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Effect of Animation Instructional Strategy on Senior Secondary School Students' Achievement and Retention in Biology

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Abstract

This study investigated the Effect of Animation Instructional Strategy (AIS) on Senior Secondary Two (SS II) Students' Achievement and Retention in Biology in Abakaliki Education Zone of Ebonyi State. Six research questions and six hypotheses guided the study. A quasi-experiment of the pre-test, post-test non-equivalence control group research design was adopted for the study. Senior secondary two (SS 2) students from all the 85 public secondary schools in Abakaliki Education Zone numbering 11,758 formed the population of this study. The sample of the study comprised 468 students of the intact classes of 4 randomly sampled schools from the four local government areas in the zone. Biology Achievement Test (BAT) with reliability coefficients of 0.79 (for internal consistency) and 0.89 (for stability) were used as instruments for data collection of this study. Mean and standard deviation were used to answer the research questions while analysis of covariance (ANCOVA)

was used to test the hypotheses at 95% confidence level. The results revealed that: AIS significantly enhanced the mean achievement and retention scores of the students in biology more than the conventional chalk and talk method. Equally, the result further revealed that there is no significant difference between the mean achievement and retention scores of male and female students taught biology using AIS. In addition, the interaction between the methods and gender on the students mean achievement and retention scores in biology was not statistically significant. The study concluded that AIS was superior to the conventional chalk and talk method in enhancing students' academic achievement and retention in biology. Based on the findings of the study, it was recommended among others that biology teachers should prioritize the use of AIS since it has been proven to have a significant positive effect on the interest and academic achievement of students in biology.

Keywords: Biology, Secondary School Students, Animation Instructional Strategy, Academic Achievement, and Retention

Introduction

In addition to helping students better comprehend the natural world, biology is a fundamental science subject that is essential for tackling issues like disease outbreaks, food security, and climate change. Biology instruction in secondary schools is essential for encouraging students' interest in scientific subjects, particularly in a nation that is developing quickly like Nigeria. Applications in biotechnology, agriculture, health, and environmental conservation further highlight the importance of biology. A strong grasp of biology is crucial in Nigeria, where diseases like malaria and tuberculosis are common and agriculture is still a crucial industry (Adebayo & Adeyanju, 2023; Ojo & Ebenezer, 2022) ^[4, 46].

Nigerian secondary school students frequently show little interest in and proficiency in biology, despite the subject's importance. According to Aina (2021) ^[9], traditional teaching approaches, which frequently rely mostly on lectures and rote memorization, make it impossible for many students to understand complicated biological ideas. Ojo and Ebenezer (2022) ^[46], who claim that sociocultural views about science education, teaching techniques, and a lack of resources all contribute to low interest and achievement, which in turn impacts their retentive ability, further support this argument. On the other hand, traditional teaching approaches frequently fall short of igniting students' desire and interest, which results in poor achievement and retention, according to Adesoji and Olatunji (2021) ^[7]. Furthermore, the conventional chalk and talk approach can lead to a limited understanding of biological concepts, resulting in poor academic achievement, and lack of interest among students (Kolawole, 2020; Akinbobola & Daramola, 2019) ^[31, 12]. As a result, exploring innovative teaching strategy like animation

could potentially improve students' academic achievement and retention in biology.

