



ENHANCING STUDENTS' RETENTION IN BIOLOGY THROUGH VIDEO-BASED MULTIMEDIA INSTRUCTION IN AWKA EDUCATION ZONE

¹Josephine N. Okoli

<https://orcid.org/0009-0003-4401-6354>, jn.okoli@unizik.edu.ng

²Betty A. Ifediba

<https://orcid.org/0009-0008-3095-6077>, adaifediba@gmail.com;

^{1,2}Science Education Department, Nnamdi Azikiwe University, Awka, Nigeria

ABSTRACT

Despite the persistent use of conventional approaches in secondary school Biology, students often experience difficulty retaining biological concepts because many topics are abstract and visually complex. This study investigated the effect of video-based multimedia instruction (VBMI) on Senior Secondary School II students' retention in Biology in Awka Education Zone, while examining the influence of gender and the interaction between gender and instructional method. The study adopted a quasi-experimental posttest, retention-test control group design using intact classes, with 102 SS2 students participating in the study. Students were assigned to either the VBMI or expository teaching method (ETM) group, and retention scores were analysed using Analysis of Covariance (ANCOVA) with pretest scores as the covariate. Findings revealed a significant difference in students' retention in favour of VBMI, $F(1,99) = 810.279$, $p < .001$, partial $\eta^2 = .891$, indicating a very large instructional effect. Gender had no significant effect on retention, $F(1,99) = 0.080$, $p = .779$, partial $\eta^2 = .001$, while the interaction between instructional method and gender was also not significant, $F(1,97) = 0.476$, $p = .492$, partial $\eta^2 = .005$. These findings suggest that the retention advantage of VBMI was consistent across male and female students. Grounded in the Cognitive Theory of Multimedia Learning, the study concludes that synchronised visual and verbal instructional representations can promote sustainable learning in Biology. The study therefore recommends a purposeful integration of VBMI into Biology classrooms, supported by teacher professional development, adequate digital infrastructure, and the development of high-quality multimedia instructional resources.

Keywords: Video-Based Multimedia Instruction, Retention, Biology Education, Gender, Multimedia Learning, Secondary School Students.

Introduction

Biology education is expected to develop students' capacity to understand living systems, retain scientific concepts, and apply knowledge beyond the immediate instructional settings. Yet, persistent weaknesses in students' ability to retain Biology knowledge remain a concern because learning that is not retained has limited value for subsequent scientific reasoning and academic development. Evidence from Nigerian secondary schools indicates that the conventional mode of instruction does not consistently produce durable learning. For example, Gambari et al. (2014) found that although video-based multimedia instruction produced higher immediate Biology



achievement than conventional teaching, the conventional group recorded better retention. This finding is particularly consequential because many Biology concepts involve dynamic, microscopic, sequential, and abstract processes that require students to coordinate verbal explanations with visual representations. Research on multimedia learning suggests that well-designed combinations of words, images, animation, and video can support the selection, organisation, and integration of information, strengthening conceptual processing and subsequent recall (Çeken & Taşkın, 2022; Rosalis & de Oliveira, 2023). This concerns not only students' immediate performance but also their long-term retention of Biology knowledge.

Previous studies have examined multimedia, animation, video, flipped learning, virtual environments, and other technology-supported approaches as alternatives to conventional Biology instruction. Several studies report positive effects on students' learning outcomes such as achievement and, in some cases, retention. Animated instruction improved students' achievement and retention of Genetics concepts (Faruk et al., 2022), while animation and infographics produced significant differences in achievement and retention among students (Mbonu et al., 2025; Ukpai & Fomsi, 2023). Flipped classroom and PowerPoint instruction have also improved students' achievement and retention, with flipped learning producing stronger outcomes than PowerPoint (Adonu et al., 2021). Similar benefits have been reported for technology-supported science learning and video-based instruction in other subject areas (Ahmed et al., 2024; Oguezie & Osuafor, 2021; Osei et al., 2025). However, this evidence does not establish a consistent case for video-based multimedia as a mechanism for durable learning in Biology. The contradictory retention finding reported by Gambari et al. (2014) challenges the assumption that stronger achievement necessarily translates into better retention. The literature is also methodologically fragmented because several studies embed video or multimedia within broader interventions, including flipped classrooms, inquiry learning, games, or dynamic classroom instruction (Arici & Yilmaz, 2025; Kassa et al., 2024; Tetteh et al., 2025). Such designs make it difficult to isolate the contribution of video-based multimedia itself. Other studies have concentrated primarily on immediate achievement, conceptual understanding, motivation, or perceptions rather than delayed retention (Christopoulos et al., 2023; Lacey et al., 2024; Soltura, 2021). Consequently, a specific empirical gap remains concerning whether video-based multimedia instruction, when examined as a distinct instructional approach, can produce sustained retention of Biology knowledge among secondary school students. Evidence from southeastern Nigeria, particularly Awka Education Zone, is also limited, leaving the applicability of existing findings to this educational context insufficiently established.

