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EFFECT OF IMMERSIVE 3D ANIMATED SCIENCE NARRATIVES ON BIOLOGY RETENTION IN SECONDARY SCHOOLS

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ABSTRACT

This study examined the effect of immersive, three-dimensional (3D) animated science narratives on the retention of complex biology concepts among Senior Secondary Two (SS 2) students in Zing Education Zone, Taraba State, Nigeria. A quasi-experimental pre-test/post-test control group design was adopted. A sample of 120 SS 2 biology students from four public secondary schools was selected through multi-stage purposive and random sampling and assigned to experimental (n = 60) and control (n = 60) groups. The experimental group received instruction through 3D animated science narratives while the control group received conventional chalk-and-talk instruction. Two instruments were used: the Biology Retention Achievement Test (BRAT; KR-20 = 0.81) and the Students' Motivation towards Biology Instruction Questionnaire (SMBIQ; α = 0.78). Three hypotheses were tested at the 0.05 level using Analysis of Covariance (ANCOVA) and independent samples t-tests. Results showed that the experimental group achieved significantly higher retention scores than the control group, $F(1, 117) = 47.31$, $p < .001$, partial $\eta^2 = .288$. Gender was not a significant moderator of this advantage, $t(58) = 1.61$, $p = .113$. The experimental group also reported significantly higher motivation than the control group, $t(118) = 10.36$, $p < .001$. The study recommends integrating 3D animated science narratives into biology instruction, supported by investment in ICT infrastructure and teacher training.

Keywords: 3D animation, biology retention, immersive narratives, multimedia learning, cognitive load, science education

Introduction

Science education continues to grapple with helping learners build accurate, lasting mental models of phenomena that are abstract, microscopic, or too slow or fast to observe directly. This challenge is acute in biology, where core topics such as cell division, circulation, and genetic inheritance require learners to mentally represent dynamic processes at scales invisible to the naked eye (Nwosu & Eze, 2021; Ogundele & Adeyemi, 2022). Conventional instruction, which relies on static diagrams and verbal exposition, often leaves students with fragile and incomplete conceptual structures in these domains.

Immersive three-dimensional (3D) computer-generated animation, embedded within structured narrative frameworks, offers a theoretically grounded alternative. Unlike static diagrams or conventional video, 3D animated narratives externalize dynamic spatial processes, distribute cognitive load across visual and auditory channels, and

recruit motivational engagement that deepens encoding and retrieval (Mayer, 2020; Skulmowski & Xu, 2022). Nigeria's National Digital Economy Policy and ongoing NERDC curriculum reforms have created room for multimedia integration in classrooms (Federal Ministry of Education [FME], 2022), and rising smartphone access is gradually narrowing the digital divide in some areas (Aliyu & Bello, 2023). Even so, evidence on 3D animated science instruction in North-Eastern Nigeria, particularly Taraba State, remains thin; most available studies come from South-Western Nigeria or international settings whose infrastructural realities differ markedly from those of rural Taraba schools.

Zing Education Zone, in Zing Local Government Area of Taraba State, serves a largely rural and semi-urban population. Biology is compulsory for science students at the senior secondary level and is a gateway subject for tertiary study in medicine, agriculture, and life sciences. School inspection reports and supervisory accounts point to persistently weak performance in biology topics demanding dynamic spatial reasoning, such as cell division and genetics. This study was therefore designed to generate locally relevant evidence on whether 3D animated science narratives improve biology concept retention among SS 2 students in this zone.

Statement of the Problem

Despite strong policy advocacy for technology-enhanced instruction in Nigeria, empirical evidence on the effectiveness of 3D animated science narratives for biology retention among secondary students in North-Eastern Nigeria is scarce. Studies from South-Western Nigeria and abroad report substantial gains from 3D animated instruction (Ogundele & Adeyemi, 2022; Ibrahim et al., 2023; Hou et al., 2023), but whether these findings generalize to Zing Education Zone's infrastructural and pedagogical context is unknown. It is also unclear whether any retention advantage differs by gender, or whether it is accompanied by changes in student motivation.

