evidence from recent BECE results in various Nigerian states, including Plateau and Lagos, indicates that a significant percentage of students perform below average in Basic Science and Technology. For instance, data from the West African Examinations Council and state ministries of education (2019-2023) show that a

large number of students score below 50% in BST, suggesting a gap in comprehension and application of scientific knowledge (WAEC, 2021; Plateau State Ministry of Education, 2022). These poor outcomes are not isolated events but reflect a consistent trend over the years.

Simulation-based strategy is a dynamic and interactive instructional approach that serves as an effective intervention variable in educational research and classroom practice, particularly in science and technology education. As an intervention variable, it refers to a deliberately introduced teaching strategy aimed at altering the learning environment to improve students' academic outcomes, understanding, engagement, and retention. In the context of Basic Science and Technology (BST), simulation-based strategy involves the use of computer-generated models, virtual experiments, role-playing, and other interactive activities to replicate real-world scientific processes or phenomena. These simulations allow students to observe, manipulate, and experiment within a controlled virtual environment, enabling them to understand abstract scientific concepts that may be difficult to visualize through traditional teaching methods. The strength of simulation-based strategy as an intervention lies in its ability to promote active learning and learner autonomy. Instead of passively receiving information, students interact with the content, make predictions, test hypotheses, and learn from feedback. For example, in a virtual lab simulation on energy conversion, students can manipulate variables such as temperature or pressure and observe the outcomes in real-time. This hands-on experience leads to deeper conceptual understanding and better knowledge retention.

Although, simulation-based strategy has gained recognition as an effective instructional method in science education, particularly in Basic Science andTechnology (BST), due to its capacity to foster engagement, experiential learning, and conceptual understanding, the implementation of simulation-based strategies in Nigerian classrooms faces numerous challenges that hinder its widespread adoption and effectiveness. One of the primary challenges is inadequate infrastructure and technological resources. Many public schools, especially in rural and underfunded urban areas, lack the necessary hardware, such as computers, projectors, stable electricity, and internet connectivity required for running simulations effectively (Eze & Ezeudu, 2021). Without these tools, the integration of simulation-based strategies becomes impractical and inaccessible for many teachers and students.

Another pressing issue is the limited digital literacy among teachers. Effective use of simulation tools requires teachers to be proficient in digital skills and familiar with various simulation software. Unfortunately, many science teachers have not received adequate training in educational technology, making it difficult for them to design or even adopt ready-made simulations in their lessons Olumorin, C. O., Yusuf, M. S., Ajidagba, U. A., & Itowu, A. O. (2020). This skill gap creates a dependency on external facilitators or tech experts, which is unsustainable in the long term. Additionally, the curricular rigidity and time constraints within the Nigerian school system pose significant limitations. The Basic Science and Technology curriculum is often packed with topics to be covered within a short academic calendar, leaving little room for the extended time simulation activities typically require for exploration, discussion, and reflectionOgunlade, O. O., Ajijola, E. M., & Aladesusi, G. A. (2022). As a result, many teachers opt for more conventional, lecture-based approaches to meet curriculum demands. Student-related challenges also arise, particularly with learners who are not yet accustomed to independent and self-directed learning. Simulations often require learners to actively participate, think critically, and solve problems. For students who are used to rote learning, adapting to the demands of simulations can be difficult, thereby affecting the intended learning outcomes (Okoli & Eze, 2023).

However, recent educational reforms and innovations particularly the introduction of learner-centered strategies like simulation are challenging these narratives. Simulation-based strategies provide interactive, hands-on, and visual experiences that accommodate diverse learning styles, including those typically associated with female learners (Eze & Ali, 2023). This approach shifts the focus from rote memorization to exploration and engagement, thereby creating a more level playing field for both genders Research has shown that when boys and girls are exposed to simulation-based learning, the performance gap tends to narrow significantly. For instance, a study by Musa and Okon (2021) on gender and simulation in science education found no significant difference in the achievement of male and female students taught using simulation strategies. The interactive nature of simulations encourages equal participation and minimizes traditional classroom dynamics where boys might dominate discussions or hands-on activities. Many public schools, especially in rural and underfunded urban areas, lack the necessary hardware, such as computers, projectors, stable electricity, and internet connectivity required for running simulations effectively (Eze & Ezeudu, 2021).