The present study addresses this gap by examining the effect of Video-Based Multimedia Instruction on secondary school students' retention in Biology in Awka Education Zone. The study treats retention as a distinct learning outcome rather than assuming that post-instruction achievement represents durable learning. Video-based multimedia instruction provides students with coordinated visual and verbal representations that can make dynamic and abstract Biology processes more concrete, while allowing important instructional information to be presented through controlled sequences that students can revisit and process. This approach is consistent with the Cognitive Theory of Multimedia Learning, which proposes that meaningful learning is facilitated when learners actively select, organise, and integrate information from verbal and



pictorial representations (Oguezue & Okigbo, 2026; Rosalis & de Oliveira, 2023; Çeken & Taşkın, 2022). The study therefore extends existing research by isolating video-based multimedia as the instructional intervention and evaluating its influence on delayed retention among secondary Biology students in a Nigerian educational setting. Although the study can provide evidence of the effectiveness of the approach within the sampled context, its quasi-experimental design and geographical focus may limit causal generalisation beyond similar school settings. The central proposition is that appropriately designed Video-Based Multimedia Instruction can strengthen the retention of Biology learning, providing an empirically testable alternative to conventional instructional practice for improving students' retention in Awka Education Zone.

Research Questions

The following Research questions guided the study

1. What are the mean retention scores of students taught biology with Video-based multimedia instruction (VBMI) and those taught with the expository teaching method (ETM)?
2. What are the mean retention scores of male and female students taught biology with VBMI and ETM?

Hypotheses

1. There is no significant difference in the mean retention scores of SS2 students taught biology using VBMI and those taught with ETM.
2. There is no significant difference in the mean retention scores of male and female students taught biology using VBMI and ETM.
3. There is no significant interaction effect of gender and teaching methods on students' retention scores in biology.

Methods

The study adopted a quasi-experimental pretest-posttest non-randomised control group design. This design was considered appropriate because intact SSS2 classes were used, making individual random assignment impossible within the participating schools. Two groups were involved: an experimental group taught using Video-Based Multimedia Instruction (VBMI) and a control group taught using the Expository Teaching Method (ETM). The study was conducted in the Awka Education Zone of Anambra State, Nigeria, with a population comprising 4,940 male and female SSS2 students enrolled in government secondary schools in the zone. A sample of 102 SSS2 students was drawn from two government-owned co-educational secondary schools. Intact classes were used to preserve the existing school organisation and minimise disruption to normal instructional activities. One class was assigned to the experimental condition and the other to the control condition. Because the groups were not individually randomised, the posttest was used to examine baseline comparability and reduce concerns about pre-existing differences.

Data were collected using the Biology Achievement Test (BAT), serving as the delayed retention measure. The BAT consisted of 50 multiple-choice items with four response options, A to D, covering mitosis, meiosis, and Kingdom Animalia. Items were drawn from relevant past



West African Examinations Council (WAEC) Biology questions to ensure curricular relevance and appropriate difficulty. A Table of Specification was developed to establish adequate representation of the content areas and cognitive objectives covered during instruction. The BAT was administered before the intervention as a pretest and immediately after four weeks of instruction as a posttest. Two weeks after the posttest, the same items were reshuffled and administered as a delayed retention test. Reshuffling was intended to reduce position-based recall while maintaining equivalence of content across administrations. Each correct response attracted 2 marks, whereas incorrect and unanswered items received zero (0). Thus, the maximum obtainable score was 100.