For many years, the traditional "chalk and talk" style of instruction has been a mainstay in education. It is typified by a teacher-centered approach in which knowledge is imparted through lectures supported by writing on a whiteboard or chalkboard (Ojo & Ebenezer, 2022) ^[46]. Despite its advantages, this approach is heavily criticized in light of contemporary theories of learning and educational needs. The chalk and speak method's effectiveness in disseminating knowledge to a large number of students at once is one of its main benefits (Kolawole, 2020) ^[31]. It is appealing in curricula with tight deadlines because it enables teachers to cover a significant quantity of content in a comparatively short length of time (Adesoji & Olatunji, 2021) ^[7]. Furthermore, this method can be effective for introducing new concepts, providing a structured outline of content, and ensuring that all students receive the same foundational knowledge (Akinbobola & Daramola, 2019) ^[12]. However, the chalk and talk method has several notable drawbacks, particularly in fostering students' engagement and critical thinking (Adesoji and Olatunji, 2021) ^[7]. Modern educational researches (Adebayo & Adeyanju, 2023; Ojo & Ebenezer, 2022; Aina, 2021) ^[4, 46, 9], emphasizes the importance of active learning, where students engage with the material through discussion, collaboration, and hand-on-activities. The traditional chalk and talk or lecture format often leads to passive learning, where students become mere recipients of information rather than active participants in their learning process. This passivity can result in lower retention rates and a lack of deep understanding of material (Bello & Okeke, 2022) ^[16]. Moreover, the chalk and talk method does not cater to diverse learning styles. Students have varying preferences for how they absorb and process information and a one-size-fits-all approach can alienate those who thrive in interactive or experiential learning environments (Kolawole, 2020) ^[31]. Recent advancements in educational technology like the use of digital tools allow for more dynamic and interactive learning experience. These methods according to Adebayo and Adeyanju (2023) ^[4], encourage collaboration, critical thinking, and creativity, aligning more closely with the skills needed in the 21st century workforce. Hence the exploration of the efficacy of animated instructional strategy on students' interest, achievement and retention in biology.

According to Mayer (2021) ^[35], animation is the process of simulating movement by showcasing a sequence of discrete images, or frames. Animations can be used in education to help students understand difficult subjects by visualizing them (Hattie, 2021) ^[26]. Animation is a multimedia teaching tool that uses visual representation to make complex biological concepts and processes easier for students to understand (Mayer, 2017) ^[34]. Additionally, animation can make complex concepts like genetic inheritance, cellular respiration, reproduction, and ecological interaction easier for students to understand than text-based or static imagery alone, which is what the traditional chalk-and-talk method provides (Rogers *et al.*, 2021) ^[56]. According to studies, animated content can greatly improve learning outcomes by encouraging active participation and improving memory (Bello & Okeke, 2022) ^[16]. Zhang, Zhou, Briggs, & Nunamaker (2020) ^[65], report that animation can lead to improved learning outcomes, and retention of scientific concepts, particularly in subjects that require the

comprehension of intricate processes, such as biology. This is critical in secondary school education where students are introduced to more advanced biological concepts that necessitate a deeper understanding of processes such as cellular respiration, reproduction, genetics and ecological interactions.

The effectiveness of animation as an instructional approach can be attributed to several cognitive theories. Mayer's cognitive Theory of Multimedia Learning posits that learners can better understand content when it is presented through multiple modalities (Mayer, 2017) ^[34]. Equally, the dual coding theory also supports this notion, suggesting that visual and auditory information is processed in different ways, allowing for a more comprehensive understanding when modalities are employed (Paivio, 1986) ^[54]. Furthermore, engaging animations can stimulate interest and curiosity, which are vital components of the learning process. Research by Hattie (2021) ^[26], emphasizes the importance of student engagement in improving academic achievement and retentive ability, underscoring that interest in a subject can significantly impact students' motivation and effort.

The effectiveness of animation as an instructional approach can be attributed to several cognitive theories. Mayer's cognitive Theory of Multimedia Learning posits that learners can better understand content when it is presented through multiple modalities (Mayer, 2017) ^[34]. Equally, the dual coding theory also supports this notion, suggesting that visual and auditory information is processed in different ways, allowing for a more comprehensive understanding when modalities are employed (Paivio, 1986) ^[54]. Furthermore, engaging animations can stimulate interest and curiosity, which are vital components of the learning process. Research by Hattie (2021) ^[26], emphasizes the importance of student engagement in improving academic achievement and retentive ability, underscoring that interest in a subject can significantly impact students' motivation and effort.