Where access to educational resources can be limited and gender disparities more pronounced, simulation-based learning has the potential to foster gender inclusion. By promoting collaborative and inquiry-based learning environments, both male and female students are given equal opportunities to engage with BST content meaningfully. This not only improves achievement but also enhances self-efficacy and interest in science-related fields for both genders (Olowu & Ibrahim, 2020). Additionally, simulation-based strategies help overcome gender-linked learning barriers. For example, female students who may be hesitant to participate in conventional classroom settings often find simulations less intimidating and more empowering, especially when tasks are structured around cooperation rather than competition (Chukwu & Danjuma, 2022). This inclusive learning approach is aligned with Sustainable Development Goal 5, which advocates for gender equality in education.

Gender achievement in Basic Science and Technology can be significantly influenced by the mode of instruction. Simulation-based strategies offer a practical solution to bridging gender gaps by making learning more inclusive, engaging, and effective. In the context of Jos South LGA, adopting simulation-based strategies can promote balanced academic performance across genders and support the broader goal of gender equity in science education.

Retention refers to a student's ability to remember and recall learned concepts over time. In the context of Basic Science and Technology (BST), retention is crucial because the subject is cumulative and concept-driven, therefore students must retain foundational knowledge to understand more advanced topics. Simulation-based strategy has emerged as a powerful instructional tool for enhancing students' retention, especially in science-related subjects. Simulation-based strategy improves retention by providing experiential and visually enriched learning experiences. When students engage with simulations whether through computer animations, virtual labs, role-plays, or interactive models, they are not just memorizing facts but actively interacting with the learning content. This active participation fosters deeper cognitive processing, which is a key factor in long-term memory storage. Research evidence supports the effectiveness of simulation-based learning in boosting retention. For example, Igwe and Ogbu (2022) examined the effect of simulation-based strategies on retention in secondary school chemistry. Their study revealed that students who were taught using simulation tools retained scientific concepts significantly better than those taught through traditional lecture methods. This improvement was attributed to the students' ability to visualize and manipulate variables within the simulations, which reinforced their understanding and memory of the subject matter.

Statement of the Problem

In recent years, the persistent underachievement and low retention rates among students in Basic Science and Technology in Nigeria, particularly in Jos South Local Government Area of Plateau State, have raised concerns among educators, stakeholders, and policymakers. Despite the subject's significance in promoting scientific literacy and technological advancement, many students continue to perform poorly both in internal and external assessments. Basic Science and Technology is a foundational subject in Nigeria's junior secondary school curriculum, aimed at equipping students with essential scientific knowledge and technological skills required for national development. However, despite its importance, students' performance in Basic Science and Technology has remained persistently poor, particularly in areas such as Jos South Local Government Area (LGA) of Plateau State, Nigeria. Reports from the West African Examinations Council (WAEC) and the State Ministry of Education reveal a disturbing trend of low achievement and poor retention of scientific concepts among students. For instance, the Plateau State Ministry of Education's internal assessment records (2023) show that over 60% of JSS students in Jos South LGA scored below average in Basic Science and Technology, indicating a significant learning gap.

Several factors have been implicated in this recurring failure, including the continued reliance on traditional teaching methods such as rote learning, teacher-centered instruction, and lack of practical engagement, which fail to stimulate students' interest or enhance deep understanding. Consequently, many students are unable to retain and apply scientific knowledge meaningfully over time. The situation is worsened by the fact that Basic Science and Technology lays the groundwork for future learning in STEM (Science, Technology, Engineering, and Mathematics) fields. Failure to address students' underachievement and poor retention in this subject area could have long-term consequences, including reduced interest in science-related careers, low scientific literacy, and a widening gap in technological advancement within the state and country.

