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EFFECT OF MULTIMEDIA INSTRUCTION ON PERFORMANCE IN RESPIRATORY SYSTEM CONCEPT AMONG BIOLOGY STUDENTS IN ZARIA EDUCATION ZONE, KADUNA STATE, NIGERIA

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Abstract

This study examined the effect of multimedia instruction on students' performance in the respiratory system concept among Biology students in Zaria Education Zone, Kaduna State, Nigeria. Two research objectives, questions, and hypotheses guided the study. A quasi-experimental non-randomized pretest–posttest control group design was adopted. The population comprised 3,709 SS II Biology students in public co-educational secondary schools within the study area. A sample of 138 students (56 males and 82 females) selected from two schools participated using purposive and simple random sampling techniques, while intact classes were used for the experiment. Data were collected using the Respiratory System Performance Test (RSPT), validated by experts and found reliable with a Pearson Product-Moment Correlation coefficient of 0.85. The experimental group was taught using multimedia instruction, while the control group received the conventional lecture method. The treatment lasted six weeks. Data were analysed using mean and standard deviation to answer the research questions, while Analysis of Covariance (ANCOVA) and Independent Samples t-test were used to test the hypotheses at a 0.05 level of significance. Findings revealed that students exposed to multimedia instruction performed significantly better than those taught using the lecture method, and pretest scores significantly predicted students' post-test performance. Gender had no significant effect on students' performance. The study concluded that multimedia instruction enhances students' academic performance in Biology more effectively than the conventional method, and offers an equitable learning environment for both male and female students. It is recommended that biology teachers should adopt multimedia instructional strategies, and relevant stakeholders should invest in teacher training and the provision of multimedia facilities in schools.

Keywords: Multimedia Instruction, Academic Performance, Respiratory System, Biology, Quasi-experimental Design, Senior Secondary School.

Introduction

Biology is the branch of natural science concerned with the study of life and living organisms, including their structure, functions, growth, and interactions with the environment (Fantini et al., 2024). The subject contributes significantly to scientific and technological advancement through its applications in health, agriculture, biotechnology, and environmental sustainability (Afolabi & Oba, 2024; Zaman, 2024; Lea-Smith et al., 2025). As a core science subject, biology also promotes scientific literacy, problem-solving skills, and critical thinking among learners. One important concept in biology is the respiratory system, which enables the exchange of gases by supplying oxygen to body cells and removing carbon dioxide from the body. The respiratory system consists of organs such as the nose, pharynx, larynx, trachea, bronchi, bronchioles, and alveoli that function together to ensure effective respiration. Oxygen obtained through respiration is essential for the production of adenosine triphosphate (ATP), the major source of cellular energy, while carbon dioxide is removed as a waste product (StatPearls, 2023).

Despite the importance of the respiratory system, many secondary school students perceive the concept as difficult because several processes, such as gaseous exchange and cellular respiration, are abstract and occur at microscopic levels that cannot be directly observed. As a result, students often experience difficulty understanding the concept when taught using conventional lecture methods, leading to poor academic performance in biology. Academic performance refers to the level of achievement demonstrated by students in tests, assignments, and examinations, reflecting their understanding and application of learned concepts (Shuaib et al., 2023; Eneda & Ude, 2024). Students' academic performance is influenced by factors such as instructional methods, learning environment, and the availability of instructional resources. Consequently, the use of effective instructional strategies is necessary for improving students' understanding and performance in biology.

In Nigeria, the National Policy on Science and Technology Education advocates the integration of Information and Communication Technology (ICT) and multimedia instructional tools into classroom teaching and learning to improve science education (FRN, 2013). Multimedia instruction involves the use of text, graphics, audio, videos, animations, and simulations to facilitate learning and make abstract concepts more concrete and interactive. Studies have shown that multimedia instructional strategies enhance students' understanding and academic performance in biology by promoting active engagement and better conceptual understanding (Candido & Cattaneo, 2025; Nkwocha, 2023).