The instrument was validated by three experts in the field of Measurement and Evaluation, Psychology, and Biology Education. The experts examined the items for content relevance, clarity, appropriateness to the SSS2 level, and alignment with the instructional objectives. The reliability of the BAT was established using the Kuder-Richardson Formula 20 (KR-20), which was appropriate because the test comprised dichotomously scored multiple-choice items with potentially unequal item difficulty. The assessment approach was also consistent with previous retention studies in Biology that have used objective achievement tests and delayed testing to distinguish immediate learning from subsequent retention (Gambari et al., 2014; Faruk et al., 2022; Ukpai & Fomsi, 2023).

The instructional intervention consisted of structured lesson plans and VBMI packages covering the selected Biology concepts. The lesson plans for both groups were identical in content, objectives, sequence, and duration, differing only in instructional method. The experimental group received VBMI through visual and verbal multimedia representations presented with stand-alone computers and an LCD projector. Students watched and listened to the instructional videos and could interact with the presentations through Next, Previous, Pause, and Stop functions. Such coordinated verbal and visual representations are consistent with the Cognitive Theory of Multimedia Learning, which proposes that meaningful learning occurs through active selection, organisation, and integration of information from verbal and pictorial representations (Mayer, 2009; Çeken & Taşkın, 2022). The control group received ETM, in which the teacher introduced and explained the topics orally, asked questions, guided students in note-taking, responded to questions, summarised the lessons, and evaluated students' understanding. This arrangement enabled the study to compare VBMI with conventional classroom instruction while controlling exposure to content and instructional time.

The experiment was implemented in five stages. First, the researcher conducted a three-day briefing and practical training for the participating Biology teachers who served as research assistants. The experimental-group teacher was trained to operate and implement the VBMI packages, while the control-group teacher was briefed on the study purpose, lesson schedule, content, and assessment procedures. Both teachers received the respective lesson plans, and a microteaching session was conducted on the final day of the briefing to promote procedural consistency. Second, the researcher, assisted by the participating Biology teachers, administered the BAT as a pretest before instruction commenced. Third, the four-week intervention was implemented. The experimental group received VBMI in the school ICT laboratory, where the teacher projected the multimedia lessons and guided students' interaction with the materials. The



control group received ETM covering the same concepts for the same duration. Fourth, immediately after the four-week intervention, the BAT was administered as the posttest. Fifth, two weeks later, the reshuffled BAT was administered as the delayed retention test. All completed scripts were collected and scored using the predetermined marking scheme.

Data collection was conducted by the researcher with the assistance of the participating Biology teachers. Standardised lesson plans, training, instructional duration, assessment conditions, and scoring procedures were used to minimise implementation differences between groups. The researcher monitored the intervention to ensure adherence to the prescribed procedures. The data were analysed using descriptive and inferential statistics. Means and standard deviations were used to answer the research questions, and Analysis of covariance (ANCOVA) was used to test the hypothesis to determine the effect of instructional method on delayed posttest while controlling for students' posttest scores. ANCOVA was also used to examine the main effect of gender and the interaction between instructional method and gender. Statistical decisions were made at the .05 level of significance. Partial eta squared (η^2) was reported as a measure of effect size to determine the magnitude of statistically significant and non-significant effects.

Results

Research question 1: What is the difference between the mean retention scores of SS2 students taught biology with VBMI and those taught with ETM?

Table 1: Mean retention score of students taught biology using VBMI and ETM

Method	N	Posttest		Retention		Mean Gain
		Mean	SD	Mean	SD	
VBMI	48	68.54	8.01	66.33	9.35	-2.21
ETM	54	30.54	8.20	26.52	6.48	-4.02

The results indicate that the VBMI group recorded a posttest mean of 68.54 (SD = 8.01), which declined to 66.33 (SD = 9.35) at retention, representing a mean loss of 2.21 points. The ETM group declined from a posttest mean of 30.54 (SD = 8.20) to a retention mean of 26.52 (SD = 6.48), representing a mean loss of 4.02 points. Thus, the VBMI group demonstrated a smaller decrease in performance, indicating comparatively better retention of Biology learning than the ETM group.

Research question 2: What is the difference between the mean retention scores of male and female students taught biology using VBMI and LM?

