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Effect of Computer Simulation Instruction on Biology Students' Performance and Retention in Ecosystem in Kaduna North, Nigeria

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Abstract

The study determined the effect of computer simulation instruction on students' performance and retention in Biology in Kaduna North. The study was guided by two research questions and two hypotheses. This study employed quasi-experimental control group design involving pre-test, post-test and post post-test control group design. The population of the study comprised all 14,951 (6746 males and 6746 females) SS 2 Biology students in 17 public Secondary Schools in Kaduna North Local Government Area. A sample of 177 students was selected for the study using multistage sampling procedure. The instrument for data collection is an Ecosystem achievement test which was validated and with a reliability index of 0.85. The experimental procedure lasted 6 weeks. Collected was analysed using mean, standard deviation and ANCOVA. Findings revealed that: the experimental group taught with computer simulation instruction (CSI) had a better mean gain in performance and retention than their counterpart taught using lecture method. However, there is a significant difference in the mean performance of students taught Biology using CSI and those taught using lecture method but no significant difference in their mean retention scores. The study recommended that: Biology teachers should integrate computer simulation instruction into regular classroom teaching to enhance the effectiveness of Biology instruction and support better learning outcomes among students.

Keywords: Computer Simulation Instruction, Biology, Performance, Retention, Kaduna North

Introduction

Biology is a core science subject in the Nigerian secondary school curriculum and provides a foundation for careers in medicine, pharmacy, nursing, agriculture and environmental sciences. It is the science that deals with the study of living organisms and their life processes (Abidoye, 2023; Olayinka, 2023). Biology equips learners with knowledge and skills required for understanding health, food production and environmental sustainability (Akinwumi & Falemu, 2020). However, many Biology concepts are abstract and difficult for students to understand when taught through conventional instructional approaches such as lecture method (Eze & Nworgu, 2023). These challenges have continued to affect students' performance and retention in Biology and have generated concern among educators and examination bodies.

Biology as a life science is central to understanding the natural world and serves as the bedrock for many scientific and technological fields such as biotechnology, medicine and environmental management. It contributes to national development by providing solutions to problems related to disease control, food security and environmental conservation (Odu & Ozurumba, 2022; Olayinka, 2023). Through the study of Biology, students develop scientific literacy and problem solving skills that are necessary for addressing real life challenges (Adebayo, Modupe & Tokunbo, 2025). Mastery of Biology therefore prepares learners for productive participation in science related professions and promotes technological growth in society (Akinwumi & Falemu, 2020).

Despite the importance of Biology, reports from external examinations show persistent low performance among secondary school students. Evidence from West African Senior School

Certificate Examination results indicates that a large proportion of candidates record low scores in Biology, thereby limiting their chances of pursuing Biology related courses in higher institutions (WAEC, 2023). Similar trends have been observed in National Examination Council results (NECO, 2022). This situation suggests that the objectives of Biology education at the secondary school level are yet to be fully realised, particularly with respect to students' performance and retention of learned concepts.

Poor performance of students in Biology has remained a major concern to researchers and examination bodies. Studies have shown that students' performance in Biology is generally low and inconsistent across years (Bichi, Ibrahim & Ibrahim, 2019; Aniaku & Nwankwo, 2024). Chief examiners' reports have also revealed that many students demonstrate weak understanding of key concepts and show poor ability to apply learned knowledge in examination situations (WAEC, 2023). This pattern of underperformance underscores the need for continuous search for more effective instructional strategies for teaching Biology.

Several factors have been identified as contributors to students' poor performance in Biology. These include continued use of teacher centred instructional strategies, inadequate laboratory facilities, overcrowded classrooms, poor study habits and limited integration of information and communication technology in instruction (Eze, Nwankwo & Ugwuanyi, 2024; Eze & Nworgu, 2023). Lecture method, which dominates classroom practice, presents Biology concepts mainly through verbal explanation and provides limited opportunity for visualisation and interaction with content. This approach makes it difficult for students to form clear mental representations of biological processes and to retain learned information over time (Adelana, Ajose & Ishola, 2023).