Purpose of the Study

The study examined the effect of immersive 3D animated science narratives on biology concept retention among SS 2 students in Zing Education Zone. Specifically, it sought to:

1. Determine the mean retention scores of students taught using 3D animated science narratives versus conventional instruction.
2. Ascertain whether retention scores differ significantly by gender among students taught using 3D animated narratives.
3. Examine the effect of 3D animated narrative instruction on students' motivation towards biology learning.

Research Questions and Hypotheses

1. What is the difference in mean retention scores between students taught using 3D animated science narratives and those taught conventionally?
2. What is the difference in mean retention scores between male and female students taught using 3D animated narratives?

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3. What is the difference in mean motivation scores between students taught using 3D animated narratives and those taught conventionally?

The following null hypotheses, corresponding to the three research questions above, were tested at the 0.05 significance level:
H01: There is no significant difference in the mean retention scores of students taught using 3D animated science narratives and those taught using conventional instruction.

H02: There is no significant difference in the mean retention scores of male and female students taught using 3D animated science narratives.
H03: There is no significant difference in the mean motivation scores of students taught using 3D animated science narratives and those taught using conventional instruction.

Methodology

Research Design

The study adopted a quasi-experimental pre-test/post-test control group design, appropriate because intact SS 2 classes could not be randomly reassigned without disrupting school timetables. Pre-test scores served as covariates to control for baseline differences between groups (Creswell & Creswell, 2023).

Study Area and Population

The study was conducted in Zing Education Zone, Taraba State, an agrarian, largely underserved area with respect to educational technology. The target population comprised all 748 SS 2 biology students across the zone's twelve public secondary schools during the 2025/2026 academic session.

Sample and Sampling Technique

A sample of 120 SS 2 students was drawn from four public secondary schools using multi-stage sampling. Schools were purposively selected based on availability of a functional projector or computer and administrative willingness to participate. One intact biology class was then randomly selected from each school by balloting. Two schools were randomly assigned to the experimental condition and two to the control condition, yielding 60 students per group (51 male, 69 female overall). Table 1 presents the distribution of respondents by group and gender.

Table 1. Distribution of Respondents by Group and Gender

Group	Male	Female	Total
Experimental	26	34	60
Control	25	35	60
Total	**51**	**69**	**120**

Instrumentation

Two instruments were used. The **Biology Retention Achievement Test (BRAT)** was a 40-item multiple-choice test covering cell division, the circulatory system, and Mendelian genetics, drawn from past WAEC

papers (2020–2025) and textbook exercises, and adapted to the treatment content. It was administered as a pre-test one week before instruction and as a delayed post-test two weeks after instruction ended. The Students' Motivation towards Biology Instruction Questionnaire (SMBIQ) was a 20-item, four-point Likert instrument (maximum score 80) administered alongside the post-test. Both instruments underwent face and content validation by three experts. Pilot testing with 30 students not in the main sample yielded a KR-20 of 0.81 for the BRAT and a Cronbach's alpha of 0.78 for the SMBIQ, both exceeding the 0.70 threshold recommended by Pallant (2020).

Procedure

Data collection proceeded in three phases. In Phase 1, the BRAT was administered as a pre-test to all 120 students. In Phase 2 (three weeks), the experimental group received instruction via 3D animated modules (sourced from the Visible Biology 3D library and supplemented with open-source Blender modules), projected in class with structured teacher facilitation: a five-minute activation activity, 20-minute animation viewing, 10-minute paired discussion, and 10-minute reflective exercise per lesson. The control group received conventional chalk-and-talk instruction on the same topics from their regular teacher. Both groups received twelve 45-minute periods. In Phase 3, two weeks after instruction ended, the delayed BRAT post-test and the SMBIQ were administered to all students.

