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EFFECTS OF EXPLICIT MULTIMEDIA LEARNING STRATEGY ON STUDENTS' ACADEMIC PERFORMANCE AND RETENTION IN AGRICULTURAL SCIENCE AMONG SENIOR SECONDARY SCHOOL STUDENTS IN KATSINA STATE, NIGERIA

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Abstract

This study investigated the effects of the Explicit Multimedia Learning Strategy (EMLS) on academic performance and retention among senior secondary school students in Agricultural Science in Katsina State, Nigeria. A quasi-experimental pre-test, post-test, and post-post-test design was employed. A total of 142 SSII students were selected using multistage sampling and divided into control and experimental groups. The experimental group received instruction using multimedia packages designed to deliver content on Nutrient Cycles and Organic Components, while the control group received conventional instruction. Instruments used included the Agricultural Science Achievement Test (ASAT). Results revealed a statistically significant improvement in performance and retention among students exposed to multimedia instruction. Gender was an insignificant factor in student outcomes. These findings validate the potential of multimedia strategies in improving cognitive outcomes and engagement in Agricultural Science education and provide empirical support for broader implementation.

Keywords: Multimedia, Explicit Multimedia Learning Strategy, Academic performance, Agricultural science, Retention.

Introduction

Education is the best legacy the older generation can bestow on the younger ones. Quality education when such learners possess the competencies and values needed to thrive in highly competitive global communities socially, mentally, and economically. In retrospect, writing and speaking have been the best mechanisms used in extending knowledge and wisdom to younger generations. Recently, research has proven that humans best learn when multimedia are incorporated during learning. Meaningful learning outcome has been the recommended learning outcome for this modern age learners; learners who can think for themselves and are capable of constructing new knowledge using previous knowledge. The importance of multimedia in enhancing meaningful learning has been acknowledged in previous studies, and the findings of learning through multimedia have resulted in a coinage of technical names for learning that occurred through words and pictures as multimedia learning (Mayer, 2009).

Agricultural Science education plays a critical role in achieving sustainable food systems, especially in agrarian economies like Nigeria. Yet, teaching and learning this subject is often hindered by outdated mechanisms of learning, low student engagement, and poor, meaningful learning of content. The persistent use of conventional written and spoken (lecture-based) approaches limits interactivity and visualization, and has failed to meet the learning needs of 21st-century learners as mentioned earlier. In light of this, educational technology offers promising alternatives through multimedia instruction that comprises a combination of written, spoken, visuals, animations, and motion mechanisms to enhance learning.

Multimedia learning mechanism, as prescribed by Mayer (2009, 2020) in his Cognitive Theory of Multimedia Learning, suggests that people learn more deeply from words and pictures than from words alone. Multimedia learning is also known as learning media, which involves the use of a computer or smartphone, by bringing together two or more elements consisting of voice, video, text, and images incorporated in multimedia software for students interactively (Iskandar, Rizal, Kurniasih, Sutiksno & Purnomo, 2018). When a well-structured, explicitly designed, and delivered mechanism is used, multimedia instruction provides learners with multiple representation formats that enhance meaningful and comprehensive learning and better knowledge assimilation.

Almost all versions of constructivism acknowledged the importance of multimedia in creating a meaningful learning environment. However, the line of division between them, most especially cognitive constructivism, is the behavioral outcomes of students' engagement in teaching and learning. The explicit multimedia instruction is of the cognitive-constructivists' school of thought on how meaningful learning can take place. Instructors in this context pay more emphasis on active learning (cognitive) rather than active instructional activities (physical). This study, therefore, focuses on evaluating the effects of an explicit multimedia learning strategy (EMLS) on students' performance and retention in Agricultural Science, particularly among SSII students in Katsina state.

Statement of the Problem

Over the past decade, results from the West African Examination Council (WAEC) and internal school assessments have consistently highlighted poor performance among students in Agricultural Science in Katsina State. Some of the contributing factors include students' inability to assimilate scientific knowledge and the lack of modern teaching and learning mechanisms when engaging with the curriculum. The traditional methods of instruction often involve rote memorization and teacher dominance, providing minimal stimulation and suppressing learners' experience and perspectives.