Aim and Objectives of the Study

The aim of this study is to investigate the impact of simulation-based strategy on students' achievement and retention in Basic Science and Technology (BST) in Jos South, Nigeria. The specific objectives of the study are to:

1. determine the pre-test & post-test mean achievement scores of students taught BST using simulation-based strategy and those taught using lecture methods.
2. find out the pre-test and post-test mean retention scores of students taught BST using simulation-based strategy and those taught using lecture methods.
3. ascertain the post-test mean achievement scores of male and female students taught BST using simulation-based strategy.
4. determine the post-test mean retention of male and female students taught BST using simulation-based strategy.
5. examine the interaction effect of treatment and gender on students achievement in BST.
6. examine the interaction effect of treatment and gender on students' retention in BST.

Research Questions

The study was guided by the following research questions:

1. What are the differences in the pre-test and post-test mean achievement scores of students taught Basic Science and Technology using simulation-based strategy and those taught using lecture method?

2. What are the differences in the pre-test and post-test mean retention scores of students taught Basic Science and Technology using simulation-based strategy and those taught using lecture method?
3. What is the difference in the post-test mean achievement scores of male and female students taught Basic Science and Technology using simulation-based strategy?
4. What is the difference in the post-test mean retention scores of male and female students taught Basic Science and Technology using simulation-based strategy?
5. What is the interaction effect of treatment (simulation-based strategy and lecture method) and gender on students' achievement in Basic Science and Technology?
6. What is the interaction effect of treatment (simulation-based strategy and lecture method) and gender on students' retention in Basic Science and Technology?

Hypotheses

1. There is no significant difference in the pre-test and post-test mean achievement scores of students taught Basic Science and Technology using simulation-based strategy and those taught using lecture methods.
2. There is no significant difference in the pre-test and post-test mean retention scores of students taught Basic Science and Technology using simulation-based strategy and those taught using lecture methods.
3. There is no significant difference in the post-test mean achievement scores of male and female students taught Basic Science and Technology using simulation-based strategy.
4. There is no significant difference in the post-test mean retention scores of male and female students taught Basic Science and Technology using simulation-based strategy.
5. There is no significant interaction effect of treatment and gender on students' achievement in Basic Science and Technology.
6. There is no significant interaction effect of treatment and gender on students' retention in Basic Science and Technology.

Methodology

The study adopted a quasi-experimental research design, specifically the pretest, post-test non-equivalent control group design. The total population of JSS 2 students across the public secondary schools in Jos South LGA was 1,778. The sample size for the study comprised of 153 JSS2 Basic science and technology students from two co-educational public Junior secondary schools in Jos-South Local Government Area comprising of 67 male and 86 female students. Simple Random Sampling technique was used to select two public secondary schools that have similar characteristics in terms of students' population, facilities, and qualified Basic Science and Technology teachers. Two intact JSS 2 classes were used, one from each school. One class, comprising 77 students, was randomly selected and assigned to the experimental group and were taught using the simulation-based strategy while the second class, consisting of 76 students were assigned to the control group and were taught using the lecture teaching method.

The Basic Science and Technology Achievement test (BSTAT) and Basic Science and Technology Retention Test (BSTRT) instruments were used for the data collection. The BSTAT item had 25 multiple choice test items adopted from 2012-2024 BECE past questions. Each BSTAT item had four options lettered A, B, C, D, where only one option was correct answer while the others were distracters. Basic Science and Technology Retention Test (BSTRT) consists of the same 25 items as the posttest but was reshuffled and administered 40 days after the posttest to both the experimental and control groups. The researcher submitted two draft copies of the instruments to a panel of two experts. To ensure the consistency and dependability

