

Enhancing Genetics Education: Effects of Audio-visual and Simulation-based Learning Strategies on University Pre-service Biology Teachers' Academic Achievement in Ogun State, Nigeria

¹ Isyaku MOHAMMED

Federal College of Education Abeokuta, Ogun State, Nigeria

mohammedisyaku354@gmail.com

+2348033280995

&

² Christianah Olajumoke SAM-KAYODE

Lead City University, Ibadan, Nigeria

samkayodeolajumoke@gmail.com

+2348165357640

Abstract

The effectiveness of traditional teaching methods in Genetics education has often been questioned, especially as Pre-service Biology teachers struggle to comprehend abstract and complex Genetic concepts. This study determined the Effects of Audio-visual and simulation-based strategies on Academic Achievement in Genetics among University pre-service Biology teachers in Ogun State, Nigeria. Hypothesis was formulated and tested at 0.05 level of significance. A pretest–posttest quasi–experimental design was applied. A total of 90 Biology education students, comprising 45 male and 45 female participants, took part in this study. Genetics Achievement Test with reliability at 0.79 (KR-20 = 0.79) and Guides for Instruction in Teaching and Learning of Genetics were used as instruments for data collection. Analysis of Covariance (ANCOVA) was used for data analysis. There was significant interaction effect of audio-visual and simulation-based learning strategies on academic achievement in Genetics among pre-service Biology teachers in Ogun Central Senatorial District of Ogun State, Nigeria ($F_{(1; 67)} = 17.717, p < 0.05$). It was concluded that a blended approach, incorporating both audio-visual Strategy and Simulation-based learning strategy enhanced achievement in Genetics among university pre-service Biology teachers in Ogun State, Nigeria. Based on the findings, it was suggested that institutions should encourage the simultaneous use of Audio-visual and Simulation-based Learning Strategies, designing lessons that integrate visual aids and interactive simulations for teaching Genetics.

Keywords: Audio-visual learning strategy, Simulation-based learning strategy, Traditional teaching strategy, Academic achievement in Genetics

Word Count: 213

Introduction

Academic achievement is a key indicator of students' learning outcomes, often measured through tests and practical assessments. In science education, where understanding complex and abstract concepts is crucial, academic success is not only a reflection of knowledge but also a predictor of future academic and professional competence (Cayubit, 2022; Sakineh & Ali, 2020; Idris et al, 2023). Students exposed to innovative, student-centered instructional strategies tend to perform better, especially when these approaches encourage active engagement and experiential learning (Gisoi et al., 2023).

In the Nigerian education system particularly in Colleges of Education across Ogun State; Biology is a foundational subject for pre-service teachers who are being trained to foster scientific literacy at the secondary school level. Within the Biology curriculum, Genetics stands out as a core component that requires deep conceptual understanding. Topics such as DNA replication, gene expression, and genetic inheritance are intellectually demanding and often abstract, posing significant learning challenges to many students (Gericke & McEwen, 2023; Machová & Ehler, 2023; Novakovsky et al., 2023). For pre-service Biology teachers, mastering Genetics is essential not only to succeed academically but also to effectively teach these concepts to future secondary school students.

Research shows that traditional lecture-based approaches often fall short in supporting meaningful learning of Genetics due to their limited interactivity and reliance on rote memorization. This has led to the adoption of alternative instructional methods such as inquiry-based, cooperative, and project-based learning, which aim to foster critical thinking, collaboration, and deeper engagement with content (Wale & Bishaw, 2020; Ferguson-Patrick, 2020; Firdausih & Aslan, 2024). However, the impact of these strategies has been inconsistent across various educational settings, highlighting the need for more tailored and visually oriented approaches, especially for abstract scientific topics.

In this context, audio-visual and simulation-based strategies have gained increasing attention for their potential to simplify complex genetic concepts and improve academic achievement. Audio-visual interventions use multimedia tools such as animated videos, interactive graphics, and narrated presentations to explain intricate biological processes in a more relatable and engaging format. This approach is grounded in dual-coding theory, which suggests that learning is enhanced when information is presented through both verbal and visual channels,

thereby improving comprehension and memory retention (Kahsay et al., 2024). For instance, animated sequences of DNA replication or gene expression can provide students with a clearer mental picture, making abstract ideas more accessible (Muhiuddin et al., 2023; Feeley et al., 2023). Similarly, simulation-based learning uses computer-generated models and virtual labs to mimic real-life biological processes. This method allows learners to actively experiment with genetic phenomena such as inheritance patterns, mutations, and gene interactions in a controlled digital environment. It supports deeper learning by promoting visualization, exploration, and problem-solving skills (Chernikova et al., 2020; G'ofurova & Kimsanova, 2024). Simulations offer pre-service teachers a practical and immersive way to engage with genetics, especially in situations where access to physical laboratory facilities is limited (Low & Ellefson, 2024; Irmer et al., 2024). Despite their advantages, both strategies face implementation challenges. Limited access to digital tools, insufficient teacher training, and the cost of developing quality multimedia content are barriers that must be addressed. Successful integration of these methods into teacher education requires institutional support, resource investment, and professional development initiatives (Arshad et al., 2024).

