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Computer Simulation and Expository Teaching Strategies on Students' Academic Achievement in Basic Science and Technology in Junior Secondary Schools

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Abstract **Original Research Article**

This study investigated on the effect of computer simulation and expository teaching strategies students' academic achievement in Basic Science and Technology in junior secondary schools in Eket Local Government Area of Akwa Ibom State. The study adopted a quasi-experimental design, specifically a pretest-posttest non-randomized design. The population of the study consisted of 1755 Junior Secondary Two (JS2) Basic Science and Technology students in the ten (10) public secondary schools in the study area. A sample of 95 JS2 students (43 males and 76 females) was drawn from two coeducational schools participating in the study. Two secondary schools out of the ten in the study area were chosen using a simple random sampling method. Data were collected using the Basic Science and Technology Achievement Test (BSTAT). The reliability of the instrument was assessed using the Kuder Richardson formula (K-R20), yielding a reliability coefficient of 0.84. The gathered data underwent coding, and the research question was addressed through calculations of mean and standard deviation. Hypotheses were subsequently tested at a 0.05 level of significance using Analysis of Covariance (ANCOVA). The study's findings indicated a significant difference in the achievement mean scores of Basic Science and Technology students taught the solar system and space using computer simulation or expository teaching strategies. No significant difference was observed in the achievement mean scores between male and female Basic Science and Technology students who received instruction on the solar system and space. The research concluded that instructional methods are a crucial factor in shaping students' academic achievement in Basic Science and Technology, especially when dealing with abstract and intricate topics like the solar system and space. Among other recommendations, it was suggested that teachers integrate computer simulation teaching strategies into their pedagogical approaches to enhance students' understanding and engagement with science topics.

Keywords: Computer Simulation, Expository, Teaching Strategies, Academic Achievement Basic Science and Technology.

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INTRODUCTION

Science and technology play an indispensable role in national development, innovation, and global competitiveness. For a nation like Nigeria to secure its place in the global knowledge economy, the foundation must be laid through high-quality science education at the basic level. Science education remains a cornerstone of sustainable national development, particularly in technologically aspiring nations like Nigeria. Basic Science and Technology (BST) forms the bedrock of science education, being a subject delivered at the primary and junior secondary levels with the aim of cultivating scientific literacy, technological understanding, and critical thinking abilities. The curriculum for Basic Science and Technology, implemented at the primary and junior secondary stages, seeks to impart scientific literacy and process skills vital for continuous learning, civic engagement, and contributions to technological progress (Federal Republic of Nigeria, 2014). BST acts as a foundational subject, supporting the subsequent learning of other science disciplines such as Chemistry, Physics, and Biology at the senior secondary and tertiary education levels.

The BST curriculum emphasizes the development of scientific process skills, including observation, classification, experimentation, inference, and interpretation of data. These skills enable students to navigate their physical and social environments confidently and intelligently (Chima, 2021).

According to Balaraba (2016), by introducing children to scientific knowledge early, BST aims to create a generation of individuals who can contribute meaningfully to sustainable development. BST is designed to equip learners with scientific process skills such as observation, classification, prediction, experimentation, and interpretation. These competencies are necessary for logical reasoning, problem-solving, and technological advancement (Babayemi, Akpan & Emah, 2018). BST not only enhances cognitive and psychomotor skills but also acts as a catalyst for students' interest in science-based careers, encouraging self-reliance and innovation. Chima (2021) noted that the BST curriculum is crucial for preparing Nigerian children to understand and adapt to scientific and technological changes in their environment. Likewise, Enemarie (2016) stressed that students' success in Basic Science and Technology is a strong indicator of their future performance in senior secondary science subjects, thus underlining BST's foundational significance.

However, despite the stated objectives and the importance of BST, students' academic achievement in the subject has remained below expectations. Reports from the National Examinations Council (NECO, 2023) and Basic Education Certificate Examination (BECE) consistently show low performance in science over the years, raising concerns about the effectiveness of teaching. A major challenge contributing to this underachievement is the widespread use of traditional teaching methods, especially the expository approach. This method is teacher-centered and typical of lectures and rote memorization, often failing to actively involve students in meaningful learning experiences. Although it allows for covering a lot of content quickly, it does not foster deep understanding, inquiry, or critical thinking (Babayemi & Ahmed, 2019).