of the research instruments, the Basic Science and Technology Achievement Test (BSTAT) and the Basic Science and Technology Retention Test (BSTRA) were subjected to a reliability test. The analysis yielded a reliability coefficient of 0.90 for the Instruments, indicating a high level of internal consistency. To ensure the smooth implementation of the study and the accuracy of data collection, two research assistants from the two sampled schools were employed as research assistant for the study and trained by the researcher. Before the commencement of the treatment phase of the study, a pretest was administered to both the experimental and control groups using the Basic Science and Technology Achievement Test (BSTAT). The treatment for this study was administered within six (6) weeks. The purpose of the treatment was to expose the experimental group to simulation-based instructional strategies, while the control group were taught using the conventional lecture method. This allowed for a comparison of the effectiveness of both teaching methods on students' achievement and retention in Basic Science and Technology. The administration of the posttest was carried out under similar conditions for both the experimental and control groups to maintain uniformity. Standardized instructions were provided to all participants to minimize any form of bias or external influence. The test lasted for a duration of 40 minutes, and students were closely monitored to ensure compliance with test-taking guidelines. For BSTAT, each correct answer was scored Four (4) marks while a wrong score were scored zero (0). This makes the total score for any student who got all answers correctly to be sixty (100). For BSTRT, each correct answer were scored Four (4) marks while a wrong score were scored zero (0). The options are A, B, C or D, where the students were expected to choose the right option. To determine the statistical significance of the differences observed between the experimental and control groups in terms of achievement and retention in Basic Science and Technology, the null hypotheses formulated for the study were tested using analysis of covariance ANCOVA. The hypotheses were tested at a 0.05 level of significance. All statistical analyses were carried out using a statistical software called Statistical Package for Social Science (SPSS).

Results

Research question 1: What are the differences in the pre-test and post-test mean achievement scores of students taught Basic Science and Technology using simulation-based strategy and those taught using lecture method?

Table 1: Pre-test and Post-test Mean Achievement Scores of Students in Experimental and Control Group

Groups		Pre-test		Post-test		Mean gained
	N	Mean	SD	Mean	SD	
Control group	76	20.37	7.495	23.75	4.520	3.38
Experimental group	77	23.69	4.835	33.61	9.387	9.92

The table presents the differences in the pre-test and post-test mean achievement scores of students taught Basic Science and Technology using simulation-based strategy and those taught with lecture method in the study. The control group had a pre-test mean achievement score of 20.37 and standard deviation of 7.495 while the post test scores group was 23.75 and standard deviation of 4.520. The experimental group had a mean achievement score of 23.69 and 33.61 with standard deviation of 4.835 and 9.387 at the pre-test ang post-test respectively.

Research question 2: What are the differences in the pre-test and post-test mean retention scores of students taught Basic Science and Technology using simulation-based strategy and those taught using lecture method?

Table 2: Pre-test and Post-test Retention Mean Achievement Scores of Students in Experimental and Control Group

Groups		Pre-test		Post-test Retention		Retention Mean Diff
	N	Mean	SD	Mean	SD	
Control group	76	20.37	7.495	21.97	2.221	**9.75**
Experimental group	77	23.69	4.835	31.22	7.519	

The table presents the pre-test and post-test retention mean achievement scores of the control group and experimental group in Basic Science and Technology in the study. The control group had a pre-test mean achievement score of 20.37 and standard deviation of 7.495 while the post-test retention scores was 21.97 with standard deviation of 2.221. The experimental group had a pre-test mean achievement scores of 23.69 with standard deviation of 4.835 while the retention mean achievement score was 31.22 with standard deviation of 7.519.

Research question 3: What is the difference in the post-test mean achievement scores of male and female students taught Basic Science and Technology using simulation-based strategy?