Table 2: Mean retention and standard deviation scores of male and female students taught Biology using VBMI and LM

Method	Sex	N	Posttest Scores		Retention Score		Mean Gain
			Mean	SD	Mean	SD	
VBMI	Male	27	70.29	6.34	65.48	8.24	-4.81
	Female	21	66.29	9.56	67.42	10.42	1.13
<i>Mean Diff.</i>			4.00		-1.94		
ETM	Male	30	31.80	8.54	25.77	5.79	-6.03
	Female	24	28.96	7.65	27.45	7.28	-1.51
<i>Mean Diff.</i>			2.84		-1.68		



The VBMI group recorded a posttest mean of 68.54 (SD = 8.01), declining to 66.33 (SD = 9.35) at retention, a mean loss of 2.21 points. The ETM group decreased from 30.54 (SD = 8.20) to 26.52 (SD = 6.48), representing a mean loss of 4.02 points. Thus, the smaller decline in the VBMI group suggests better retention of Biology learning compared with ETM.

Test of Null Hypotheses

Hypothesis 1: There is no significant difference in the mean retention scores of SS2 students taught biology using VBMI and those taught with ETM.

Table 3: ANCOVA test of significance of difference in students' Retention

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial η^2	Remark
Corrected Model	41602.562 ^a	2	20801.281	410.322	.000	.892	
Intercept	11336.290	1	11336.290	223.617	.000	.693	
Pretest	1319.338	1	1319.338	26.025	.000	.208	
Method	41077.130	1	41077.130	810.279	.000	.891	Sig.
Error	5018.810	99	50.695				
Total	255518.000	102					
Corrected Total	46621.373	101					

Table 3 shows a significant difference in the adjusted retention scores of students taught Biology using VBMI and those taught using ETM, after controlling for pretest scores, $F(1, 99) = 810.279$, $p < .001$, partial $\eta^2 = .891$. Therefore, the null hypothesis was rejected. The partial eta squared indicates a very large effect of instructional method on students' retention. The pretest was also a significant covariate, $F(1, 99) = 26.025$, $p < .001$, partial $\eta^2 = .208$. Thus, instructional method had a substantial effect on students' retention of Biology concepts.

Hypothesis 2: There is no significant difference in the mean retention scores of male and female students taught biology with VBMI and those taught with ETM.

Table 4: ANCOVA test of significance of difference in male and female students' Retention

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial η^2	Remark
Corrected Model	562.430 ^a	2	281.215	.604	.548	.012	
Intercept	13419.857	1	13419.857	28.845	.000	.226	
Pretest	503.397	1	503.397	1.082	.301	.011	
Gender	36.997	1	36.997	.080	.779	.001	Sig.
Error	46058.942	99	465.242				
Total	255518.000	102					
Corrected Total	46621.373	101					

Table 4 indicates that there was no significant difference in the adjusted retention scores of male and female students after controlling for pretest scores, $F(1, 99) = 0.080$, $p = .779$, partial $\eta^2 = .001$. Therefore, the null hypothesis was not rejected. The effect size indicates a negligible effect of gender on students' retention. Similarly, pretest scores did not significantly predict retention, $F(1, 99) = 1.082$, $p = .301$, partial $\eta^2 = .011$. Thus, gender did not significantly influence students' retention in Biology under the instructional conditions examined.



Hypothesis 3: There is no significant interaction effect of gender and teaching methods on students' retention scores in biology

Table 5: ANCOVA test of significant interaction effect of instructional approaches and gender on students' retention

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial η^2	Remark
Corrected Model	41669.782 ^a	4	10417.446	204.074	.000	.894	
Intercept	11110.507	1	11110.507	217.651	.000	.692	
Pretest	1303.619	1	1303.619	25.537	.000	.208	
Method	40674.349	1	40674.349	796.797	.000	.891	Sig.
Gender	46.249	1	46.249	.906	.344	.009	Not Sig.
Method * Gender	24.299	1	24.299	.476	.492	.005	
Error	4951.590	97	51.047				
Total	255518.000	102					
Corrected Total	46621.373	101					

Table 5 indicates that the interaction effect of instructional method and gender on students' retention scores was not statistically significant, $F(1, 97) = 0.476$, $p = .492$, partial $\eta^2 = .005$. Therefore, the null hypothesis was not rejected. The effect size indicates a negligible interaction effect, suggesting that the effectiveness of VBMI relative to ETM on students' retention did not significantly differ by gender. Thus, gender did not moderate the effect of instructional method on students' retention in Biology.