Given these considerations, this study seeks to investigate the effects of audio-visual and simulation-based learning strategies on the academic achievement of university pre-service Biology teachers in Genetics within Ogun State, Nigeria. By focusing on this region and subject area, the research aims to fill a critical gap in the local literature, offering evidence-based recommendations to improve the teaching and learning of Genetics. The findings will not only inform instructional practices in Institutions of Education but also contribute to broader efforts aimed at enhancing science education through innovative, inclusive, and effective teaching approaches.

Statement of the Problem

Genetics is a central yet conceptually challenging component of Biology education, particularly for pre-service Biology teachers who are expected to master and later teach these complex concepts effectively. Despite its significance, students often struggle with understanding topics such as DNA replication, gene expression, and inheritance patterns due to their abstract and intricate nature. This difficulty has contributed to persistently low academic achievement in Genetics among many pre-service teachers in Nigeria's Institutions of Education, especially in

Ogun State. Traditional teaching methods primarily lecture-based and textbook-driven remain widely used in many tertiary institutions. However, these approaches often fail to meet the diverse learning needs of students or to facilitate deep conceptual understanding. Innovative instructional strategies such as audio-visual and simulation-based learning have been shown to enhance student engagement, comprehension, and performance by offering dynamic, interactive, and visual representations of complex scientific ideas. Yet, the adoption and effectiveness of these strategies in Genetics education within the Nigerian teacher training context remain underexplored. Moreover, challenges such as limited access to digital tools, insufficient training for educators and inconsistent implementation of modern teaching practices continue to hinder meaningful integration of these strategies. As a result, there is a pressing need to investigate whether and how audio-visual and simulation-based instructional methods can significantly improve academic achievement in Genetics among university pre-service Biology teachers. This study, therefore, seeks to address this gap by evaluating the effects of audio-visual and simulation-based learning strategies on the academic achievement of university pre-service Biology teachers in Genetics within Ogun State. The findings are expected to inform evidence-based improvements in instructional practices and support the development of more effective, inclusive, and engaging methods for teaching Genetics in Nigerian Colleges of Education.

Aim and Objective of the Study

The aim of this study is to investigate the effects of audio-visual and simulation-based learning strategies on the academic achievement of pre-service Biology teachers in Genetics within Ogun State, Nigeria.

The objective is to:

- i. ascertain the interaction effects of Audio-visual and Simulation-based Learning Strategies on Academic Achievement in Genetics Among University Pre-service Biology teachers in Ogun Central Senatorial District of Ogun State, Nigeria

Hypothesis

The null hypothesis will be tested at 0.05 level of significance:

H₀: There will be no significant interaction effects of Audio-visual and Simulation-based learning strategies on Academic Achievement in Genetics among University Pre-service Biology teachers in Ogun Central Senatorial District of Ogun State, Nigeria.

Methodology

This study adopted a quasi-experimental design with a pre-test and post-test structure to examine the effects of audio-visual and simulation-based strategies on academic achievement in Genetics among University pre-service Biology teachers in Ogun Central Senatorial District, Nigeria. A total of 92 students (45 males and 47 females) from three tertiary institutions were selected using total enumeration from intact Biology Education classes and randomly assigned to three groups. Group A (30 students) from Lagos State University (Affiliated) received the Simulation-Based Learning Strategy (SBLS). Group B (30 students) from the University of Ibadan (Affiliated) was taught using the Audio-Visual Strategy (AVIS). Group C (32 students) from the National Open University of Nigeria (NOUN), Abeokuta Centre, served as the control group and received Traditional Teaching Strategy (TTS). All groups received the same Genetics content over an eight-week period, delivered by trained lecturers using the assigned methods. The Genetics Achievement Test (GAT), validated for content, face, and construct validity, was used for data collection. A pilot test with 20 students yielded a reliability coefficient of 0.79 (KR-20). Data were analyzed using ANCOVA, with pre-test scores as covariates, to determine significant differences in academic achievement at a 0.05 level of significance.