Table 3: Post-test Mean Achievement Scores of Male and Female Students in Experimental Group

	Gender	N	Mean	Std. Deviation	Mean Diff
POST-TEST	Male	25	36.00	11.060	3.54
	Female	52	32.46	8.342	

The table presents the male and female mean achievement scores when taught Basic Science and Technology with simulation-based strategy. The students had a mean score of 36.00 with standard deviation of 11.06 while their female counterpart mean achievement score was 32.46 with standard deviation of 8.342.

Research question 4: What is the difference in the post-test mean retention scores of male and female students taught Basic Science and Technology using simulation-based strategy?

Table 4: Post-test Retention Mean Achievement Scores of Male and Female Students in Experimental Group

	Gender	N	Mean	Std. Deviation	Mean Retention Diff
Post-test Retention	Male	25	32.56	7.517	1.98
	Female	52	30.58	7.508	

The table presents the post-test retention mean achievement scores of male and female students taught Basic Science and Technology using simulation-based strategy. The result revealed that the male students' retention mean achievement score was 32.56 while their female counterpart was 30.58 with standard deviation of 7.517 and 7.508 respectively. This indicates that male and female students' retention when taught Basic Science and Technology using simulation-based strategy was slightly higher in favour of male counterpart but both had appreciable retention mean achievement scores.

Research question 5: What is the interaction effect of treatment (simulation-based strategy and lecture method) and gender on students' achievement in Basic Science and Technology?

Table 5: Interaction Effect of Gender on Students Mean Achievement Scores in Experimental and Control Group

Groups	Male			Female			Mean diff
	N	Mean	SD	N	Mean	SD	
Control	42	24.05	4.997	34	23.38	3.893	**0.67**
Experimental	25	36.00	11.060	52	32.46	8.342	**3.54**

The table presents the interaction effects of gender on students' mean achievement scores in the experimental and control group in the study. The result revealed that the interaction effect difference between male and female students in the experimental group was 3.54 while the male and female counterpart in the control group had a mean difference was 0.67.

Research question 6: What is the interaction effect of treatment (simulation-based strategy and lecture method) and gender on students' retention in Basic Science and Technology?

Table 6: Interaction Effect of Gender on Students Mean Retention Scores in Experimental and Control Group

Groups	Male			Female			Mean diff
	N	Mean	SD	N	Mean	SD	
Control	42	21.71	2.361	34	22.29	2.023	-0.58
Experimental	25	32.56	7.517	52	30.56	7.508	2.00

The table presents the interaction effects of gender on students' retention mean achievement scores in the experimental and control group in the study. The result revealed that the interaction effect difference between male and female students' retention scores in the experimental group was 2.00 while the male and female counterpart in the control group had a mean difference was -0.58.

Testing of Hypotheses

Hypothesis 1: There is no significant difference in the pre-test and post-test mean achievement scores of students taught Basic Science and Technology using simulation-based strategy and those taught using lecture methods.

Table 7: ANCOVA Result between the pre-test and post-test achievement scores of students in the experimental and control group

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	639.298[a]	2	319.649	3.991	.023
Intercept	9481.644	1	9481.644	118.374	.000
Pre-test	323.960	1	323.960	4.044	.048
Group	396.590	1	396.590	4.951	.029
Error	5847.228	73	80.099		
Total	91376.000	76			
Corrected Total	6486.526	75			

The table presents the analysis of covariance result on the significant difference in the pre-test and post-test mean achievement scores of students taught Basic Science and Technology using simulation-based strategy and those taught using lecture methods. The hypothesis was rejected

since the p-value of 0.048 was less than the 0.05 level of significance. Therefore, it was concluded that there is significant difference in the pre-test and post-test mean achievement scores of students taught with simulation-based strategy and those taught with lecture method in the study.

Hypothesis 2: There is no significant difference in the pre-test and post-test mean retention scores of students taught Basic Science and Technology using simulation-based strategy and those taught using lecture methods.