The integration of animation instructional strategies in teaching biology at the secondary school level in Nigeria has become increasingly essential for enhancing students' academic achievement. Traditional teaching methods (e.g., the chalk and talk method), often fail to engage students effectively, particularly in subjects that require a deep understanding of complex biological processes (Kolawole, 2020) ^[31]. Animation, as a dynamic and interactive form of instruction, addresses these challenges by providing visual representation of abstract concepts, thereby facilitating better understanding and retention (Adebayo & Adeyanju, 2023; Khalid & Al-Nafai, 2021) ^[4, 30]. Research by Mayer (2020) indicates that students who learn through animated content tend to perform better in assessments than those who rely solely on traditional methods. This is owing to visual nature of animation that helps to simplify intricate biological mechanisms; making them more accessible to learners. More so, today's students are accustomed to multimedia content, and incorporating animations into biology lessons can capture their attention and foster greater engagement. This is particularly important in Nigeria where the traditional education system often emphasizes rote memorization over critical thinking and application of knowledge (Bello & Okeke, 2022) ^[16]. By leveraging the power of visual learning and catering for the individual learning needs of 21st – century learners, educators can

promote a deeper understanding of biology, ultimately leading to better academic achievement and retentive ability of students irrespective of their gender.

On students' retention, the effects of animation instructional strategies on Nigerian secondary school students' retentive ability in biology is significant. Animation enables students to understand and retain complex biological concepts by providing dynamic visual representations that simplify intricate processes (Zhang, Wang & Chen, 2021). Research indicates that students exposed to animated instructional process demonstrated improved retention rates compared to those taught through traditional methods (Ajayi & Ogunsola, 2021). This improvement can be attributed to the dual coding theory, which posits that information is better retained when presented in both visual and verbal formats (Mayer, 2017) [34].

Gender differences in academic achievement and retention have been a significant area of research, particularly in the context of science subjects like biology among secondary school students in Nigeria. Research indicates that female students often achieve higher in biology-related topics, particularly those related to health, environment, and social issues than their male counterparts (Ajayi, Eze & Omenyior, 2023) [11]. Equally, study by Ogunniyi (2020) have pointed out that girls frequently align their achievement and retention in biology with real-world applications, reflecting concerns about community health and environmental sustainability. In contrast, male students might display a greater interest in competitive and theoretical aspects of biology, often driven by social expectations and gender norms that associate masculinity with performance in science and technology. This is consistent with findings by Ajayi, Eze and Omenyior (2021), who noted that boys tend to gravitate towards biological topics that highlight competition and dominant narratives, which can be reflective of traditional masculine identities. Regarding achievement in biology, recent studies indicate that gender differences are nuanced. Despite the engagement levels, statistical outcomes show a mixed picture. For instance, research by Ojo, Adeshina and Oluwaseun (2022) [47] found that girls perform equally well or even better than boys in biology. This trend might indicate not only academic capability but also a higher level of motivation and effort among female students, counteracting some of the stereotypical views of female underachievement in sciences. The inconsistency of research over gender achievement and retention when taught with different instructional techniques, demands for an empirical investigation to find out if an innovative instructional strategy like animation can be gender stereotyped. Thus, the investigation whether animation instructional strategy can lead to significant gender differences in male and female students' interest, achievement and retention in biology.

Problem Statement

The increasing poor achievement of students in science subjects including biology, has been a subject of concern in Nigeria. This ugly development which has continued over the years is mainly attributed to poor instructional strategy like the conventional chalk and talk method. The conventional method has been criticized due to its passiveness, encouragement of rote memorization and inability to concretize lesson. In subject like biology, that necessitates deeper understanding of the processes involved

in some concepts such as cellular respiration, reproduction, genetics and ecological interactions, the conventional method has been found ineffective. Recent reports by the West African Examination Council's Chief Examiners report for the years 2022, 2023 and 2024, emphasize that students' performance in biology continues to be below satisfactory levels (West African Examination Council, 2022, 2023, 2024) [59, 60, 61]. This trend is indicative of a broader issue: many students struggle to connect with biological concepts, seeing them as abstract and irrelevant to their everyday lives. Thus, there is an urgent need to explore modern pedagogical strategies that can augment traditional teaching strategies, enhance student interest, and improve outcomes in biology education. Consequently, exploring the efficacy of a method like animation that is capable of arousing students' interests and improving understanding as well as academic achievement is essential.

Research Questions

The following research questions guided the study

1. What is the effect of animation instructional strategy on Students' mean achievement scores in biology?
2. What is the effect of animated instructional strategy on the mean achievement scores of male and female students in biology.?
3. What is the interaction effect of methods and gender on students mean achievement scores in biology?
4. What is the effect of animation instructional strategy on students' mean retention scores in biology?
5. What is the effect of animated instructional strategy on the mean retention scores of male and female students in biology.?
6. What is the interaction effect of methods and gender on students mean retention scores in biology?