Although previous studies have examined the effectiveness of multimedia instruction in science education, poor performance in biology concepts, such as the respiratory system, continues to persist among secondary school students. Furthermore, limited studies have specifically investigated the effect of multimedia instruction on students' performance in respiratory system concepts among biology students in Zaria Education Zone, Kaduna State, Nigeria. Therefore, this study investigated the effect of multimedia instruction on students' performance in respiratory system concepts among biology students in Zaria Education Zone, Kaduna State, Nigeria.

Statement of the Problem

Despite the central role of Biology in science education, secondary school students in Nigeria continue to perform poorly in abstract concepts such as the respiratory system. This persistent poor performance has been linked to the continued use of conventional teacher-centred instructional methods that inadequately engage students and fail to make complex biological concepts accessible (Nkwocha, 2023; Ezechi & Anyanwu, 2022). Concepts related to the respiratory system involve dynamic processes that are often difficult for students to visualise and understand through lecture and textbook-based instruction alone.

Scholars have argued that multimedia instructional strategies involving videos, animations, simulations, and interactive visuals can improve students' understanding of difficult scientific concepts by providing clearer representations of abstract processes (Kassa et al., 2024). Studies on multimedia-integrated instruction in Biology have reported significant improvements in students' academic achievement compared to conventional teaching methods (Kassa et al., 2024).

Despite these promising findings, empirical evidence on the effect of multimedia instruction on students' performance in respiratory system concepts among Biology students in the Zaria Education Zone, Kaduna State, Nigeria, remains limited. Most existing studies in Nigeria have focused on other Biology topics rather than the respiratory system concept. Therefore, the problem of this study is the persistent poor performance of students in respiratory system concepts and the limited local evidence on the effectiveness of multimedia instruction in improving students' performance in the study area.

Objectives of the Study

The main objective of the study is to determine the effect of multimedia instruction on performance in the respiratory system concept of biology among senior secondary school students in Zaria Education Zone, Kaduna State, Nigeria. The specific objectives are:

1. Determine the effect of multimedia Instruction on Performance in Respiratory system concepts of Biology among senior secondary school students.
2. Examine the effect of multimedia Instruction on performance in the respiratory system concept among male and female students.

Research Questions

The following research questions guided the study:

1. What is the mean difference between students' Performance scores when taught the Respiratory System concept in senior secondary using Multimedia Instruction and the Conventional Method?
2. What is the mean score difference between the performance of male and female Secondary School students taught Respiratory System concepts of Biology using Multimedia Instruction?

Hypotheses

The following null hypotheses were formulated and tested at the 0.05 level of significance:

Ho_1: There is no significant difference between the mean Performance scores of students taught the respiratory system using Multimedia Instruction and those taught using the conventional lecture method.

Ho_2: There is no significant difference between the Performance scores of male and female students taught the Respiratory system using multimedia Instruction.

Methodology

This study adopted a non-randomised pretest-posttest quasi-experimental design involving an experimental group and a control group (Biu et al., 2025; Yusuf et al., 2026). The design was considered suitable because intact classes were used without random assignment of students. The experimental group was taught using multimedia animation and video-based classroom discussions, while the control group received instruction through the conventional lecture method. The study was guided by two research questions and two null hypotheses. The population of the study comprised 3,709 Senior Secondary School II (SS II) Biology students in Zaria Education Zone, Kaduna State. A sample of 138 students (56 males and 82 females) was selected using purposive and simple random sampling techniques. The Respiratory System Performance Test (RSPT), adapted based on the SS II Biology curriculum, was used for data collection. The instrument was validated by three experts from the Department of Science Education. Item analysis was conducted using the Facility Index (FI) and Discrimination Index (DI), with acceptable ranges of 0.30–0.70 and 0.20–0.60, respectively. Reliability was established through a test-retest pilot study involving 58 students outside the study sample, and Pearson Product-Moment Correlation (PPMC) yielded a reliability coefficient of 0.85.

The RSPT was administered to both groups as a pre-test and post-test. During the treatment, the experimental group learned about the respiratory system using multimedia animation and instructional videos, while the control group was taught using the conventional lecture method. Data collected were analysed using appropriate descriptive and inferential statistics to answer the research questions and test the null hypotheses.