Expository teaching strategy, though widely practiced in Nigerian schools due to its simplicity and coverage efficiency, is predominantly teacher-centered. It involves direct instruction through lecture, dictation, and repetition, often leaving minimal room for student participation, inquiry, or exploration (Guy & Lownes-Jackson, 2015). While the method may support quick content delivery, it has been criticized for limiting higher-order thinking, creativity, and real-world application of knowledge (Umanah & Sunday, 2022). This ongoing reliance on expository teaching, despite its limitations, has proven insufficient for developing the critical thinking, creativity, and practical skills needed in today's rapidly changing scientific and technological world. As a result, there is a growing demand within the education sector for more dynamic, interactive, and student-centered approaches that meet 21st-century learning needs. This paradigm shift has positioned Information and Communication Technology (ICT) as a leading catalyst for innovative pedagogical approaches in science education.

In response, the integration of Information and Communication Technology (ICT) into science education has gained significant momentum, offering innovative instructional strategies such as computer simulation. Computer simulations teaching strategy provide interactive, visual, and exploratory environments that help bridge the gap between abstract scientific concepts and students' understanding. Computer simulations teaching strategy offer dynamic and interactive models of scientific phenomena, enabling students to manipulate variables, visualize complex concepts, and test hypotheses in a risk-free virtual environment (Seoane, Greca, & Arriassecq, 2020; Olorukooba, Sani, & Kazeem, 2016). These simulations allow learners to observe cause-and-effect relationships, reinforce learning through repetition, and engage in self-paced inquiry.

Empirical studies have affirmed the efficacy of simulation-based instruction in various science domains. For instance, Umoetuk, Atabang, and Babayemi (2025) observed a notable variation in the average achievement scores among Basic Science and Technology students when instructed on living and non-living things using computer simulation, tutorials, and flipped classroom approaches. Sunday, Umanah, & Udofia, (2025) reported that in Chemistry, computer-based molecular modelling was found to significantly improve students' understanding of chemical reactions compared to the traditional method. Their research indicated that students who learned through computer-based molecular modeling achieved significantly better post-test scores than those who received instruction via the expository method. Similarly, the use of simulation in BST has shown promise. Lasisi, Oti, Arowolo, Agbeyenku, and Ojoko (2021) and Omoedu, Adolphus, and Agbigo (2022) reported higher retention and performance among students taught with simulations in difficult science topics.

Beyond cognitive gains, simulation-based learning environments appear to be gender-inclusive. While some older studies have suggested gender-based disparities in science achievement, recent evidence shows that interactive digital strategies minimize such gaps. Voyer & Voyer (2014) reported male superiority in science achievement while others reported better outcomes for females under specific pedagogical conditions (Gambari, Bello, Agboola, & Adeoye, 2016). Nevertheless, current research suggests that carefully designed digital instructional strategies, including computer simulation, often equalize academic performance, resulting in no notable achievement gaps between male and female students (Umoetuk, Atabang, & Babayemi, 2025; Umanah & Akpan, 2024; Sunday & Edet, 2024). Similarly, Umanah and Sunday (2025); Umoteuk and Akpan (2023) found no significant effect of gender on academic performance. This indicates that such teaching strategies offer equitable learning opportunities, fostering inclusive classrooms where both genders thrive.

Despite the varied conclusions concerning gender and the encouraging results linked to computer simulation, there is a distinct lack of localized empirical research evaluating the effectiveness of computer simulation versus expository teaching methods within Basic Science and Technology instruction, especially in Nigerian junior secondary schools. Moreover, few studies have explored the interplay between these instructional strategies and gender in shaping students' academic performance in Basic Science and Technology topics like 'the solar system and space. This void in existing

literature highlights the importance of the current investigation, which aims to comparatively evaluate the influence of computer simulation and expository teaching strategies on students' academic achievement in Basic Science and Technology, concurrently exploring the moderating role of gender. The findings are expected to inform evidence-based instructional practices that promote equitable and effective science education in Nigerian classrooms. Furthermore, by contextualizing empirical findings within a real-world educational environment, this research contributes to the growing literature on innovative science teaching strategies and supports the advocacy for equitable, inclusive, and technology-enhanced learning in Nigerian classrooms.