Method of Data Analysis

Research questions were answered using means and standard deviations. Hypothesis 1 was tested using ANCOVA with pre-test scores as covariate; Hypotheses 2 and 3 were tested using independent samples t-tests. All tests were conducted at the 0.05 significance level using SPSS Version 27.

Results

Research Question 1. Table 2 shows that the groups were comparable at baseline (Experimental: M = 38.42, SD = 6.17; Control: M = 37.95, SD = 6.43; difference = 0.47). Post-instruction, the experimental group's mean rose to 71.83 (SD = 8.34), a gain of 33.41 marks, compared with the control group's rise to 54.27 (SD = 9.12), a gain of 16.32 marks a post-test difference of 17.56 marks favouring the experimental group.

Table 2. Pre-test and Post-test Mean Retention Scores

Group	N	Pre-test M (SD)	Post-test M (SD)	Mean Gain
Experimental	60	38.42 (6.17)	71.83 (8.34)	33.41
Control	60	37.95 (6.43)	54.27 (9.12)	16.32

Hypothesis 1. ANCOVA results (Table 3) showed a statistically significant effect of instructional method on post-test retention after controlling for pre-test scores, $F(1, 117) = 47.31$, $p < .001$, partial $\eta^2 = .288$ a large effect, accounting for roughly 29% of

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variance in retention scores. H01 was rejected.

Table 3. ANCOVA Summary for Instructional Method on BRAT Post-test

Source	Df	F	P	Partial η^2
Pre-test (covariate)	1	85.47	< .001	.422
Instructional Method	1	47.31	< .001	.288
Error	117	—	—	—

Research Question 2. Within the experimental group, male students (M = 73.61, SD = 7.92) scored marginally higher than female students (M = 70.17, SD = 8.51), a difference of 3.44 marks; both subgroups scored well above the control group mean of 54.27.

Hypothesis 2. An independent samples t-test found no statistically significant gender difference, t (58) = 1.61, p = .113. H02 was not rejected.

Research Question 3. The experimental group's mean SMBIQ score (M = 63.47, SD = 7.81; 79.3% of maximum) considerably exceeded the control group's (M = 48.12, SD = 9.34; 60.2% of maximum), a gap of 15.35 points.

Hypothesis 3. An independent samples t-test confirmed this difference was statistically significant, t (118) = 10.36, p < .001. H03 was rejected.

Discussion of Findings

Three key findings emerged: (i) students taught using 3D animated science narratives achieved significantly higher retention than those taught conventionally, with a large effect size; (ii) gender did not significantly moderate this retention advantage; and (iii) the experimental group reported significantly higher motivation towards biology learning than the control group.

Discussion

The large retention advantage for the 3D animated group aligns with the theoretical predictions of Cognitive Load Theory (Sweller et al., 2019) and the Cognitive Theory of Multimedia Learning (Mayer, 2020), and corroborates earlier findings. The effect size obtained here (partial η^2 = .288) is comparable to the large effect reported by Ogundele and Adeyemi (2022) in a study where learners taught the circulatory system via 3D animated narratives scored significantly higher on a delayed retention test than peers taught conventionally, and sits within the range synthesized by Hou et al. (2023) in their meta-analysis of animation-enhanced science instruction. The advantage likely reflects multiple mechanisms: 3D visualization externalized dynamic spatial processes that would otherwise demand heavy mental simulation, reducing intrinsic cognitive load (Ayres & Paas, 2021); narrative structure provided a coherent causal framework that scaffolded schema construction, consistent with Vygotsky's (1978) social constructivist account; and structured teacher facilitation kept

engagement active rather than passive (Abubakar & Suleiman, 2024).

The non-significant gender difference is consistent with Aliyu and Bello (2023) and Ogundele and Adeyemi (2022), who similarly found no significant gender moderation of retention gains once access barriers and teacher facilitation were held constant. The marginally higher male mean may reflect residual spatial-processing advantages reported in some studies, but the absence of statistical significance suggests that well-facilitated 3D animated instruction is broadly equitable across gender in this context a positive signal for biology education in a zone where gender gaps in science achievement are a recognised concern.