Discussion of Findings

The findings demonstrate that video-based multimedia instruction (VBMI) improved students' retention in Biology compared with the expository teaching method (ETM). After controlling for pretest scores, instructional method had a statistically significant effect on retention, $F(1, 99) = 810.279$, $p < .001$, partial $\eta^2 = .891$, indicating an exceptionally large effect. This finding is consistent with evidence that multimedia and video-supported instruction can strengthen students' retention by combining visual and verbal representations of subject matter. Adonu et al. (2021) similarly reported improved achievement and retention when Biology was taught using technology-supported instructional approaches, while Ahmed et al. (2024) found that instructional videos enhanced both academic performance and retention. Comparable evidence has been reported for animated instructional media in genetics (Faruk et al., 2022), multimedia-integrated Biology instruction (Kassa et al., 2024), and multimodal instruction for photosynthesis (Tetteh et al., 2025). The present finding extends this literature by demonstrating a particularly strong retention advantage for VBMI within secondary school Biology in the Nigerian context. The result may be explained by the capacity of well-designed videos to make biological processes observable, sequential, and concrete, thereby reducing the abstraction inherent in topics that students may struggle to visualise through verbal exposition alone. This interpretation is compatible with the Cognitive Theory of Multimedia Learning, which proposes that learners can construct stronger mental representations when relevant verbal and visual information are meaningfully integrated (Çeken & Taşkın, 2022; Rosalis & de Oliveira, 2023). The finding therefore supports the use of



multimedia as a cognitive support for Biology learning rather than merely as a technological substitute for conventional teaching.

Contrary to the instructional-method effect, gender did not significantly influence students' retention, $F(1, 99) = 0.080$, $p = .779$, partial $\eta^2 = .001$. The negligible effect size indicates that male and female students demonstrated broadly comparable retention after accounting for pretest performance. This finding agrees with evidence suggesting that technology-enhanced instruction can provide comparable learning opportunities across gender groups. Osei et al. (2025), for example, found no meaningful gender-based disadvantage in the use of video-based multimedia instruction for learning linear equations, while the present result is also broadly compatible with research showing that technology-supported approaches can enhance learning without necessarily producing gender-based differences in outcomes. However, the finding differs from studies that have identified gender differentials in technology-supported learning, including Kutigi et al. (2023). Such differences may reflect variation in subject matter, instructional design, learners' prior experience, or the nature of the outcome assessed. Retention may also be less sensitive to gender-related differences than affective or motivational outcomes because it primarily reflects the extent to which learned information is maintained over time. The present finding therefore suggests that VBMI may offer a relatively equitable learning environment in which both male and female students can benefit from the same multimedia representations. It also cautions against assuming that gender alone determines students' capacity to retain Biology knowledge following technology-enhanced instruction.

The absence of a significant gender effect is complemented by the non-significant interaction between instructional method and gender, $F(1, 97) = 0.476$, $p = .492$, partial $\eta^2 = .005$. This indicates that the retention advantage associated with VBMI did not depend significantly on whether students were male or female. The finding is particularly relevant because it suggests that the instructional benefit was relatively consistent across gender groups rather than concentrated in one group. This pattern is consistent with the evidence of Osei et al. (2025), whose investigation of video-based multimedia instruction similarly points to the potential for gender-neutral learning benefits. It also contrasts with findings such as those reported by Kutigi et al. (2023), where gender differentials were observed in technology-supported instruction. A possible explanation is that video-based multimedia provides common visual and auditory representations that reduce dependence on gender-linked differences in preferred modes of classroom participation. The negligible interaction effect also indicates that gender did not constitute a meaningful boundary condition for the effectiveness of VBMI in the present sample. From a theoretical perspective, this strengthens the argument that the cognitive mechanisms proposed by multimedia learning theory, rather than gender membership, may have been primarily responsible for the observed retention gains. From a practical perspective, teachers can therefore implement appropriately designed VBMI without assuming that separate multimedia approaches are required for male and female learners.

Conclusion

The study demonstrates that video-based multimedia instruction (VBMI) significantly outperformed expository teaching in enhancing students' retention of Biology, with a very large



effect size. The absence of significant gender differences and method-by-gender interaction indicates that VBMI provided comparable retention benefits for male and female students. Grounded in the Cognitive Theory of Multimedia Learning, the findings suggest that integrating coordinated visual and verbal representations can promote more durable learning. The study therefore supports the purposeful adoption of VBMI in Biology teaching, alongside teacher capacity building and adequate digital infrastructure. Future research should examine the durability of these effects across longer retention periods and diverse educational contexts.

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