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Effect of Multimedia-Based Instructional Strategy on Achievement in Genetics Concepts among Secondary School Biology Students in Niger State, Nigeria

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Abstract
The study examined the Effect of Multimedia-Based Instructional Strategy on Achievement in Genetics Concepts among Secondary School Biology Students in Niger State, Nigeria. A quasi-experimental design, specifically a pretest-posttest, non-equivalent control group design, was used for the research. The population of the study consist of all Senior Secondary School class two (SSII) Biology students during the 2024/2025 academic session in Niger state. A sample size of 519 students was selected from the target population using a multi-stage sampling technique for the study. Two research questions were posed, and two corresponding null hypotheses were formulated and tested at a 0.05 significance level. Two experts validated the research instrument. The test-retest method was used to determine the reliability coefficient of the Biology Achievement Test (BAT). The scores were analysed using the Pearson Product-Moment Correlation Coefficient, which yielded a reliability index of 0.78. Data were analysed using mean, standard deviation, with the Statistical Package for Social Sciences (SPSS) version 23.00. The findings indicated that secondary school biology students exposed to multimedia-based instructional strategies performed significantly better than those taught genetics only, as shown by the mean scores. The results further revealed that the experimental group performed better than the control group in the study, demonstrating the effectiveness of the multimedia approach. Based on the findings of the study, this recommendation is proposed: educational policymakers and school administrators should encourage the integration of multimedia-based instructional strategies into the biology curriculum to enhance teaching and learning outcomes.
Keywords: Achievement, Multimedia-Based Instructional Strategies and Biology.

Introduction
In contemporary Nigeria, greater emphasis is placed on science and technological development, which results in students being required to take science subjects in their senior secondary school classes. Based on this, science focuses on collecting data for the designated order that exists in natural phenomena and happenings around us (Sani, 2015). The core fundamental science subjects are typically offered and need to be introduced to prepare students for future scientific exploration and endeavours (Etobro and Fabinu, 2017). Biology is a prerequisite science subject for many fields of learning, significantly contributing to the nation's technological growth (Ahmed, 2021). These include medicine and surgery, veterinary science, Biotechnology, Agriculture, Pharmacy, and

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Microbiology, to mention a few. Biology encourages intellectual curiosity, increases awareness of fragile ecosystems, and equips students with the necessary skills for problem-solving, critical thinking, communication, and objective reasoning —21st-century skills that will make them applicable in future workplaces (Yilshik, 2020). The teaching and learning of biology at the secondary school level is aimed at increasing students' understanding of living systems, including human beings and other organisms in the natural environment. However, student achievement at this level is unsatisfactory (Salisu, 2018). Several factors identified by researchers contribute to this unsatisfactory achievement, including inappropriate instructional strategies, inadequate laboratory facilities, poorly trained or unqualified biology teachers, insufficient instructional materials, and low student motivation. The abstract nature of biological concepts, such as ecology, plant systems, energy transformation in nature, and genetics, also plays a role (Martens, 2018; Umar et al., 2020).

Many students exhibit high levels of apathy toward learning genetics because they perceive it as difficult and uninteresting (Jeremiah and Joy, 2019). They believe this perception stems from the invisible processes of cell division, such as mitosis and meiosis, which contribute to their lack of understanding and misconceptions about the concept. For instance, Visscher (2012) revealed that "a single gene controls a single trait." This is often oversimplified and misleading because: Polygenic Traits: Most traits (e.g., height, skin colour, intelligence) are influenced by multiple genes working together (polygenic inheritance). Pleiotropy: A single gene can affect multiple, seemingly unrelated traits (e.g., mutations in the CFTR gene cause cystic fibrosis, impacting the lungs, pancreas, and other organs). Environmental Influence: Traits often result from gene-environment interactions (e.g., diet affecting height, sun exposure altering skin pigmentation). Epigenetics: Gene expression can be modified by external factors (like stress or nutrition) without changing the DNA sequence. This misconception stems from early Mendelian genetics (e.g., pea plant traits like flower colour), which simplified genetic concepts for basic understanding. However, most real-world traits are far more complex.

Multimedia learning is the use of different types of media, such as text, images, audio, video, and animation, to enhance learning outcomes and engagement (Akinoso, 2018). Multimedia aids the instructor in delivering effective and diverse training, catering to various learning styles and preferences. Guan et al. (2018) multimedia is a combination of more than one media type, such as text (Alphabetic or numeric), symbols, pictures, audio, and animation, usually with the aid of technology to enhance understanding or memorisation. It supports verbal instruction with the use of static and dynamic images, utilising visualisation technology for enhanced expression and comprehension. Kapi et al. (2017); Alemdag and Cagiltay (2018) reported that multimedia technology is identified with some qualities such as integration, diversity and interaction that enable people to communicate information or ideas effectively with digital and print elements, which are referred to as multimedia-based applications or tools purposely used for delivering information to people for better understanding of the concept. Umar et al. (2020) opined that multimedia is a combination of instructional approaches that encourage learners to participate in learning through the mental representation of materials in words and pictures, making connections between pictorial and verbal presentations. Furthermore, multimedia can also be referred to as a combination of data carriers, such as video, CD-ROM, Floppy Disk, Flash Drive, the internet, and software, through which an interactive approach can be offered.