Computer simulation instruction has been proposed as an instructional strategy that can address some of these challenges. Computer simulation instruction uses digital models to represent biological structures and processes that are difficult to observe directly, thereby reducing abstraction in learning (Smetana & Bell, 2018). Through computer simulation instruction, learners are able to manipulate variables, observe outcomes and actively engage with subject matter, which can enhance conceptual understanding and promote retention (Abdulrahaman et al., 2020; Yusuf & Afolabi, 2019). This approach aligns with contemporary views of learning that emphasise active participation and meaningful interaction with instructional content.

Research evidence has shown that computer simulation instruction can improve students' performance in science subjects when compared with conventional lecture method (Owusu, Monney & Appiah, 2020; Yusuf & Afolabi, 2019). However, findings on the effect of computer simulation instruction on retention are mixed, with some studies reporting significant improvement and others indicating no clear difference when compared with lecture method (Abdulrahaman et al., 2020; Smetana & Bell, 2018). Moreover, empirical studies on the use of computer simulation instruction in Nigerian secondary schools remain limited, particularly in Northern Nigeria and in Kaduna North in particular.

The continued low performance and retention of students in Biology, coupled with the dominant use of lecture method in classroom practice, suggest the existence of an instructional gap that requires empirical investigation. There is therefore a need to determine whether computer simulation instruction can provide a more effective alternative to lecture method in improving students' learning outcomes in Biology. Kaduna North, like many other educational zones in Nigeria, faces challenges related to inadequate instructional resources and reliance on traditional teaching methods, which may contribute to students' learning difficulties.

Consequently, innovative instructional strategies such as computer simulation instruction have been advocated as possible means of improving Biology teaching and learning. These strategies are believed to enhance understanding by presenting concepts in visual and interactive forms that promote active learning (Smetana & Bell, 2018). However, the effectiveness of computer simulation instruction in improving students' performance and retention in Biology has not been sufficiently established in Kaduna North, Nigeria. This lack of adequate empirical evidence constitutes a gap in both practice and literature. It is against this background that the present study determined the effect of computer simulation instruction on Biology students' performance and retention in Kaduna North, Nigeria.

Research Questions

1. What is the difference in the mean academic performance scores of students taught Biology using CSI and those taught using lecture method?
2. What is the difference in the mean retention scores of students taught Biology using CSI and those taught using lecture method?

Hypotheses

The following null hypotheses were formulated and tested at P≤0.05 level of significance.

Ho_1: There is no significant difference in the mean academic performance scores of students taught Biology using CSI and those taught using lecture method.

Ho_3: There is no significant difference in the mean retention scores of students taught Biology using CSI and those taught using lecture method.