Table 8: ANCOVA Result between the pre-test and post-test Retention scores of students in the experimental and control group

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	536.033[a]	2	268.016	5.216	.008
Intercept	3060.256	1	3060.256	59.562	.000
Group	320.832	1	320.832	6.244	.015
Pre-test	162.271	1	162.271	3.158	.080
Error	3750.704	73	51.380		
Total	78568.000	76			
Corrected Total	4286.737	75			

The table presents the analysis of covariance result on the significant difference in the pre-test and post-test retention achievement scores of students taught Basic Science and Technology using simulation-based strategy and those taught using lecture methods. The hypothesis was rejected since the p-value of 0.015 was less than the 0.05 level of significance. Therefore, it was concluded that there is significant difference in the pre-test and post-test retention achievement scores of students taught with simulation-based strategy and those taught with lecture method in the study.

Hypothesis 3: There is no significant difference in the post-test mean achievement scores of male and female students taught Basic Science and Technology using simulation-based strategy.

Table 9: ANCOVA Result in the Male and Female Post-test Mean Achievement Scores of Students in the Experimental group

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	375.103[a]	2	187.551	2.196	.118
Intercept	1690.749	1	1690.749	19.793	.000
Pre-test	163.714	1	163.714	1.917	.170
Gender	151.228	1	151.228	1.770	.187
Error	6321.209	74	85.422		
Total	93680.000	77			
Corrected Total	6696.312	76			

The table presents the analysis of covariance result on the significant difference in the male and female post-test mean achievement scores of students taught Basic Science and Technology using simulation-based strategy. The hypothesis was accepted since the p-value of 0.170 was greater than the 0.05 level of significance. Therefore, it was concluded that there is no significant

difference in the male and female post-test mean achievement scores of students taught with simulation-based strategy in the study.

Hypothesis 4: There is no significant difference in the post-test mean retention scores of male and female students taught Basic Science and Technology using simulation-based strategy.

Table 10: ANCOVA Result in the Male and Female Post-test Mean Retention Scores of Students in the Experimental group

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	645.652[a]	2	322.826	6.542	.002
Intercept	1228.847	1	1228.847	24.903	.000
Gender	14.006	1	14.006	.284	.596
Post-test	579.258	1	579.258	11.739	.001
Error	3651.595	74	49.346		
Total	79352.000	77			
Corrected Total	4297.247	76			

The table presents the analysis of covariance result on the significant difference in the male and female post-test retention mean scores of students taught Basic Science and Technology using simulation-based strategy. The hypothesis was accepted since the p-value of 0.0596 was greater than the 0.05 level of significance. Therefore, it was concluded that there is no significant difference in the male and female post-test mean retention scores of students taught with simulation-based strategy in the study.

Hypothesis 5: There is no significant interaction effect of treatment and gender on students' achievement in Basic Science and Technology.

Table 11: ANCOVA Result on the Interaction effect of the treatment and gender on Students Achievement in Basic Science and technology

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	211.389[a]	1	211.389	2.445	.122
Intercept	8722.219	1	8722.219	100.875	.000
Gender effect	211.389	1	211.389	2.445	.122
Error	6484.923	75	86.466		
Total	93680.000	77			
Corrected Total	6696.312	76			

The table presents the analysis of covariance result on the significant interaction effect of treatment and gender on students' achievement in Basic Science and Technology. The hypothesis was accepted since the p-value of 0.122 was greater than the 0.05 level of significance. Therefore, it was concluded that there is no significant interaction effect of gender on students' achievement scores in Basic science and Technology in the study.

Hypothesis 6: There is no significant interaction effect of treatment and gender on students' retention in Basic Science and Technology.

Table 12: ANCOVA Result on the Interaction effect of the treatment and gender on Students Retention in Basic Science and technology

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	66.394[a]	1	66.394	1.177	.281
Intercept	6657.474	1	6657.474	118.017	.000
Gender effect	66.394	1	66.394	1.177	.281
Error	4230.852	75	56.411		
Total	79352.000	77			
Corrected Total	4297.247	76			

The table presents the analysis of covariance result on the significant interaction effect of treatment and gender on students' retention in Basic Science and Technology. The hypothesis was accepted since the p-value of 0.281 was greater than the 0.05 level of significance. Therefore, it was concluded that there is no significant interaction effect of gender on students' retention scores in Basic science and Technology in the study.