Research shows that when students are presented with content through multiple channels such as text, graphics, narration, and interactivity, they are more likely to process, retain, and apply the information. However, in many secondary schools in Katsina, multimedia tools are underutilized due to limited training, infrastructural challenges, and teacher resistance to change. This study is therefore designed to explore whether integrating EMLS can bridge the existing learning gaps and foster improved performance and long-term content retention.

Objectives of the Study

The main objective of this study is to evaluate the effects of an Explicit Multimedia Learning Strategy on academic achievement and retention in Agricultural Science. The specific objectives are to:

1. Determine the difference in academic performance between students taught using EMLS and those taught with conventional methods.
2. Assess the effect of EMLS on student retention in Agricultural Science.
3. Evaluate gender differences in academic performance among students exposed to EMLS.
4. Evaluate gender differences in retention among students exposed to EMLS.

Literature Review

The focus of this study is to establish that significant differences exist in students' learning outcomes (academic performance and retention abilities in Agricultural Science) based on the types of multimedia learning strategies they are exposed to while learning selected topics in Agricultural Science. The paradigm shifts in classroom practices from knowledge transmission to knowledge construction came with new concepts that attempt to describe the nature of the new classroom and what activities teachers and learners engage in that bring about knowledge construction. Teachers and learners in a knowledge construction classroom are co-hosts; therefore, they are given a set of activities that each party participates in to make learning interactive. One of these concepts is learning strategies, which is new to what we had, i.e., teaching strategies, because the classroom, as it was then, was teacher-centered, which has now shifted to learner–centered.

Learning strategies are regarded as internal and external actions influencing the learner's motivation, attention, as well as the selection and processing of information. The increasing integration of technology in education has led to the development of a new concept known as multimedia learning, a form of learning based not only on a self-discovery of new knowledge but also on interactive approaches, through information processing and problem-solving (Zubairu, Soretire & Patrick, 2020; Soretire, Shehu & Abubakar, 2020).

The use of multimedia in teaching and learning is an attempt at a better way of integrating educational technology in the classroom. Gabreyohannes and Hasan (2016) see multimedia as any computer-mediated software or interactive application that integrates text, color, graphical images, animation, audio, and full-motion video. Olori and Igbosanu (2016) opined that multimedia is the ability of a system to communicate information simultaneously through multiple media: text, still images, graphics, photos, animated images, movies, and sound. The essence of multimedia learning is distributed into several elements of media that can affect student achievement. Both in the cognitive, psychomotor, and their attitudes to learning (Shah, 2019; Rajendra & Sudana, 2017). It is also revealed that the use of multimedia learning can contribute to and have a very significant impact on student learning outcomes. Ado, Essien, and Job (2018) also found that students exposed to animated diagrams in soil science topics showed improved enthusiasm for Agricultural Science. Ado *et al.* (2018) found that students taught soil nutrient cycles using animated media and guided narration achieved higher academic outcomes than those taught using chalk-and-talk methods.

Multimedia can be used as a very effective tool to improve skills in the process of practicum learning (Iskandar *et al.,* 2018). It further accelerates facilitation and effective management of learning, allowing individualization and personalization of learning, providing rapid information, stimulating discovery learning, promoting the interactive learning model, providing simulation opportunities, problem-solving, and deepening knowledge (Tudor, 2013). On the part of the learners, multimedia stimulates students' reflection capacities and critical thinking, and creates avenues for interacting with fellow students in achieving a common goal. Ofem and Domike (2015) noted that learners' interest increased when instruction was engaging, context-specific, and visually stimulating. In a similar vein, Olaniyan and Omowumi (2022) observed that students in Agricultural Science classes became more participatory and inquisitive when taught with multimedia packages that included animations and narrative voiceovers.

One innovation with increasing empirical support is the Explicit Multimedia Learning Strategy (EMLS), which is a structured approach that incorporates multimedia tools in a guided instructional format. For Agricultural Science, where abstract and complex concepts abound, EMLS enhances learners' visualization, comprehension, and retention (Mayer, 2020; Sani, Musa & Aliyu, 2023). Unlike unstructured multimedia use, EMLS employs specific design and sequencing principles, creating a focused and cognitively accessible learning experience. EMLS refers to the deliberate design and delivery of instructional materials using multimedia elements combined with explicit teaching principles, i.e., clarity, scaffolding, segmentation, and sequential learning.