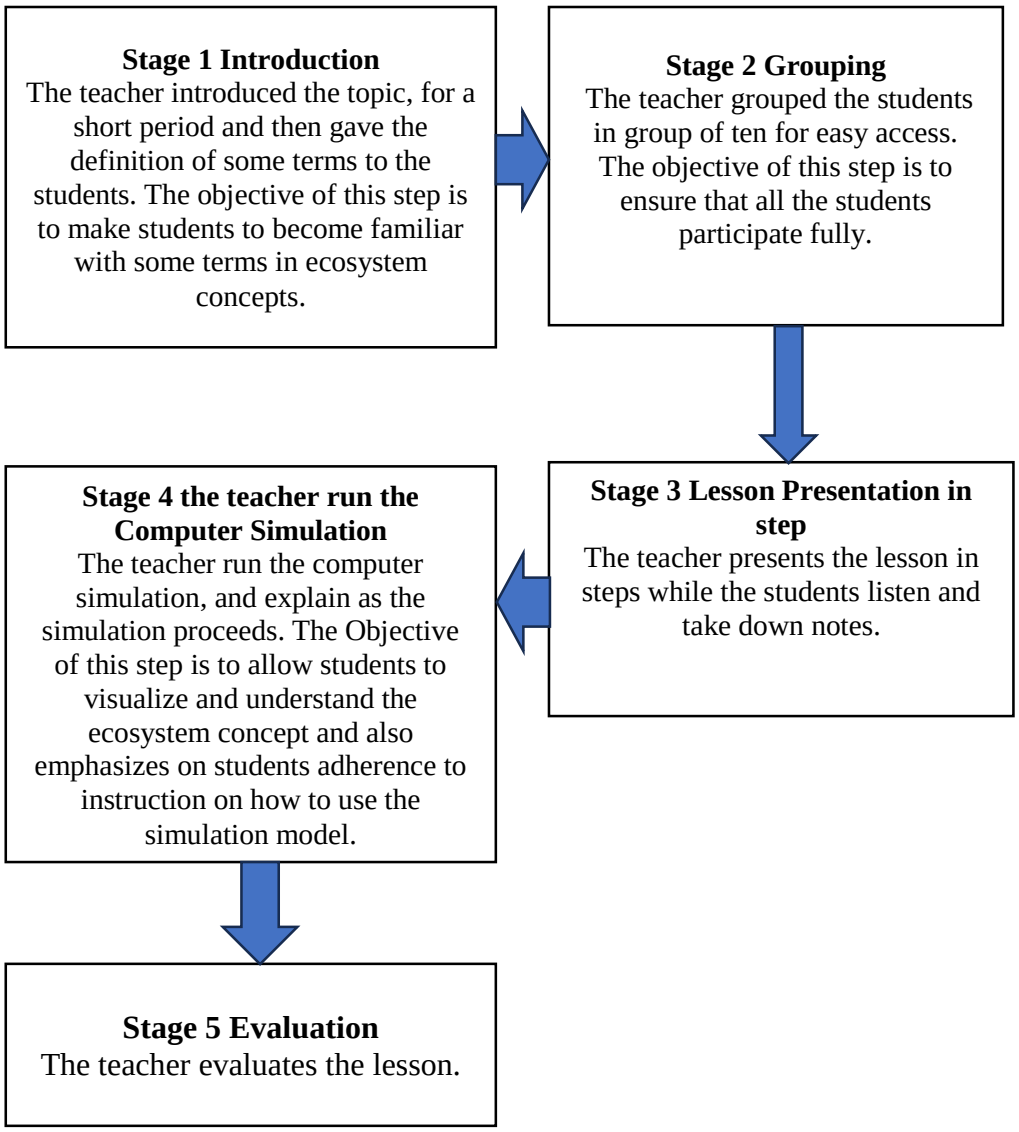
Methods

This study employed quasi-experimental control group design involving pre-test, post-test and post post-test control group design. The study used two groups: experimental and control groups. A pre-test (01) was administered to both experimental and control groups using same test instrument before treatment; the pre-test scores was used to determine the varied ability level of the students (high, average and low). The treatment (X1) was done by teaching ecosystem concepts to the experimental groups, using Computer Simulation Instruction (CSI) by showing the ecosystem simulation videos while the control group was exposed to the same concept using lecture method. The post-test (02) was given to test if the treatment is effective or not by exposing to EPT performance test. After two weeks, post post-test (O3) was administered to the students to determine their retention ability of ecosystem.

The population of the study comprised all 14,951 (6746 males and 6746 females) SS 2 Biology students in 17 public Secondary Schools in Kaduna North Local Government Area. A sample of 177 students was selected for the study using multistage sampling procedure. In the first stage, four public secondary schools were selected using purposive sampling technique. The criteria for purposiveness was that the schools will have a functioning and well-equipped computer laboratory (to allow the researcher implement the experimental package), have an ICT-proficient staff and a source of electricity. In stage two, one intact SS 2 Biology class was sampled using random sampling technique from each of the sampled schools. In the final stage, two SS 2 classes were assigned to the experimental group whereas the other two were assigned to the control group.