Methodology

Research Design: This study adopted the quasi experimental of non-equivalent pre-test-post-test control group design. Subjects were not randomly assigned to groups, rather, intact classes were assigned to experimental and control groups through a toss of coin. The choice of this design was because it offers maximum control over extraneous variables. Also, the researcher is not in a position to assign subjects randomly to treatment conditions. The reason is to avoid disruption of normal school periods assigning subjects randomly to treatment conditions will cause. The design is symbolically represented in the table below.

Table 1: Symbolical representation of the research design

E	0 ₁	X	0 ₂	0 ₃
C	0 ₁	Y	0 ₂	0 ₃

Where;

E = Experimental Group;

C = Control Group

0₁=Pre-test achievement and retention

0₂=Post-test achievement and retention

0₃ = Retention test

X = Animation Instructional Strategy (AIS)

Y = Conventional talk and chalk method (CTCM)

Population of the Study: The population of this study was 11,758 comprising all the senior secondary two (SS 2)

biology students in the 85 public secondary schools in Abakaliki Education Zone. The justification for choosing to use SS 2 students in this study is because they have covered enough content areas in biology, unlike those in SS 1 who are freshly introduced to the subject or SS 3 students who are going into their final year examination.

Sample and Sampling Technique: The sample of the study comprised 468 (i.e., 253 in the treatment group comprising 140 male and 113 female and 215 in the control group comprising 99 male and 116 female) students in the intact classes of the sampled schools. Multi-stage sampling was employed. Abakaliki Education zone was stratified into four local government areas it houses. Through simple random sampling by balloting, one school was drawn from each of the four local government areas, making it four schools that were used for the study. Two schools each out of the four schools that were drawn for the study were assigned to experimental and control groups respectively through simple random sampling approach by toss of the coin.

Instruments for Data Collection: Biology Achievement Test (BAT) developed by the researchers was used for data collection. The BAT is a multiple-choice objective test containing 30 questions with each item having five options lettered A – E. The test is based on the units of study (i.e., reproduction, cells and respiration) in SSII biology curriculum.

Reliability of the Instrument: The BAT after pilot testing was subjected to test of reliability using Kuder Richardson's formula-20 (K-R20) procedure and it yielded a coefficient of 0.79. Furthermore, the stability of BAT was established after test re-test using Pearson's Product Moment Coefficient (r) and it yielded a coefficient of 0.89 indicating that the instrument is reliable for use in this study.

Data Collection: The classroom teachers of the different schools that were used as research assistants administered the instruments on three occasions to the same students who participated in the experiment. First, pre-test was administered before treatment administration. After six weeks which the experiment lasted, the same instrument items were reshuffled with different paper type and re-administered to the students as post-test. After two weeks of post-test, the same instrument was reshuffled and readministered to the same students as retention test. The pre-test, post-test, and retention scores were recorded after each marking exercise. The BAT items were scored 1 mark each. The maximum mark for the BAT was 30 marks.

Data Analysis: The six research questions were answered using mean and standard deviation scores while the null hypotheses were tested at 0.05 alpha level using analysis of covariance (ANCOVA).

Results

Research question 1

For this research question, data obtained using BAT on the achievement of the students in the treatment and control groups were used to answer the research question. Mean for pre and post tests were adjusted statistically in the analysis to take care of the initial equivalence of the research subjects. Summary of result of data analysis is presented in Table 2.

Table 2: Summary of mean achievement scores of students taught biology using animation instructional strategy and those taught with the conventional method

Group	Mean	Standard deviation	N
Experimental (Animation Strategy)	22.26	2.88	253
Control (Chalk and Talk)	16.58	2.24	215

Summary of result in Table 2 showed that students taught biology using the animation instructional strategy had a higher mean achievement score (22.26) than their counterparts taught with the conventional talk and chalk approach (16.58). This implies that animation instructional strategy enhanced the achievement of students in biology more than those exposed to conventional approach.

Research question 2

For this research question, data obtained with BAT on the achievement of the students in the treatment control group was used to answer the research question. Mean for pre and post tests were adjusted statistically in the analysis to take care of the initial equivalence of the research subjects. Summary of result of data analysis is presented in Table 3.