STATEMENT OF THE PROBLEM

In Nigeria's junior secondary education system, Basic Science and Technology (BST) functions as a fundamental component, aiming to impart scientific literacy, critical thinking abilities, and practical problem-solving competencies crucial for national progress. Notwithstanding its strategic significance, students' academic outcomes in Basic Science have shown a persistent pattern of underperformance, a fact underscored by reports from the National Examinations Council (NECO, 2023) and the West African Examinations Council (WAEC). These trends of underachievement have raised serious concerns about the effectiveness of prevailing instructional methods in facilitating students' understanding of critical scientific concepts. One of the main teaching methods used in Nigerian schools is the expository teaching strategy, characterized by lecture-based, teacher-centered delivery. While this method allows for structured and time-efficient content dissemination, it often limits student engagement, inquiry, and conceptual mastery, particularly in abstract or spatially complex topics. Such limitations hinder learners from developing scientific thinking and visualization skills, which are critical in grasping planetary motion, gravitational forces, and other celestial phenomena. To address these instructional difficulties, academics and educators have progressively championed the incorporation of Information and Communication Technology (ICT)-based teaching strategies, including computer simulation, computer tutorials, and computer-based molecular modeling, all of which offer interactive, dynamic, and immersive learning experiences. However, despite the promising evidence supporting ICT-based innovative teaching strategies as an effective teaching strategy, a considerable void persists in local research that contrasts the efficacy of computer simulation and expository teaching methods for complex BST subjects such as 'the solar system and space' among Nigerian junior secondary school students. Furthermore, limited investigations have examined how instructional strategies and gender interact to impact students' academic performance in Basic Science within this specific educational setting. The absence of empirical data from regional contexts like the Eket Local Government Area in Akwa Ibom State further widens this knowledge deficit. Consequently, this research aims to address this gap by conducting a comparative inquiry into the effects of computer simulation and expository teaching strategies on junior secondary school students' academic achievement in Basic Science and Technology, specifically focusing on the topic 'the solar system and space,' alongside an analysis of gender's moderating role. The findings from this study are anticipated to offer evidence-informed recommendations for educational reforms, encourage gender-equitable practices, and enhance the provision of science education in Nigeria.

RESEARCH OBJECTIVES

This study's objective is to ascertain the impact of computer simulation and expository teaching strategies on students' academic achievement in Basic Science and Technology in Eket Local Government Area of Akwa Ibom State. More precisely, the research aimed to:

1. Determine the difference in the achievement mean scores of Basic Science and Technology students taught the solar system and space using computer simulation and expository teaching strategies.
2. Determine the difference in the achievement mean scores of male and female Basic Science and Technology students taught the solar system and space.

RESEARCH QUESTIONS

The study was guided by the following research questions:

1. What is the achievement mean scores of Basic Science and Technology students taught the solar system and space using computer simulation and expository teaching strategies?
2. What difference exist in the achievement mean scores of male and female Basic Science and Technology students taught the solar system and space?

HYPOTHESES

The subsequent null hypotheses were tested at a 0.05 significance level:

1. No significant difference exists in the achievement mean scores of Basic Science and Technology students taught the solar system and space using computer simulation and expository teaching strategies.
2. No significant difference exists in the achievement mean scores of male and female Basic Science and Technology students taught the solar system and space.

METHODS

A quasi-experimental design, specifically a pretest-posttest non-randomized approach, was employed for this study. The research was carried out in the Eket Local Government Area, Akwa Ibom State, Nigeria. The population for this study encompassed 1755 Junior Secondary Two (JS2) Basic Science and Technology students enrolled in the ten public secondary schools within the research vicinity. A

sample of 95 JS2 students, comprising 43 males and 76 females, was drawn from two coeducational schools included in the study. A simple random sampling technique was utilized to select two secondary schools from the ten available in the study area. Of the two selected schools, one was designated as the experimental group and the other as the control group. The Basic Science and Technology Achievement Test (BSTAT) served as the data collection instrument. This 20-item, four-option multiple-choice test (options A-D) was developed by the researcher and focused on the concept of 'the solar system and space' within Basic Science and Technology. For validation purposes, the instrument was reviewed by two lecturers specializing in Integrated Science Education and a measurement and evaluation expert from the Department of Science Education at Akwa Ibom State University. A pilot test of the instrument was conducted with a sample of 30 Junior Secondary Two (JS2) Basic Science and Technology students.