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Statement of the Research Problem

One of the greatest challenges facing secondary schools in Nigerian society over the years has been the relative decline in the academic achievement of students, particularly in the Sciences. Niger State Secondary Schools are not exempt. The academic achievement of students in science subjects, especially in Biology, has been inconsistent. Evidence from the previous biology examination results of NECO and WEAC, 2020, 2021, 2022, and 2023, respectively. Most research findings revealed that poor achievement in biology could be attributed to several factors, such as poor or inappropriate instructional strategy, inadequate or a lack of laboratory facilities, poorly trained or unqualified biology teachers, insufficient instructional materials, and lack of motivation in students (Martens, 2018 and Umar et al., 2020). This led to a shift to a constructivist instructional strategy that emphasises an active role for students, enabling them to create their understanding through interaction with their learning environment. It appears that there is a need to address the issue of instructional innovation. Hence, the researcher was compelled to extend her search to consider the use of multimedia-based instructional strategies to determine whether they can enhance the achievement of secondary school biology students in Niger State.

Objectives of the study

1. Find out the effect of multimedia-based instructional strategy on Secondary School Students' academic achievement in biology.
2. Find out the effect of multimedia-based instructional strategy on Secondary School Students' academic achievement in biology based on Gender.

Research Questions

1. What is the difference in mean achievement scores of secondary school students taught Biology using a multimedia-based instructional strategy and those trained with the Conventional Instructional Strategy?
2. What is the effect of multimedia-based instructional strategy on Secondary School Students' academic achievement in biology based on Gender?

Methodology

The study also employed a quasi-experimental design (pre-test post-test non-equivalent, non-randomised, control group). The reason for choosing a quasi-experimental design is that the researcher used intact classes to avoid disrupting the school timetable at each of the sampled schools, and the rules and regulations governing secondary school affairs also helped eliminate the threat of biased selection.

Table 1 Schematic Diagram of Research Design

Group	Pretest	Treatment	Posttest
Experimental I	O_1	X_1	O_2
Control	O_1	-	O_2

Where:

O_1, O_1 - Pretest Scores of experimental and control groups.
O_2, O_2 - Posttest Scores of experimental and control groups.
X_1 – Treatment for the experimental group only.
-– No Treatment for the Control group.

The population for this study comprises all the Senior Secondary School Biology Students in Niger State. There are three hundred and twenty (320) Senior Secondary Schools in the three (3) zones of Niger State. There are ten thousand three hundred and sixty-four (10,364) students who registered for Biology in the 2023/2024 academic session (Niger State Ministry of Education, 2023) with a Male

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and Female ratio of 6640:4300. The targeted population of the study were made up of the entire Senior Secondary School II (SS2) Biology students in Niger State with a total number of eight hundred and thirty-three (833) students which consisted Male 499 and Female 334. A multistage sampling technique was employed to select six (6) schools from the state to be used for the study. The first stage involves purposive sampling of two (2) schools from each of the senatorial zones of the state. The schools were purposively selected because the state government owns them, funds and supplies science equipment to these schools, controls teacher and student admission into these schools, and is all under the control of the same state government. Co–educational schools were used to include both male and female students in the sample, allowing for the determination of gender differences in student achievement of the concept of genetics in biology. The second stage involved the random assignment of one school from each zone to the experimental group, another to the control group, and the last school to the control group. The third stage involved random selection of one intact class for each of the nine selected schools. This instrument, also known as the Biology Achievement Test (BAT), was developed to measure students' achievement after treatment. The content of the test was based on the topics to be taught during the study for 3 Weeks. The test instruments were (50) multiple-choice question tests. Some of the questions were adapted from past WAEC and NECO examination questions, while the remaining questions were developed by the researcher from biology textbooks based on the SS11 syllabus. Each Biology Achievement Test (BAT) have options A to E as possible answers to the questions. This implies that there is one correct option and four distractors to measure the participants' knowledge of Biology in line with Bloom's cognitive taxonomy. The instrument (BAT) was used for pretest and posttest.