Table 3: Summary of mean achievement scores of male and female students taught biology using animation instructional strategy

Gender	Mean	Standard deviation	N
Male	23.71	2.48	140
Female	20.46	2.27	113

Summary of result in Table 3 showed that male students taught biology using animation instructional strategy had a higher mean achievement score (23.71) than their female counterparts taught with the same strategy (20.46). This implies that animation instructional strategy improved the achievement of male students in biology more than their female counterparts exposed to same strategy.

Research question 3

Adjusted mean for the two levels of gender that were subjected to animation instructional strategy and those subjected to the conventional chalk and talk method were used to access the interaction. Summary of result is presented in Table 4.

Table 4: Summary of interaction between gender and teaching strategies on students mean achievement scores in biology

Gender group	Mean for Treatment Group	Mean for Control Group
Males	23.66	17.10
Females	20.52	16.13

Summary of result presented in Table 7 revealed clearly that there is no interaction effect of gender and teaching methods on students' achievement scores in biology. Result presented in the table indicated that animation instructional strategy is superior to conventional chalk and talk method at the two levels of gender (male and female). This is because both male and female students in the treatment group had higher mean achievement scores (23.66 and 20.52)

respectively, than their counterparts in the control group (17.10 and 16.13) respectively.

Research question 4

What is the effect of animation instructional strategy on students' mean retention scores in biology?

For this research question, data obtained using BAT on the retention of the students in the treatment and control groups were used to answer the research question. Mean for pre and post tests were adjusted statistically in the analysis to take care of the initial equivalence of the research subjects. Summary of result of data analysis is presented in Table 5.

Table 5: Summary of mean retention scores of students taught biology using animation instructional strategy and those taught with the conventional method

Group	Mean	Standard deviation	N
Experimental (Animation Strategy)	23.82	3.75	253
Control (Chalk and Talk)	16.41	2.88	215

Summary of result in Table 5 showed that students taught biology using the animation instructional strategy had a higher mean retention score (23.83) than their counterparts taught with the conventional talk and chalk approach (16.41). This implies that animation instructional strategy enhanced the retention of the students in biology more than those exposed to conventional approach.

Research question 5

What is the effect of animated instructional strategy on the mean retention scores of male and female students in biology?

For this research question, data obtained with BAT on the retention of male and female students in the treatment group was used to answer the research question. Mean for pre and post tests were adjusted statistically in the analysis to take care of the initial equivalence of the research subjects. Summary of result of data analysis is presented in Table 6.

Table 6: Summary of mean retention scores of male and female students taught biology using animation instructional strategy

Gender	Mean	Standard deviation	N
Male	26.44	2.47	140
Female	20.58	2.47	113

Summary of result in Table 6 showed that male students taught biology using animation instructional strategy had a higher mean retention score (26.44) than their female counterparts taught with the same strategy (20.58). This implies that animation instructional strategy improved the retention of male students in biology more than their female counterparts exposed to same strategy.

Research question 6

What is the interaction effect of methods and gender on students mean retention scores in biology?

Adjusted mean for the two levels of gender that were subjected to animation instructional strategy and those subjected to the conventional chalk and talk method were used to access the interaction. Summary of result is presented in Table 7.

Table 7: Summary of interaction between gender and teaching strategies on students mean retention scores in biology

Gender group	Mean for Treatment Group	Mean for Control Group
Males	26.41	17.22
Females	20.62	15.72

Summary of result presented in Table 7 revealed clearly that there is no interaction effect of gender and teaching methods on the students' retention scores in biology. Result presented in the table indicated that animation instructional strategy is superior to conventional chalk and talk method at the two levels of gender (male and female). This is because both male and female students in the treatment group had higher mean retention scores (26.41 and 20.62) respectively, than their counterparts in the control group (17.22 and 15.72) respectively.

Hypotheses

H01: There is no significant difference in mean achievement scores of students taught biology using animated instructional strategy and those taught using conventional talk and chalk method.

H03: There is no significant interaction between methods and gender on students' mean achievement scores in biology.