The instrument used for the purpose of this study is Ecosystem Performance Test (EPT) developed by the researcher and consisting of 50 multiple choice items. The items were adapted from past Senior School Certificate Examination (SSCE) question papers and covered the entire topic unit and was used in determining the performance of students prior and after treatment. Each of the 50 multiple choice items have four options, one correct answer and three plausible distractors. The items were developed based on Bloom's taxonomy of educational objectives. The content areas covered by the instrument are: Autotrophs and Heterotrophs, Components of Ecosystem, Food Chains and Food Web, and Trophic Level. Content validity was established for the instrument using the test blueprint, whereas face validation was established by three experts in the faculty of Education, Ahmadu Bello University, Zaria. The items in the EPT were reshuffled to obtain a retention test used to determine students' retention. The EPT was trial-tested on 30 Biology students outside the study area and a reliability index of 0.85 was obtained following K-20 analysis.

The experimental procedure lasted 6 weeks. Pretest instruments were administered before the treatment whereas posttest were administered after the treatment phase. The Lesson flowchart of Computer Simulation Instruction (CSI) used in this study is presented in Figure 1 below:



In control group, students were taught the ecosystem using lecture method. This involves verbal presentation of the concepts to the leaners. The students are expected to listen to the teacher and take down note presented on the chalk board. Students were allowed to ask questions at intervals and the teacher responded to the students' questions. Collected data was analysed using mean, SD and ANCOVA in SPSS v. 25.

Results

Results from the analysis of data collected for this study are presented in tables below.

Table 1: Mean effect of CSI on students' performance in Biology.

Group		Pre-Test		Post-Test		Mean Diff.
	N	X	SD	X	SD	
Experimental Group	92	27.17	1.15	47.27	1.67	20.1
Control Group	85	26.67	1.15	29.23	4.47	2.56

Results on Table 1 shows that the experimental group taught with CSI had a better mean gain in performance than their counterpart taught using lecture method. This shows that CSI had more effect on students' performance in Biology (from 27.17 to 47.27) than their counterparts in the control group (from 26.67 to 29.23).

Table 2: Summary of Analysis of Covariance (ANCOVA) for the effect of CSI on students' performance in Biology.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Dec.
Corrected Model	9.991[a]	5	1.998	1.751	0.13	
Intercept	171332.20	1	171332.20	150155.31	0.01	
Treatment	9.43	2	4.72	4.134	0.02	Sig.
Error	98.13	86	1.14			
Total	202491.00	92				
Corrected Total	108.120	91				

The result presented on Table 2 shows that there is a significant difference in the mean performance of students taught Biology using CSI and those taught using lecture method, F (1,92) = 4.134, p = .002.

Table 3: Mean effect of CSI on students' retention in Biology.

Group	N	Post-Test X	SD	Retention X	SD	Mean Diff.
Experimental Group	92	47.27	1.67	48.12	1.78	0.85
Control Group	85	29.23	4.47	28.00	2.52	-1.23

Results on Table 3 shows that the experimental group taught with CSI had a better mean gain in retention (0.85) than their counterpart taught using lecture method (-1.23). This shows that CSI had more effect on students' retention in Biology than lecture method.

Table 4: Summary of Analysis of Covariance (ANCOVA) for the effect of CSI on students' performance in Biology.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Dec.
Corrected Model	12.17[a]	5	2.43	1.032	0.40	
Intercept	118820.02	1	118820.02	50402.683	0.01	
Treatment	10.92	2	5.46	2.316	0.11	Not Sig.
Error	0.05	1	0.05	.020	0.89	
Total	202.74	86	2.36			
Corrected Total	140381.00	92				

The result presented on Table 4 shows that there is no significant difference in the mean retention of students taught Biology using CSI and those taught using lecture method, F (1,92) = 2.316, p = .011.