The researcher developed two lesson packages. One for the computer simulation group and one for expository group. The lesson package for computer simulation was prepared in such a way that it was compatible with most computer operating systems and therefore can be used with a variety of computers. The computers used were install with simulation packages which was able to display the solar system and space as well as simulate the process. The computer programs consisted of simulation, tutorials, videos and audios based on the requirement of each of the teaching strategies. The lesson packages also contained a set of quizzes, exercises and assignments at the end of each content. The lesson package on expository was prepared based on the requirement of expository method. The lesson as effectively carried out in the respective groups. To assess students' Basic Science and Technology achievement both prior to and following the interventions, the achievement test was administered as a pretest and post-test to both the experimental and control groups. The scores were subjected to analysis using the Kuder Richardson formula (K-R20), yielding a reliability coefficient of 0.84. The gathered data were coded, and the research questions were addressed using mean and standard deviation. The hypotheses were subsequently tested at a 0.05 significance level via Analysis of Covariance (ANCOVA).

RESULTS

Research Question One: What is the achievement mean scores of Basic Science and Technology students taught the solar system and space using computer simulation and expository teaching strategies?

Table 1: Summary of mean and standard deviation of achievement mean scores of students on pretest posttest based on teaching strategies

Teaching Strategies	n	Pretest		Posttest		Mean Gain
		Mean	Sd	Mean	Sd	
Computer Simulation	45	5.40	1.94	15.48	3.25	10.08
Expository	50	5.76	1.50	12.49	2.96	6.73

The Table 1 analysis indicates that students who were taught the ‘solar system and space’ using computer simulation demonstrated more substantial gains in their achievement mean scores than those who were taught using expository method. Categorically, the computer simulation group's students began with a mean pretest score of 5.40, which then increased notably to a posttest mean of 15.48, resulting in a mean gain of 10.08. Conversely, students in the expository group registered a pretest mean of 5.76 and a posttest mean of 12.49, showing a mean gain of 6.73. This implies that although both instructional strategies proved effective in boosting student performance, computer simulation had a more pronounced impact on improving students' comprehension and achievement in Basic Science and Technology, especially concerning the solar system and space topic.

Research Question Two: What difference exist in the achievement mean scores of male and female Basic Science and Technology students taught the solar system and space?

Table 2: Mean and standard deviation of mean achievement scores between male and female students on pretest posttest scores based on teaching Strategies

Gender	N	Pretest		Posttest		Mean Gain
		Mean	SD	Mean	SD	
Male	43	5.72	1.47	14.0	3.53	8.28
Female	52	5.44	1.95	14.1	3.41	8.66

Table 2 presents the findings regarding the difference in achievement mean scores among male and female Basic Science and Technology students taught the ‘solar system and space’. The data indicate that male students achieved a mean

pretest score of 5.72, which subsequently rose to a posttest mean of 14.00, yielding a mean gain of 8.28. Female students, on the other hand, had a slightly lower pretest mean of 5.44 but achieved a higher posttest mean of 14.10, resulting in a mean gain of 8.66. While both male and female students exhibited considerable improvement in their achievement scores following instruction, the discrepancy in average gain between the two cohorts was negligible, with females marginally surpassing males. This implies that the instructional strategies employed yielded comparable benefits for both genders, showing no significant variation in their learning achievements.

Hypothesis One: No significant difference exists in the achievement mean scores of Basic Science and Technology students taught the solar system and space using computer simulation and expository teaching strategies.

Table 3: ANCOVA on the difference in the achievement mean scores of Basic Science and Technology students based on teaching strategies

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	215.015[a]	2	107.508	10.982	.000
Intercept	1496.593	1	1496.593	152.882	.000
Pretest	3.119	1	3.119	.319	.574
Teaching Strategies	214.942	1	214.942	21.957	.000
Error	900.606	92	9.789		
Total	19904.000	95			
Corrected Total	1115.621	94			

a. R Squared = .193 (Adjusted R Squared = .175); *p<.05

As indicated by the ANCOVA results in Table 3, the effects of teaching strategies on students' achievement was statistically significant, evidenced by an F-value of 21.957 and a p-value of .000, which is below the 0.05 significance threshold. This outcome signifies that the chosen teaching strategies notably impacted students' achievement scores. Therefore, the null hypothesis one is rejected. Based on the earlier descriptive statistics, students taught using computer simulation recorded a higher mean achievement gain compared to those taught with the expository method. Therefore, the significant result points towards computer simulation being a more effective strategy for enhancing students' academic performance in Basic Science and Technology, specifically for the topic of the solar system and space. Accordingly, a significant difference exists in the achievement mean scores of Basic Science and Technology students instructed on the solar system and space through computer simulation versus expository teaching strategies.