Results

This section presents the results of the data analysis based on the research questions and hypotheses formulated for the study. The findings were presented using descriptive statistics (mean and standard deviation) to answer the research questions, and inferential statistics, ANCOVA and Independent samples t-test were used to test the null hypotheses at a 0.05 level of significance.

Research Question One: What is the mean difference between students' Performance scores when taught the Respiratory System concept in senior secondary using Multimedia Instruction and the Conventional Method?

Table 1: Mean and Standard Deviations of Students' Academic Performance Scores in the Experimental and Control Groups

		Pretest		Posttest		
Groups	**N**	**M**	**SD**	**M**	**SD**	**MD**
Experimental	76	12.45	1.98	20.93	4.12	2.24
Control	62	12.79	1.86	18.69	3.18	

The results in Table 1 show that students in the Experimental group had a pretest mean score of 12.45 (SD = 1.98), while those in the Control group had a pretest mean score of 12.79 (SD = 1.86), indicating that both groups had relatively similar performance scores before treatment and were therefore comparable at baseline. After the intervention, the Experimental group obtained a post-test mean score of 20.93 (SD = 4.12), while the Control group recorded a post-test mean score of 18.69 (SD = 3.18), with a mean difference of 2.24, indicating that students taught using Multimedia Instruction performed better in the Respiratory System concept of Biology than those taught using the Lecture Method.

Hypothesis One: There is no significant difference between the mean Performance scores of students taught the respiratory system using Multimedia Instruction and those taught using the conventional lecture method.

Table 2: Analysis of Covariance (ANCOVA) of Post-test Scores of Students Taught Respiratory System Using the Multimedia Instruction and Conventional Lecture Method

Source	Type III Sum of Squares	f	Mean Square	F	Sig.
Corrected Model	301.441[a]	2	150.721	11.575	.000
Intercept	557.558	1	557.558	42.820	.000
Pretest	130.014	1	130.014	9.985	.002
Group	197.515	1	197.515	15.169	.000
Error	1757.834	135	13.021		
Total	56860.000	138			
Corrected Total	2059.275	137			

Significant at $p \leq 0.05$

Table 2 shows that the pretest significantly predicted students' post-test performance, $F(1, 135) = 9.985$, $p = .002$, indicating that students' prior knowledge contributed to their final performance. After adjusting for the pretest scores, a significant effect of instructional method was observed, $F(1, 135) = 15.169$, $p < .001$, with students taught using Multimedia Instruction performing better than those taught using the Lecture Method. Therefore, the null hypothesis stating that there is no significant difference in the mean academic performance scores of students taught the Respiratory System concepts using Multimedia Instruction and those taught using the Lecture Method was rejected.

Research Question Two: What is the mean score difference between the performance of male and female Secondary School students taught Respiratory System concepts of Biology using Multimedia Instruction?

Table 3: Mean and Standard Deviation of Post-test Performance Scores of Male and Female Students Taught Multimedia Instruction

Gender	N	Mean	SD	MD
Male	34	20.47	4.09	
				0.84
Female	42	21.31	4.15	

The result in Table 3 shows the mean performance scores of male and female students taught Biology using Multimedia Instruction. Male students obtained a mean score of 20.47 (*SD* = 4.09), while female students obtained a mean score of 21.31 (*SD* = 4.15), with a mean difference of 0.84 in favour of the female students, indicating that they performed slightly better than their male counterparts in the Respiratory System taught using Multimedia Instruction.

Hypothesis Two: There is no significant mean score difference between the Performance of male and female students taught the Respiratory system using multimedia Instruction.

Table 4: Independent Samples t-test of Male and Female Students' Academic Performance in the Experimental Group

Groups	N	Mean	SD	df	t	p-value	Remark
Male	34	20.47	4.099				
				74	-.881	0.381	Not Significant
Female	42	21.31	4.147				

Not Significant at $p \geq 0.05$

Table 4 presents the Independent Samples t-test results comparing the post-test performance scores of male and female students taught the Respiratory System using Multimedia Instruction. Male students obtained a mean score of 20.47 (SD = 4.099), while female students obtained a mean score of 21.31 (SD = 4.147). The Independent Samples t-test revealed that the difference in post-test performance between male and female students was not statistically significant, $t(74) = -.881$, $p = .381$. Since the p-value of .381 exceeded the significance level of $\alpha = .05$, the null hypothesis stating that there is no significant difference between the performance scores of male and female students taught the Respiratory System using Multimedia Instruction is therefore not rejected.