The substantially higher motivation reported by the experimental group is consistent with self-determination theory (Ryan & Deci, 2020) and with prior findings linking 3D animated instruction to greater intrinsic motivation (Green & Jenkins, 2023; Sun et al., 2022; Nwosu & Eze, 2021). Some of this gain may reflect a novelty effect from introducing digital instruction in a zone where such resources are rare (Scheiter, 2021); however, the narrative framing of the animations embedding biological processes in relatable storylines plausibly activated the deeper emotional engagement that narrative-based science communication research associates with improved learning motivation (Dahlstrom, 2021; Negrete, 2022).

Implications to Science Education

These findings carry several implications for science education practice, policy, and theory. Pedagogically, they suggest that biology teachers particularly those handling high-interactivity topics such as cell division, circulation, and genetics can achieve meaningfully better learning outcomes by supplementing or replacing chalk-and-talk delivery with well-facilitated 3D animated narratives, provided the animation is paired with structured pre- and post-viewing activities rather than passive viewing alone.

For curriculum and policy, the results offer Taraba State's education authorities and the NERDC locally grounded evidence to justify investment in digital instructional resources for underserved zones, rather than relying solely on findings from better-resourced South-Western Nigerian or international settings. Because the retention advantage held regardless of gender, the findings also suggest that scaling 3D animated instruction is unlikely to widen existing gender gaps in science achievement, and may help narrow them by making abstract content more visually accessible to students who report higher anxiety toward abstract science tasks.

Theoretically, the study reinforces the applicability of Cognitive Load Theory and the Cognitive Theory of Multimedia Learning to under-researched rural Nigerian classrooms, while extending the evidence base for narrative-structured (rather than purely expository) animated instruction. The motivational findings further suggest that 3D animated science narratives may serve a dual role improving immediate retention while also cultivating the sustained engagement that underlies long-term STEM participation,

an outcome of strategic importance for regions seeking to build local scientific and technical capacity.

Conclusion and Recommendations

Immersive 3D animated science narrative instruction was significantly more effective than conventional chalk-and-talk instruction in promoting biology concept retention among SS 2 students in Zing Education Zone, Taraba State. This advantage held across gender and was accompanied by a substantial increase in student motivation towards biology learning. The findings extend theoretical predictions from Cognitive Load Theory, the Cognitive Theory of Multimedia Learning, and Social Constructivism, and replicate prior empirical patterns from South-Western Nigeria and international contexts within a North-Eastern Nigerian setting that has received limited prior research attention. These benefits at scale, however, depends on addressing persistent infrastructural constraints, including limited ICT equipment, unreliable electricity, and the need for sustained teacher professional development.

Based on the conclusion, the following recommendations are made:

1. Biology teachers in Zing Education Zone and Taraba State should integrate 3D animated science narratives into instruction for high-interactivity topics such as cell division, circulation, and genetics.
2. The Taraba State Secondary Education Board and the Universal Basic Education Commission should prioritise functional ICT infrastructure projectors, computers, and reliable electricity in public secondary schools as a precondition for scaling digital instruction.
3. The Ministry of Education and the National Teachers' Institute should design structured professional development programmes to build teachers' technical and pedagogical capacity for facilitating 3D animated science instruction.
4. The NERDC, with universities and technology developers, should invest in locally produced, curriculum-aligned 3D biology animations, including narration in local languages to reduce second-language processing demands.
5. Pre-service biology teacher education programmes should incorporate instruction in the design principles of multimedia learning to prepare future teachers for technology-enhanced instruction.