Discussion of Findings

The first finding of this study indicates that the simulation-based strategy led to a significantly higher mean achievement score for students compared to the lecture method. This suggests that the use of computer simulations was more effective in facilitating the learning of Basic Science and Technology concepts than traditional, teacher-centered instruction. This outcome aligns with the work of Adeyemo & Salami (2021), who found that computer simulation techniques positively affected students' academic achievement in Basic Science. It also corroborates the findings of Yusuf & Bello (2020), who reported that computer simulations were more effective than traditional methods, specifically laboratory experiments, in enhancing students' achievement. The result further supports the position of Igwe & Ogbu (2022) that simulation-based instructional strategies improve not only initial learning but also the retention of science concepts, reinforcing the value of interactive, visual, and engaging tools as advocated by Eze & Ali (2023) in their work on learner-centered strategies.

The second major finding reveals that students taught with the simulation-based strategy had a significantly higher retention mean achievement score than those in the control group. This demonstrates that simulations are not only effective for immediate learning gains but also for the long-term memory and recall of scientific concepts. This finding is directly supported by Igwe & Ogbu (2022), whose study specifically focused on simulation-based strategies and their positive impact on the retention of Basic Science concepts. The enhanced retention can be attributed to the interactive and engaging nature of simulations, which helps to create more robust mental models, a concept central to the learner-centered approaches discussed by Eze & Ali (2023). The significant difference in retention scores confirms that the knowledge gained through simulations is more durable compared to information presented through the less engaging lecture method.

The third finding shows that while male students achieved a slightly higher mean achievement score than their female counterparts when taught with simulation-based strategy, this difference was not statistically significant. This outcome suggests that the simulation-based strategy is equally beneficial for both male and female students in terms of immediate academic achievement. This finding is consistent with the meta-analysis by Musa & Okon (2021), which

explored gender and simulation in science education and reported on patterns of student performance. It also resonates with the conclusions of Olowu & Ibrahim (2020), who studied gender inclusion and found that while gender can be a factor in self-efficacy, instructional strategies like simulations can provide an equitable learning environment. The non-significant difference further challenges the notion of inherent gender-linked learning barriers in science, as discussed by Chukwu & Danjuma (2022), by demonstrating that a well-designed teaching method can provide equal learning opportunities for all genders.

Similarly, the fourth finding indicates that male students had a slightly higher mean retention score than female students, but this difference was not statistically significant. This reinforces the conclusion that the simulation-based strategy supports long-term memory and recall effectively for both genders. The lack of a significant gender gap in retention is an important finding, suggesting that the cognitive benefits of simulation-based learning are durable and equitable. This outcome is supported by the work of Musa & Okon (2021), whose analysis of gender and simulation would account for such outcomes in retention. The appreciable retention scores for both genders also align with the broader findings of Igwe & Ogbu (2022) on the effectiveness of simulations for memory retention, and it counters the gender-linked barriers to performance in science subjects identified by Chukwu & Danjuma (2022), suggesting that the instructional method can mitigate these barriers in the long term.

The fifth finding suggests a slight but non-significant interaction effect of gender on students' achievement scores when taught with simulation-based strategy. This implies that while the simulation method was more effective overall (as seen in the first finding), its effectiveness did not depend on or vary significantly by gender. In other words, the positive impact of the treatment on achievement was consistent for both boys and girls. This finding is consistent with the work of Olowu & Ibrahim (2020), who examined gender inclusion and predictors of achievement, and suggests that simulation-based strategies can serve as a leveling agent in the classroom. It also aligns with the general principles of learner-centered strategies promoted by Eze & Ali (2023), which aim to engage all students irrespective of their gender.