Discussion of Findings

The study revealed that the experimental group taught with computer simulation instruction had a better mean gain in performance than their counterpart taught using lecture method. It also shows that there is a significant difference in the mean performance of students taught Biology using computer simulation instruction and those taught using lecture method. This means that computer simulation instruction improved students' performance in Biology more than the lecture method. It implies that exposing students to interactive and visual representations of Biology concepts supports better understanding and retention of content. It also implies that teaching Biology with computer simulation instruction creates learning conditions that lead to higher mean performance than relying only on lecture method.

This finding may be due to the ability of computer simulation instruction to present abstract Biology concepts in concrete and visual forms, which helps students observe processes that cannot be easily demonstrated in real classrooms. It may also be due

to increased learner engagement and opportunity for repeated practice during instruction. The finding agrees with Yusuf and Afolabi (2019), who found that students taught Biology using computer simulation instruction recorded higher mean performance than those taught using lecture method. It also agrees with Smetana and Bell (2018), who reported that computer simulation instruction significantly improved students' performance in science subjects when compared with lecture method. However, the finding does not completely agree with Kirschner, Sweller and Clark (2018), who found no significant difference in the mean performance of students taught with computer simulation instruction and those taught using lecture method when strong teacher guidance was provided. It also does not completely agree with Owusu, Monney and Appiah (2020), who reported that lecture method produced comparable mean performance with computer simulation instruction in Biology when instructional time and content coverage were controlled.

The study also revealed that the experimental group taught with computer simulation instruction had a better mean gain in retention than their counterpart taught using lecture method. It also shows that there is no significant difference in the mean retention of students taught Biology using computer simulation instruction and those taught using lecture method. This means that students exposed to computer simulation instruction remembered Biology concepts slightly better than those taught using lecture method, but the difference in their mean retention was not large enough to be statistically significant. It implies that computer simulation instruction and lecture method were both effective in supporting retention of Biology content. It also implies that the advantage of computer simulation instruction in improving retention was not strong enough to produce a clear difference when compared with lecture method.

This finding may be due to the fact that both computer simulation instruction and lecture method presented the same Biology content and learning objectives, which allowed students in both groups to store information in memory. It may also be due to the short duration of exposure to computer simulation instruction, which may not have been sufficient to create a strong difference in mean retention. The finding agrees with Owusu, Monney and Appiah (2020), who found that there was no significant difference in the mean retention of students taught Biology using computer simulation instruction and those taught using lecture method. It also agrees with Abdulrahaman, Faruk, Oloyede and Surajudeen-Bakinde (2020), who reported that computer simulation instruction and lecture method produced similar levels of retention among science students. However, the finding does not completely agree with Smetana and Bell (2018), who found that computer simulation instruction significantly improved students' retention of science concepts when compared with lecture method. It also does not completely agree with Yusuf and Afolabi (2019), who reported that students taught Biology using computer simulation instruction had significantly higher mean retention than those taught using lecture method.

Conclusion

Computer simulation instruction provides a more effective instructional approach for Biology teaching and learning than the often relied upon lecture method. The evidence from the study indicates that computer simulation instruction creates learning conditions that support stronger conceptual understanding and more stable learning outcomes among secondary school students. This suggests that Biology teaching practices should incorporate technology based instructional strategies that promote active interaction with subject matter. The study therefore establishes computer simulation instruction as a viable and pedagogically sound strategy for improving the quality of Biology teaching and learning in secondary schools.

Recommendations

The study recommends that:

1. Biology teachers should integrate computer simulation instruction into regular classroom teaching to enhance the effectiveness of Biology instruction and support better learning outcomes among students.
2. School administrators should provide adequate computer facilities and simulation software to enable the practical implementation of computer simulation instruction in secondary school Biology classrooms.
3. Teacher training institutions and professional development programmes should include computer simulation instruction as part of their instructional skills training for Biology teachers.
4. Curriculum planners should formally incorporate computer simulation instruction into the Biology curriculum as an approved instructional strategy to complement the lecture method and improve teaching quality.

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