Result

Demographic Data Analysis

Table 1: Audio-visual Intervention Strategy (AVIS), Simulation Learning Strategy (SBLS) and Traditional Teaching Strategy (TTS)

Teaching Strategies	Gender		Total
	Male	Female	
AVIS	14	14	28
SBLS	15	15	30
TTS	16	16	32
Total	45	45	90

Source: Researchers’ Fieldwork, 2025

Presentation of Data

Hypothesis

H₀: There will be no significant interaction effects of Audio-visual and Simulation-based learning strategies on Academic Achievement in Genetics among Pre-service Biology teachers in Ogun Central Senatorial District of Ogun State, Nigeria.

Table 2 presents ANCOVA result on the interactive effect of audio-visual intervention and simulation-based learning strategies (AVIS*SBLS) on the academic achievement in Genetics among pre-service Biology teachers in Ogun Central Senatorial District of Ogun State, Nigeria. From the Table 2, the F–statistics ($F_{(1; 57)} = 17.717$) and the probability (significant) value = 0.000. This signified that the null hypothesis (H_0) that there would be no significant interaction effect of audio-visual intervention and simulation-based learning strategies (AVIS*SBLS) on the academic achievement in Genetics among pre-service Biology teachers in Ogun Central Senatorial District of Ogun State, Nigeria should be rejected. Therefore, there was significant interaction effect of audio-visual intervention and simulation-based learning strategies on academic achievement in Genetics among pre-service Biology teachers in Ogun Central Senatorial District of Ogun State, Nigeria ($F_{(1; 67)} = 17.717, p < 0.05$). The Partial Eta Squared value in the Table 2 shows the size of the interactive effect of audio-visual intervention and simulation-based learning strategies (AVIS*SBLS). This value was 0.237, which was small when compared with Cohen’s guidelines

(0.2 – small effect, 0.5 – moderate effect, 0.8 – large effect). This implied that about 23.7% of the variance in the posttest score of the pre-service Biology teachers’ academic achievement in Genetics in Ogun Central Senatorial District of Ogun State, Nigeria was explained by the interaction of audio-visual intervention and simulation-based learning strategies (AVIS*SBLs).

Table 2: Tests of Between-Subjects Effects of Audio-visual Intervention and Simulation-Based Learning Strategies on Academic Achievement in Genetics among Pre-Service Biology Teachers in Ogun Central Senatorial District of Ogun State, Nigeria

Dependent Variable: POSTTEST

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2394642.743 ^a	2	1197321.371	4470.473	0.000	0.994
Intercept	2714.335	1	2714.335	10.135	0.002	0.151
PRETEST	962317.407	1	962317.407	3593.032	0.000	0.984
STRATEGY	4745.038	1	4745.038	17.717	0.000	0.237
Error	15266.241	57	267.829			
Total	3892305.000	60				
Corrected Total	2409908.983	59				

a. R Squared = 0.994 (Adjusted R Squared = 0.993)

Source: Researchers’ Fieldwork, 2025

Table 3 shows the results of the estimated marginal mean of the interaction of audio-visual intervention and simulation-based learning strategies (AVIS*SBLs), which gives the adjusted means (controlling for the covariate ‘pretest score’) for each group. This signifies that the effect of ‘pretest score’ has been statistically removed. The outcomes signified that higher academic achievement in Genetics among pre-service Biology teachers in Ogun Central Senatorial District of Ogun State, Nigeria was achieved with the interaction of audio-visual intervention and simulation-based learning strategies (AVIS*SBLs) (mean = 171.42 unit) on average after adjusting for pretest score, compared to traditional teaching strategy (mean = 144.73)

Table 3: Estimates of Audio-visual Intervention and Simulation-Based Learning Strategies on Academic Achievement in Genetics among Pre-Service Biology Teachers in Ogun Central Senatorial District of Ogun State, Nigeria

Dependent Variable: POSTTEST

Strategy	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
AVIS*SBLS	171.421 ^a	3.988	163.435	179.407
Traditional Teaching	144.725 ^a	3.636	137.443	152.007

a. Covariates appearing in the model are evaluated at the following values: PRETEST = 90.3500.

Source: Researchers' Fieldwork, 2025

Discussion of Findings

The result of this study revealed a significant interaction effect of audio-visual intervention and simulation-based learning strategies on academic achievement in Genetics among university pre-service Biology teachers in Ogun Central Senatorial District. This outcome highlights the dynamic influence that multimedia instructional approaches can exert when integrated effectively into teaching and learning processes.