Table 8: Analysis of co-variance for students' overall biology achievement scores by teaching methods and by gender/teaching methods

Source	Type III Sum of Squares	df	Mean Square	F	Significance
Corrected Model	5019.131 ^a	4	1254.783	306.789	.000
Intercept	2508.736	1	2508.736	613.375	.000
Pretest	604.092	1	604.092	147.698	.000
Method	3431.588	1	3431.588	839.008	.000
Gender	477.656	1	477.656	116.785	.000
Method*Gender	102.019	1	102.019	24.943	.385
Error	1893.696	463	4.090		
Total	187571.000	468			
Corrected Total	6912.827	467			

For hypothesis 1, the ANCOVA table shows the sig. value of 0.000 is less than 0.05. The decision rule is to reject the null hypothesis when the sig. value is less than alpha value of 0.05. Since the sig. value is less than 0.05, the null hypothesis was rejected. The researcher concludes that there was significant difference in the mean achievement scores of students taught biology using animated instructional strategy and those taught biology using conventional chalk and talk method. For hypothesis 3, result in Table 8 revealed that for two-way interaction, F.Sig. is 0.385 which is greater than 0.05. Based on the decision rule, the researcher upholds the null hypothesis and concludes that there is no significant interaction between gender and teaching strategies on students' mean achievement scores in biology.

H02: There is no significant difference in the mean achievement scores of male and female students taught biology using animation instructional strategy.

Table 9: Analysis of co-variance for male and female students' overall biology achievement scores

Source	Type III Sum of Squares	df	Mean Square	F	Significance
Corrected Model	834.936 ^a	2	417.468	83.137	.000
Intercept	2441.887	1	2441.887	486.290	.000
Pretest	175.699	1	175.699	34.990	.000
Gender	580.073	1	580.073	115.519	.472
Error	1255.364	250	5.021		
Total	127419.000	253			
Corrected Total	2090.300	252			

Summary of result on Table 9 shows that the sig. value of 0.472 is greater than 0.05. The decision rule is to uphold the null hypothesis when the sig. value is greater than alpha value of 0.05. Since the sig. value is greater than 0.05, the null hypothesis was upheld. The researcher concludes that there is no significant difference in the mean achievement scores of male and female students taught biology using animated instructional strategy. This implies that animated instructional strategy enhanced the academic achievement of male and female students without a significant difference.

H04: There is no significant difference in the mean retention scores of students taught biology using animated instructional strategy and those taught using conventional talk and chalk method.

H06: There is no significant interaction between methods and gender on students' mean retention scores in biology.

Table 10: Analysis of co-variance for students' overall biology retention scores by teaching methods and by gender/teaching methods

Source	Type III Sum of Squares	df	Mean Square	F	Significance
Corrected Model	9697.627 ^a	4	2424.407	559.491	.000
Intercept	333.730	1	333.730	77.016	.000
Pretest	1104.426	1	1104.426	254.873	.000
Method	559.028	1	559.028	129.009	.000
Gender	500.357	1	500.357	115.470	.000
Method*Gender	222.170	1	222.170	51.271	.286
Error	2006.288	463	4.333		
Total	206826.000	468			
Corrected Total	11703.915	467			

For hypothesis 4, the ANCOVA table shows the sig. value of 0.000 is less than 0.05. The decision rule is to reject the null hypothesis when the sig. value is less than alpha value of 0.05. Since the sig. value is less than 0.05, the null hypothesis was rejected. The researcher concludes that there was significant difference in the mean retention scores of students taught biology using animated instructional strategy and those taught biology using conventional chalk and talk method. For hypothesis 6, result in Table 10 revealed that for two-way interaction, F.Sig. is 0.286 which is greater than 0.05. Based on the decision rule, the researcher upholds the null hypothesis and concludes that there is no significant interaction between gender and teaching strategies on students' mean retention scores in biology.

H05: There is no significant difference in the mean retention scores of male and female students taught biology using animation instructional strategy.