To ensure the validity of the research instruments for the set of students in the study, the face and content validity of the instrument were assessed. Two senior lecturers from the School of Science and Technology Education at the Federal University of Technology, Minna, a computer specialist or analyst, an English Language specialist, and two secondary school biology Teachers validated the instruments. They were requested to check the BAT items against the topic and content of the lesson plan. After which, the instruments were examined and certified by various experts to be used in the study. Their observations, corrections, and suggestions were then used to produce the final copy of the instruments used in the study. To ascertain the reliability and internal consistency index of the test instrument, a pilot test was conducted at the Government Secondary School in Lapai Local. The school is part of the study population, but it was not sampled for the main study. A total of forty (40) students (20 girls and 20 boys) were used. The test-retest approach was adopted at an interval of two weeks to enable the researcher to obtain two sets of scores for calculating the reliability coefficient of the test items using the Pearson Product-Moment Coefficient (r). A reliability Coefficient of 0.78 was obtained. The data was analysed using Mean and Standard Deviation to answer the research questions.

Presentation of Results

Research Question 1

What is the difference in mean achievement scores of secondary school students taught Biology using a multimedia-based instructional strategy and those trained with the Conventional Instructional Strategy? The descriptive statistics of mean and standard deviation were used to answer this research question, and a summary of the results is presented in Table 2 below:

Table 2: Summary of descriptive statistics of the mean and standard deviation of students' scores in the experimental and control groups at the pre-test and post-test

Groups	N	Pre-test	Post-test	Mean Difference

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		$\bar{x}$	SD	$\bar{x}$	SD	
Experimental	223	20.46	8.51	26.59	8.38	6.13
Control	296	20.63	8.58	21.76	7.99	1.13

Field Work, 2024

The data presented in Table 2 show that the experimental group (Multimedia-Based instructional strategy) had a mean score of 20.46 and a standard deviation of 8.51 in the Pre-test and a mean score of 26.59 and a standard deviation of 8.38 in the post-test, resulting in a pre-test to post-test difference in the experimental group taught with the Multimedia-Based instructional strategy to be 6.13. The control group had a mean score of 20.63 and a standard deviation of 8.58 in the pre-test, and a post-test mean of 21.76 with a standard deviation of 7.99, resulting in a pre-test to post-test difference of 1.13. With this result, the students in the experimental group (Multimedia-Based instructional strategy) performed better on the achievement test than the students in the control group, as indicated by the Mean Difference.

Research Question 2

What is the effect of multimedia-based instructional strategy on Secondary School Students' academic achievement in biology based on Gender? The descriptive statistics of mean and standard deviation were used to answer this research question, and a summary of the results is presented in Table 3 below:

Table 3: Mean and Standard Deviation of achievement scores of male and female biology students taught with Multimedia-Based

Group (Gender)	N	Pretest		Posttest		Mean Difference
		$\bar{x}$	SD	$\bar{x}$	SD	
Male	136	22.99	7.15	27.54	7.71	4.55
Female	87	16.51	8.99	25.11	10.37	8.60

Field Work, 2024

The data presented in Table 3 show that the Male students in experimental group (Multimedia Based) had a mean score of 22.99 and a standard deviation of 7.15 in the Pre-test and a mean score of 27.54 and a standard deviation of 7.71 in the post-test, resulting in a pre-test to post-test difference for the Male students in the experimental group taught with Multimedia learning instructional strategy to be 4.55. The Female students in the experimental group (Multimedia Based) had a mean score of 16.51 and a standard deviation of 8.99 in the Pre-test and a mean score of 25.11 and a standard deviation of 10.37 in the post-test, resulting in a pre-test to post-test difference for the Female students in the experimental group taught with the Multimedia learning instructional strategy to be 8.60. With this result, the Female students in the experimental group (Multimedia Based) performed better in the achievement test than the other gender, as indicated by the Mean Difference.

Conclusion

The study demonstrated that multimedia-based instructional strategies significantly enhanced the academic achievement of secondary school biology students in Niger State, particularly in the topic of genetics. The experimental group, which utilised multimedia tools, showed a marked improvement in post-test scores compared to the control group taught with conventional methods. Additionally, the findings revealed that female students benefited more from the multimedia approach, as evidenced by their higher mean difference scores. These results underscore the effectiveness of multimedia-based instruction in addressing the abstract nature of biology concepts and improving student engagement and understanding. The success of this instructional strategy underscores its

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potential to address challenges such as inadequate laboratory facilities, poorly trained teachers, and low student motivation, which have historically contributed to subpar academic performance in biology. By integrating multimedia tools into the curriculum, educators can create a more interactive and dynamic learning environment that caters to diverse learning styles and promotes a deeper understanding of complex biological concepts.

Recommendations

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

1. Educational policymakers and school administrators should encourage the integration of multimedia-based instructional strategies into the biology curriculum to enhance teaching and learning outcomes.
2. Gender-Inclusive Strategies: Educators should leverage the positive impact of multimedia instruction on female students by designing gender-inclusive learning materials that further bridge achievement gaps.

By implementing these recommendations, stakeholders in the education sector can foster a more engaging and effective learning environment, ultimately improving student achievement in biology and other science subjects.

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