This finding is in line with the work of Ali et al (2024), who examined the effect of technology-mediated dynamic and static visuals on the retention ability of pre-service Biology teachers in North Central Nigeria. While both studies focused on similar instructional tools and educational content, the current study extended its scope by assessing academic achievement, not just retention. The convergence of outcomes across studies reinforces the instructional relevance of multimedia strategies, though Ali et al.'s study noted statistically significant variations in retention scores, suggesting a nuanced difference in impact that may stem from the specific cognitive domain being assessed.

Similarly, the present finding agrees with that of Ogah (2023), who found that multimedia learning significantly enhanced academic achievement among students with special needs in Minna Metropolis. The use of technology not only boosted performance but also positively influenced students' attitudes towards learning. This supports the notion that visual and interactive teaching strategies do more than convey content; they foster engagement, inclusivity, and deeper conceptual understanding.

In the same vein, Asu and Ude (2024) reported that multimedia instruction led to a marked improvement in the Biology achievement of senior secondary students in Enugu State. Though conducted at a different educational level and geographical zone, their findings further affirm the academic value of incorporating technology-based instruction in science education.

However, not all previous studies align seamlessly with the current findings. For instance, Ahmed and Odewumi (2020), in their study conducted in Ilorin, found that visual learning devices significantly enhanced academic performance in Biology. While the tools used were similar, differences in study populations, learning environments, and the structure of instructional delivery may explain the inconsistency. Likewise, Ojelade et al. (2020) reported a significant positive effect of audio-visual instructional materials on student achievement in science subjects in Abuja, contrasting with the more modest outcome of the current study.

Additionally, the findings of Akuoma and Juliana (2021), who investigated the use of video instructional strategies in Port Harcourt, showed the experimental group outperforming their peers. Their study emphasized that video instruction helps in simplifying abstract concepts and enhancing content internalization. Although the present study utilized similar strategies, the interaction effect may not have been as pronounced due to contextual variables such as instructor competence, learner characteristics, and duration of exposure to the strategy.

Turning specifically to simulation strategies, the study resonates partially with the findings of Akhigbe and Ogufere (2020), who reported that computer simulations significantly improved students' academic performance and positively affected their attitudes toward Biology. Simulations were shown to be particularly effective in engaging students with complex scientific content. However, in contrast, the current study did not observe consistent performance gains across all learners, suggesting that simulations may benefit certain groups more than others, or that contextual factors might moderate their effectiveness.

Further contrast is observed in the work of Nkok (2021), who reported significant improvements in both achievement and retention among students taught using simulation strategies in the topic of sexual reproduction in plants. His findings, based on ANCOVA analysis, pointed to the clear superiority of simulation methods over traditional instruction. The divergence from the present study's results could be due to differing content focus, simulation quality, institutional settings, or learner preparedness.

Conclusion

The findings of this study indicate that the combination of Audio-visual and Simulation-based Learning Strategies significantly improved academic achievement in Genetics. Thus, this study concluded that a blended approach, incorporating both Audio-visual and Simulation-based Learning Strategies can enhance Academic Achievement in Genetics among pre-service Biology teachers in Ogun Central Senatorial District of Ogun State, Nigeria.

Recommendation

The findings recommend:

- i. Institutions should encourage the simultaneous use of Audio-visual and Simulation-based Learning Strategies, designing lessons that integrate visual aids and interactive simulations for teaching Genetics.

References:

- Ahmed M. A. & Odewumi M. O., (2020). Impact of Visual Learning Devices on Secondary School Biology Students' Academic Performance in Ilorin, Nigeria. *Indonesian Journal of Science and Education*, 4(2), 83-98.
- Akhigbe J. N. & Ogufere J. A., (2020). Effect of Computer Simulation Instructional Strategy on Students' Attitude and Academic Achievement in Genetics. *NIU Journal of Social Sciences*, 5(4), 305-315.
- Akuoma U. B. & Juliana I. M., (2021). Video Instructional Strategy on Biology Student's Academic Performance in Port Harcourt, Nigeria. *Britain International of Linguistics Arts and Education (BIO LAE) Journal*, 3(3), 194-202.
- Ali F., Ibrahim I. K., Falode O. C. & Daudu O. A. Y., (2024). Effect of Technology-Mediated Dynamic and Static Visuals on Pre-Service Biology Teachers' Retention in Colleges of Education in North Central, Nigeria. *Kashere Journal of Science and Education*, 2(1), 54-65.
- Arshad B., Ishak N. A. & Zaharudin R., (2024). New Norms: Enhancing Biology Achievement, Creativity, and Student Innovation Post-Covid-19 Through Virtual Science Inquiry-Based Learning and Augmented Reality Applications. *Jurnal Pendidikan Sains Dan Matematik Malaysia*, 14(2), 49-64.