Table 11: Analysis of co-variance for male and female students' overall biology retention scores

Source	Type III Sum of Squares	df	Mean Square	F	Significance
Corrected Model	2522.218 ^a	2	1261.109	305.864	.000
Intercept	425.606	1	425.606	103.225	.000
Pretest	381.095	1	381.095	92.429	.000
Gender	746.570	1	746.570	181.070	.847
Error	1030.778	250	4.123		
Total	147129.000	253			
Corrected Total	3552.996	252			

Summary of result on Table 11 shows that the sig. value of 0.847 is greater than 0.05. The decision rule is to uphold the null hypothesis when the sig. value is greater than alpha value of 0.05. Since the sig. value is greater than 0.05, the null hypothesis was upheld. The researcher concludes that there is no significant difference in the mean retention scores of male and female students taught biology using animated instructional strategy. This implies that animated instructional strategy enhanced the retention of male and female students without a significant difference.

Discussions

Findings of the study as evident in Table 2 revealed that students who were exposed to animated instructional strategy had higher mean achievement score than those who were exposed to conventional chalk and talk method. Equally, there was significance difference in the mean achievement scores of the students exposed to AIS and those who were exposed to the conventional approach as evident in Table 8. This implies that through AIS, secondary school students' achievement in biological concepts, can be improved. This further amplifies the need for AIS to be prioritised by biology teachers across all public secondary schools in Ebonyi State as a means to a sustainable end in enhancing students' achievement in biology. The findings agree with that of Oturu (2022) ^[53] investigated the effect of computer animation instructional package on students' academic performance in environmental concepts in Biology and found that the mean scores of students taught environmental concepts in biology with computer animation was higher than the mean scores of students taught with lecture method. Furthermore, this study findings align with that of Gongden, Yame and Gongden (2020) ^[25] examined the effects of animation instructional strategy (ANIS) on senior secondary one chemistry students' interest and achievement in chemical bonding and reported that it significantly enhanced achievement more than the conventional method. Consequently, it is imperative that AIS be prioritised by biology teachers as it has been proven empirically in this study and other related studies to enhance both achievement and retentive memory in biology and sciences generally. Considering the wealth of empirical evidence in literature substantiating the efficacy of animation instructional strategy in improving students' academic achievement and retention in biology, and other science subjects, it therefore portends that biology teachers should embrace its adoption during classroom interaction as a means to a sustainable end in advancing the teaching and learning of biology contents at the senior secondary level.

Result of analysis in Table 3 showed that male students taught biology using AIS had higher mean achievement score than their female counterparts taught with the same method. However, there was no significant difference in the mean achievement of students of both genders as evident in Table 9. The findings are in tandem with that of Sakiyo, Musa and Waziri (2018) ^[57] investigated the effects of multimedia instructional strategy on secondary school students' academic achievement in biology and reported that students' male students outperformed their female counterparts. Equally, the findings are in line with that of Oturu (2022) ^[53] who investigated the effect of computer animation instructional package on students' academic performance in environmental concepts in Biology and reported that gender was not a significant factor. The results of these studies coupled with that of the present study, justifies the need for biology teachers to prioritize the use of AIS to enhance the teaching and learning of biology at the secondary school level due to its proven gender friendliness. Result as evident on Tables 4 and 8 showed that there was no significant interaction between methods and gender on the students mean achievement scores in biology. This is because male and female students taught biology using animation instructional strategy had higher mean achievement scores respectively than their counterparts taught with the conventional chalk and talk approach. By implication, the AIS is suitable for use in teaching biology to both male and female students in the same class.

The result is in consonance with that of Oturu (2022) ^[53] who investigated the effect of computer animation instructional package on students' academic performance in environmental concepts in Biology and found that it enhanced the achievement of both male and female students in the treatment group more than their counterparts in the control group. The findings equally align with that of Gongden, Yame and Gongden (2020) ^[25] who examined the effects of animation instructional strategy (ANIS) on senior secondary one chemistry students' interest and achievement in chemical bonding and found that there was no interaction between the methods and gender on the students' achievement and interest in chemistry. Thus, signifying that biology teachers can adopt AIS at the classroom due to its proven gender friendliness.

Findings of the study as evident in Table 5 revealed that students who were exposed to animated instructional strategy had higher mean retention score than those who were exposed to conventional chalk and talk method. Equally, there was significance difference in the mean retention scores of the students exposed to AIS and those who were exposed to the conventional approach as evident in Table 10. This implies that through AIS, secondary school students' retentive ability in biological concepts, can be enhanced. This further amplifies the need for AIS to be prioritised by biology teachers across all public secondary schools in Ebonyi State as a means to a sustainable end in enhancing students' retentive ability in biology.