REFERENCES

Abubakar, M. S., & Suleiman, R. O. (2024). Three-dimensional animated instruction and undergraduate chemistry students' retention of molecular orbital theory in Kano State universities. Journal of Science Education Research in Nigeria, 15(2), 44–63. https://doi.org/10.46654/jsern.2024.1502.003

Aliyu, H. M., & Bello, A. R. (2023). Digital technology access and its implications for science education delivery in Northern Nigerian secondary schools: A survey report. African Journal of Educational Technology, 11(1), 12–28. https://doi.org/10.4314/ajet.v11i1.2

Ayres, P., & Paas, F. (2021). Cognitive load theory: New directions and challenges. Applied Cognitive Psychology, 35(1), 1–4. https://doi.org/10.1002/acp.3824

Creswell, J. W., & Creswell, J. D. (2023). Research design: Qualitative, quantitative, and mixed methods approaches (6th ed.). SAGE Publications.

Dahlstrom, M. F. (2021). Using narratives and storytelling to communicate science with non-expert audiences. Proceedings of the National Academy of Sciences, 118(15), e2020441118. https://doi.org/10.1073/pnas.2020441118

Federal Ministry of Education. (2022). National policy implementation framework for educational technology integration in Nigerian schools. Federal Ministry of Education Press.

Green, M. C., & Jenkins, L. D. (2023). Narrative persuasion and science communication: How story-based approaches influence knowledge and attitudes. Journal of Communication, 73(2), 112–130. https://doi.org/10.1093/joc/jqad002

Hou, X., Wang, C., & Chen, L. (2023). Animated visualization in science education: A meta-analysis of experimental studies. Computers & Education, 194, 104704. https://doi.org/10.1016/j.compedu.2022.104704

Ibrahim, R., Mokhtar, M., & Yusoff, N. H. (2023). Segmented 3D animation and the retention of organic reaction mechanisms among secondary school chemistry learners. Asia-Pacific Science Education, 9(1), 88–107. https://doi.org/10.1163/23641177-bja10053

Mayer, R. E. (2020). Multimedia learning (3rd ed.). Cambridge University Press. https://doi.org/10.1017/9781316941355

Negrete, A. (2022). Constructing science narratives: A theoretical framework for effective science communication through story. Science Communication, 44(3), 375–402. https://doi.org/10.1177/10755470221093052

Nwosu, C. E., & Eze, I. F. (2021). Effect of 3D animated instructional materials on secondary school students' retention of cell division concepts in Enugu State, Nigeria. Journal of the

Science Teachers Association of Nigeria, 56(1), 102–118. https://doi.org/10.36630/jstan_2021_5601_008

Ogundele, A. T., & Adeyemi, B. O. (2022). Retention of biological concepts and the role of 3D animation: Evidence from South-Western Nigerian secondary schools. Research in Science Education, 52(5), 1407–1426. https://doi.org/10.1007/s11165-021-10004-5

Pallant, J. (2020). SPSS survival manual: A step-by-step guide to data analysis using IBM SPSS (7th ed.). McGraw-Hill Education.

Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. Contemporary Educational Psychology, 61, 101860. https://doi.org/10.1016/j.cedpsych.2020.101860

Scheiter, K. (2021). What we still don't know about studying from visualizations: Towards establishing a meta-cognitive agenda. Educational Psychology Review, 33(3), 1387–1422. https://doi.org/10.1007/s10648-021-09584-8

Skulmowski, A., & Xu, K. M. (2022). Understanding cognitive load in digital and online learning: A new perspective on extraneous cognitive load. Educational Psychology Review, 34(1), 171–196. https://doi.org/10.1007/s10648-021-09624-3

Sun, K. T., Lin, Y. C., & Tsai, C. C. (2022). Spatial presence as a mediator of the effects of 3D animated chemistry instruction on retention and motivation. Computers in Human Behavior, 130, 107191. https://doi.org/10.1016/j.chb.2022.107191

Sweller, J., van Merriënboer, J. J. G., & Paas, F. (2019). Cognitive architecture and instructional design: 20 years on. Educational Psychology Review, 31(2), 261–292. https://doi.org/10.1007/s10648-019-09465-5

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Harvard University Press.