- Cayubit R. F. O., (2022). Why Learning Environment Matters? An Analysis on how the Learning Environment Influences the Academic Motivation, Learning Strategies and Engagement of College Students. *Learning Environments Research*, 25(2), 581-599.
- Chernikova O., Heitzmann N., Stadler M., Holzberger D., Seidel T. & Fischer F., (2020). Simulation-Based Learning in Higher Education: A Meta-Analysis. *Review of Educational Research*, 90(4), 499-541.
- Feeley T. H., Keller M. & Kayler L., (2023). Using Animated Videos to Increase Patient Knowledge: A Meta-Analytic Review. *Health Education & Behavior*, 50(2), 240-249.
- Ferguson-Patrick K., (2020). Cooperative Learning in Swedish Classrooms: Engagement and Relationships as a Focus for Culturally Diverse Students. *Education Sciences*, 10(11), 312.
- Firdausih F. & Aslan A., (2024). Literature Review: The Effect of Project-Based Learning on Student Motivation and Achievement in Science. *Indonesian Journal of Education (INJOE)*, 4(3), 1011-1022.
- Gericke N. & Mc Ewen B., (2023). Defining Epigenetic Literacy: How to Integrate Epi-Genetics into the Biology Curriculum. *Journal of Research in Science Teaching*, 60(10), 2216-2254.
- Gisoi J. M. A., Njagi M. W. & Mungiria J. N., (2023). Effectiveness of Experiential Learning Approach on Students' Academic Achievement in Biology in Secondary Schools in Maara Subcounty, Kenya. *International Journal of Novel Research and Development*, 8(9), 324-331.
- G'ofurova O. & Kimsanova S., (2024). Innovations in Biology Education: Enhancing Learning through Technological Advancements. *Академические исследования в современной науке*, 3(13), 31-37.
- Hanif M., (2020). The Development and Effectiveness of Motion Graphic Animation Videos to Improve Primary School Students' Sciences Learning Outcomes. *International Journal of Instruction*, 13(3), 247-266.
- Idris R., Govindasamy P., Nachiappan S. & Bacotang J., (2023). Exploring the Impact of Cognitive Factors on Learning, Motivation, and Career in Malaysia's STEM Education. *International Journal of Academic Research in Business and Social Sciences*, 13(6), 1669-1684.

- Irmer, M., Traub, D., & Neuhaus, B. J., (2024). Fostering ePCK in Pre-Service Biology Teacher Education using Adaptive Scaffolding in a Video-Based Simulation. *Cogent Education*, 11(1), 2422272.
- Kahsay T. T., Berhe G. G. & Tesfamariam G. M., (2024). The Extent of Audio-Visual Material Use in the Teaching and Learning of Chemistry in Secondary Schools. *African Journal of Chemical Education*, 14(2), 128-159.
- Low H. G. & Ellefson M., (2024). Punnett Farms: Developing an Immersive Educational Game-Based Platform for Learning Genetics. *Simulation & Gaming*, 55(2), 302-322.
- Machová M. & Ehler E., (2023). Secondary School Students' Misconceptions in Genetics: Origins and Solutions, *Journal of Biological Education*, 57(3), 633-646.
- Muhiuddin G., Samanta S., Aljohani A. F. & Alkhaibari A. M., (2023). A Study on Graph Centrality Measures of Different Diseases due to DNA Sequencing. *Mathematics*, 11(14), 3166.
- Nkok E. M., (2021). Effect of Computer Simulation on Students' Achievement and Retention in Sexual Reproduction in Plants in Niger State, Nigeria. *International Journal of Innovative Social & Science Education Research*, 9(3), 10-18.
- Novakovsky G., Dexter N., Libbrecht M. W., Wasserman W. W. & Mostafavi S., (2023). Obtaining Genetics Insights from Deep Learning via Explainable Artificial Intelligence. *Nature Reviews Genetics*, 24(2), 125-137.
- Ojelade I. A., Aregbesola B. G., Ekele A. & Olatunde-Aiyedun T. G., (2020). Effects of Audio-Visual Instructional Materials on Teaching Science Concepts in Secondary Schools in Bwari Area Council Abuja, Nigeria. *The Environmental Studies Journal (TESJ)*, 3(2), 52-61.
- Sakineh J. & Ali A., (2020). Predicting Students' Academic Achievement based on the Classroom Climate, Mediating Role of Teacher-Student Interaction and Academic Motivation. *Интеграция образования*, 24(1 (98)), 62-74.
- Wale B. D. & Bishaw K. S., (2020). Effects of Using Inquiry-Based Learning on EFL Students' Critical Thinking Skills. *Asian-Pacific Journal of Second and Foreign Language Education*, 5, 1-14.