Hypothesis Two: No significant difference exists in the achievement mean scores of male and female Basic Science and Technology students taught the solar system and space.

Table 4: ANCOVA on the difference in achievement mean scores of male and female Basic Science and Technology students based-on teaching strategies

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.697[a]	2	.349	.029	.972
Intercept	1624.039	1	1624.039	134.011	.000
Pretest	.111	1	.111	.009	.924
Gender	.624	1	.624	.052	.821
Error	1114.924	92	12.119		
Total	19904.000	95			
Corrected Total	1115.621	94			

a. R Squared = .001 (Adjusted R Squared = -.021); *p>.05

Table 4's ANCOVA results indicate that the influence of gender on students' achievement was not statistically significant, with an F-value of 0.052 and a p-value of .821, exceeding the 0.05 significance level. This suggests that gender had no substantial impact on students' academic outcomes. Therefore, the null hypothesis is retained. The outcome's pattern reveals that both male and female students gained comparably from the applied instructional strategies, exhibiting no considerable divergence in their achievement scores.

DISCUSSION OF FINDINGS

The analysis of achievement score differences among Basic Science and Technology students, regarding instruction

on the solar system and space via computer simulation and expository teaching strategies, indicated that the chosen teaching method significantly affected students' academic performance. In particular, students instructed with computer simulation demonstrated superior performance compared to those who learned through the expository method. This indicates that the use of interactive and visually engaging tools like simulations can enhance students' understanding and retention of scientific concepts more effectively than traditional lecture-based approaches. This finding aligns with Umoetuk, Atabang, and Babayemi (2025), who documented a significant variation in the average achievement scores of Basic Science and Technology students taught about living and non-living things using computer simulation, tutorials, and flipped classroom methods. Moreover, the outcome is consistent with Sunday, Umanah, and Udofia (2025), who observed that students instructed with computer-based molecular modeling achieved notably higher performance than those taught through expository method.

Conversely, the analysis of achievement score differences between male and female Basic Science and Technology students, when taught the solar system and space using computer simulation and expository teaching strategies, revealed no significant disparity in the achievement of male and female students exposed to identical instructional strategies. This suggests that both male and female students demonstrated comparable academic performance, irrespective of the teaching methodology employed. The finding suggests that gender does not influence the effectiveness of either computer simulation or expository teaching methods, and both groups are equally capable of benefiting from these instructional approaches. This finding corroborates previous research by Umanah and Sunday (2025) and Umoteuk and Akpan (2023), which also reported no significant impact of gender on academic performance.

CONCLUSION

Drawing from this study's findings, it can be concluded that the instructional methodology significantly influences students' academic achievement in Basic Science and Technology, particularly when presenting abstract and complex topics like the solar system and space. Computer simulation, when utilized as a teaching strategy, proved notably more effective than the conventional expository method. This suggests that simulation-based instruction, which often includes interactive visualizations and real-time feedback, helps to simplify difficult scientific concepts, sustain learners' attention, and promote active participation, all of which contribute to improved academic performance. The research also determined that gender does not significantly affect students' achievement when exposed to either instructional method, suggesting that both male and female students can derive equal benefits from innovative teaching strategies. Therefore, the integration of computer simulation into science teaching is not only effective but also inclusive, making it a valuable tool for improving science education outcomes across diverse student populations. These results emphasize the necessity of transitioning from traditional, teacher-centric methods to more technology-enhanced, student-focused approaches to align with the requirements of 21st-century science education.

RECOMMENDATIONS

In light of the findings, the subsequent recommendations are put forth:

1. Teachers are encouraged to **incorporate computer simulations** teaching strategy into their pedagogical approaches to improve students' comprehension and interest in science topics.
2. **School administrators should provide digital teaching resources**, including access to simulation software and supporting infrastructure, to enhance the quality of science education.
3. **Training and professional development programs** for teachers should focus on equipping them with the skills needed to effectively integrate computer-based instructional strategies.

Curriculum developers should integrate educational technologies like simulations into the Basic Science and Technology curriculum to foster digital literacy and enhance learning achievements.

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