Discussion of Findings

The findings revealed a significant difference in the mean academic performance scores of students taught the Respiratory System concepts using Multimedia Instruction and those taught using the Lecture Method, with students in the Experimental Group performing better than those in the Control Group. The improved performance may be attributed to the ability of multimedia instruction to combine text, audio, visuals, and animations in presenting abstract biological processes such as gaseous exchange and breathing mechanisms, thereby enhancing students' understanding and retention of concepts. This finding agrees with Kassa et al. (2024), who reported that students taught Biology concepts using multimedia-integrated instruction performed significantly better than those taught using conventional teaching methods. Similarly, Ezechi and Anyanwu (2022) and Eneda and Ude (2024) found that multimedia instruction significantly improved students' academic performance and conceptual understanding in Biology compared with conventional teaching methods. The consistency in these findings may be linked to the active cognitive engagement promoted by Multimedia Instruction, which supports meaningful learning through simultaneous visual and auditory processing, as explained by Mayer's Cognitive Theory of Multimedia Learning (2001).

The findings further revealed that pretest scores did not significantly predict students' post-test performance in the Experimental Group and that gender had no significant effect on students' academic performance when taught using Multimedia Instruction, indicating that male and female students benefited equally from the approach. Consequently, the null hypothesis stating that there is no significant difference between the academic performance of male and female students taught the Respiratory System using Multimedia Instruction was retained. This finding is consistent with Ezechi and Anyanwu (2022), who reported that gender did not significantly influence students' academic achievement when multimedia instructional strategies were used in Biology teaching. Similarly, Ayittey et al. (2019) found no significant gender difference in students' academic achievement under multimedia-based Biology instruction. The similarity across these studies may be attributed to the learner-centred and inclusive nature of multimedia instruction, which provides both male and female learners with equal access to interactive audio-visual learning experiences that enhance understanding of abstract biological concepts.

Conclusion

The findings of this study carry significant implications for Biology education at the senior secondary school level. The superior performance of students exposed to Multimedia Instruction over those taught using the conventional lecture method implies that traditional instructional approaches are inadequate for developing deep conceptual understanding of abstract biological processes such as the respiratory system. Teachers who continue to rely solely on lecture-based instruction risk limiting students' ability to engage meaningfully with complex science content, and this has broader implications for students' preparedness for advanced studies in Biology and health-related disciplines. The absence of a significant gender difference in performance under Multimedia Instruction implies that this approach creates an equitable learning environment in which both male and female students can achieve equally. This aligns with the inclusive nature of Mayer's (2001) Cognitive Theory of Multimedia Learning, which posits that well-designed multimedia activates the same dual-channel cognitive processes regardless of learner characteristics. For Nigerian secondary schools, where concerns about equal access to quality science education persist, this finding suggests that multimedia-based instruction can serve as a levelling strategy that supports all learners equally. Both findings affirm that multimedia instruction is not only a more effective but also a more equitable instructional approach for Biology at the senior secondary school level. Its integration into mainstream science teaching holds significant promise for improving learning outcomes and narrowing performance gaps in Nigerian schools.

Recommendations

Based on the findings of the study, the following recommendations are made:

1. Biology teachers should adopt multimedia instructional strategies in teaching complex and abstract concepts, such as the respiratory system, to improve students' academic performance.
2. School administrators should provide adequate multimedia facilities, including computers, projectors, and instructional software, to support effective teaching and learning.

3. Government agencies and teacher education institutions should incorporate multimedia-based pedagogy into pre-service and in-service Biology teacher training programmes, so that teachers are equipped not only with the required tools but also with the skills to deploy them effectively in classroom instruction.
4. Curriculum planners and educational policymakers should review the Biology curriculum at the senior secondary school level to formally integrate multimedia instructional strategies, particularly for abstract and process-based concepts such as the respiratory system, to institutionalise evidence-based teaching approaches across Nigerian schools.

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