The above findings agree with that of Aiyedun (2020) ^[10] who examined the effect of animation teaching strategy on secondary school students' achievement, retention and interest in climate change and found that the mean retention score of students taught environmental concepts in biology with computer animation was higher than the mean retention score of students taught with lecture method. Furthermore, this study findings align with that of Atabang and Umanah

(2024) ^[15] examined Effect of Computer Animation on Students' Academic Achievement and Retention in Basic Science and Technology and reported that computer animation enhanced students' retentive ability in Basic Science and Technology. As a result, it is vital that AIS be prioritised by biology teachers as it has been proven empirically in this study and other related studies to enhance both achievement and retentive memory of students in biology and sciences generally. Considering the wealth of empirical evidence in literature substantiating the efficacy of animation instructional strategy in improving students' academic achievement and retention in biology, and other science subjects, it therefore portends that biology teachers should embrace its adoption during classroom interaction as a means to a sustainable end in fostering the teaching and learning of biology contents at the senior secondary level.

Retention of Male and Female Students' Taught Biology using AIS

Result of analysis in Table 6 showed that male students taught biology using AIS had higher mean retention score than their female counterparts taught with the same method. However, there was no significant difference in the mean achievement of students of both genders as evident in Table 11. The findings are in tandem with that of Anekwe and Opara (2021) ^[14] who investigated the effect of animation instructional strategy on students' academic achievement and retention of chemical bonding among senior secondary school students in Otuocha Education zone of Anambra state and reported that male students outperformed their female counterparts; although the differences in their mean retention scores were not statistically significant. Equally, the findings are in line with that of Aiyedun (2020) ^[10] who examined the effect of animation teaching strategy on secondary school students' achievement, retention and interest in climate change in Lokoja, Kogi State. and reported that gender was not a significant factor. The results of these studies coupled with that of the present study, justifies the need for biology teachers to embrace AIS to enhance the teaching and learning of biology at the secondary school level due to its proven gender friendliness.

Interaction Effect of Methods and Gender on Students Retention in Biology

Result as evident on Tables 7 and 10 showed that there was no significant interaction between methods and gender on the students mean retention scores in biology. This is because male and female students taught biology using animation instructional strategy had higher mean retention scores respectively than their counterparts taught with the conventional chalk and talk approach. By implication, the AIS is suitable for use in teaching biology to both male and female students in the same class.

The result is in consonance with that of Atabang and Umanah (2024) ^[15] who examined the effect of Computer Animation on Students' Academic Achievement and Retention in Basic Science and Technology and found that it enhanced the retention of both male and female students in the treatment group more than their counterparts in the control group. The findings equally align with that of Anekwe and Opara (2021) ^[14] investigated the effect of animation instructional strategy on students' academic achievement and retention of chemical bonding among senior secondary school students in Otuocha Education zone

of Anambra state and found that there was no interaction between the methods and gender on the students' achievement and retention in chemical bonding. Thus, justifying the need for biology teachers to embrace AIS at the classroom due to its proven gender friendliness.

Conclusions

The study concluded that animation instructional strategy was superior to the conventional chalk and talk method in enhancing students' academic achievement and retention in biology. Equally, animation instructional strategy enhanced the mean achievement and retention scores of male students than their female counterparts although the differences were not statistically significant. Furthermore, the interaction of instructional methods and gender did not affect the achievement and retention of the students because both male and female students in the treatment group had higher mean achievement and retentions scores more than their counterparts in the control group.

Recommendations

In line with findings of this study, the following recommendations were made:

1. Animation instructional strategy should be given serious consideration by biology teachers because of its proven positive effect on student's' academic achievement and retentive ability in biology.
2. Biology teachers should improve on their instructional behaviour leveraging on the benefits of animation instructional strategy in order to enhance students' academic achievement and retention in biology.
3. The state ministry of education in conjunction with school authorities should conduct workshops and seminars to enlighten science teachers more on the benefits of innovative teaching strategies like the animation instructional strategy in enhancing students' interest, academic achievement and retentive ability.

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