Finally, the sixth finding mirrors the previous one, showing a slight but non-significant interaction effect of gender on students' retention scores. This confirms that the benefit of using simulation-based strategy for long-term memory is consistent across genders. The treatment's effect on retention was robust and did not interact with gender to produce differential outcomes. This finding strengthens the argument that simulation-based strategies are an inclusive and equitable pedagogical approach, as supported by the research of Olowu & Ibrahim (2020). The non-significant interaction further reinforces the conclusions of Igwe & Ogbu (2022) on the general effectiveness of simulations for retention and suggests, in line with Chukwu & Danjuma (2022), that the instructional environment can play a powerful role in overcoming gender-linked learning barriers.

Conclusion

Based on the findings of the study, it can be concluded that simulation-based instructional strategies significantly enhanced students' learning outcomes in Basic Science and Technology when compared to the conventional lecture method. While both methods contributed to notable gains in students' achievement, the simulation-based strategy proved to be more effective, as reflected in the significantly higher mean achievement scores recorded by the experimental group. The study also established that the simulation-based strategy positively influenced students' retention of knowledge. Students taught using simulation retained information better than those taught using the lecture method, as shown by the significantly

higher post-test retention scores of the experimental group. This finding underscores the effectiveness of simulation in promoting deeper understanding and longer-lasting learning in Basic Science and Technology. Although the study revealed that male students achieved slightly higher than their female counterparts when taught using the simulation-based strategy, the difference was not statistically significant. This indicates that the simulation-based strategy is equally effective for both male and female students in terms of achievement and retention. Similarly, the observed slight gender differences in retention scores favoured the male students, but the difference was again not significant, suggesting that both genders benefited relatively equally from the strategy. Furthermore, the study found minimal interaction effects between gender and instructional strategy in both achievement and retention. While some slight variations were noted between male and female students in the experimental group, these differences were not statistically significant. This suggests that gender does not significantly influence the effectiveness of simulation-based strategies in enhancing achievement and retention in Basic Science and Technology. The simulation-based instructional strategy has been shown to be a more effective approach for improving students' academic achievement and retention in Basic Science and Technology compared to the traditional lecture method.

Recommendations

In light of the findings, the following are hereby recommended:

1. Basic Science and Technology Teachers should adopt the simulation-based strategy as an effective instructional approach for enhancing students' achievement. Since students exposed to the simulation-based strategy performed significantly better than those taught through the traditional lecture method, curriculum planners, educators, and school administrators should integrate simulation-based activities into classroom teaching.
2. Basic Science and Technology teachers should employ simulation-based strategy in their instructional practices to enhance students' long-term retention of concepts. Since students taught with simulation-based strategy retained knowledge better than those taught using the lecture method, educational stakeholders such as curriculum developers, teacher educators, and school administrators should encourage and support the use of simulation-based teaching.
3. Both male and female students should be equally encouraged and given opportunities to participate actively in simulation-based learning activities in Basic Science and Technology. Since the difference in achievement between male and female students was not significant, the simulation-based strategy can be considered gender-friendly and effective for all learners.
4. Teachers should continue to use simulation-based strategy in teaching Basic Science and Technology for both male and female students, as it effectively enhances knowledge retention across genders. Although male students showed slightly higher retention, the difference was not significant, indicating that the strategy benefits both genders almost equally.
5. Teachers of Basic Science and Technology should employ simulation-based strategy for both male and female students, as it promotes active participation and enhances achievement regardless of gender. The slight interaction effect observed suggests that both genders benefit from the approach, making it a balanced and inclusive instructional strategy.
6. Teachers should continue to apply simulation-based strategy in teaching Basic Science and Technology to both male and female students, as it supports effective retention of knowledge irrespective of gender. The slight difference observed in retention scores between males and females indicates that the strategy benefits all learners nearly equally.

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