Mayer (2020) Cognitive Theory of Multimedia Learning (CTML) identifies principles such as coherence (excluding unnecessary material), signaling (highlighting key points), spatial contiguity (placing related text and visuals near each other), and redundancy (avoiding duplicate narration and text), which enhance learning when embedded in multimedia instruction. Developed by Mayer (2009, 2020), CTML asserts that learners process information through dual channels, visual/pictorial and auditory/verbal. Effective multimedia learning occurs when both channels are activated with manageable input. It also emphasizes limited capacity in each channel and the need for active processing, selecting, organizing, and integrating information. Sani (2023) observed that when these principles are systematically applied, learners are better able to retain and apply knowledge in Agricultural Science. Hsu et al. (2022) found that multimedia modules on COVID-19 protocols improved knowledge retention among healthcare trainees, surpassing traditional instruction methods. Thus, the strategy focuses on making learning visible, supporting student engagement through structured cues, narration, and graphics, especially useful in resource-constrained contexts.

EMLS aligns with CTML by providing instructional materials that reduce overload and scaffold understanding. For instance, segmenting complex Agricultural Science topics like the nutrient cycle and photosynthesis in plants allows students to digest information progressively (Mayer, 2020; Ado et al., 2018). While Sweller (2009) highlights the Cognitive Learning Theory (CTL), which emphasizes three forms of cognitive load: intrinsic, extraneous, and suitability. EMLS seeks to reduce extraneous load & unnecessary mental effort from poor design while enhancing suitable load, which is beneficial for schema construction. By delivering content in a structured, concise, and visually appealing manner, EMLS enables learners to focus on core concepts without distraction (Olaniyan & Omowumi, 2022). Yusuf and Audu (2021) reported that students taught Biology using structured multimedia scored significantly higher than those taught conventionally. Their instruction adhered to Mayer's coherence and signaling principles. Eze and Ugwoke (2022) conducted a study in Enugu State using multimedia-enhanced Biology lessons and reported improved academic performance attributed to visual clarity and structured delivery. Pius, Abumchukwu, and George (2021) demonstrated that students taught Chemistry using animated multimedia retained content significantly better during delayed post-tests than their peers.

Several studies on the explicit multimedia learning strategy reported it as a gender-neutral method, favoring neither male nor female, which makes it the perfect choice for teaching, especially in a secondary setting where students of both genders are present. Pius et al. (2021) showed that both male and female students had comparable post-test and retention scores after being exposed to Chemistry topics through EMLS. Similarly, Sani (2023) found no significant gender difference in performance and retention among Agricultural Science students taught with multimedia. Ginga and Kauru's (2019) study on mathematics instruction using multimedia reported no significant gender-based differences in learning outcomes.

Despite the evidence supporting EMLS, certain research gaps remain; most existing studies focus on Biology and Chemistry; Agricultural Science remains under-researched, particularly at the secondary school level in rural Nigeria. Few studies explore the long-term vocational impact of multimedia instruction on students' interest in agriculture-related careers. There is limited work on contextualized EMLS packages that align with Nigeria's Agricultural Science curriculum and regional agricultural practices

Methodology

A quasi-experimental research design involving pre-test, post-test, and post-post-test was used. This design was chosen to measure the effects of treatment (EMLS) on academic performance and retention. The study population comprised SSII Agricultural Science students in Katsina state.

Two schools were purposively selected, and 142 students (76 males, 66 females) were randomly sampled using Bukhari's (2020) table. The experimental group received multimedia instruction on the topic " Nutrient Cycles and Organic Components" using a custom-designed application that involved active interaction. The control group received the same content using the conventional lecture method. Lessons spanned 5 weeks. A post-post-test was administered 3 weeks after the post-test to assess retention, making the whole study 8 weeks. Validity of the instrument was tested, and the Agricultural Science Achievement Test (ASAT) obtained a reliability of 0.84 using PPMC. Data were analyzed using SPSS. Mean and standard deviation, independent t-test, related and paired t-test statistics were used to analyze the result.

Results and Discussion

Determine the difference in academic performance between students taught using EMLS and those taught with conventional methods.

This research question was raised to know whether there is an improvement in the academic performance of the learners taught plant nutrient cycles using an explicit multimedia learning strategy. To answer this question, the pretest and posttest scores of the learners were compared, and the t-test score was computed as presented in Table 1.

Table 1: Independent Sample t-test on pre-test and post-test Scores of explicit multimedia learning strategies

Tests	N	Mean	St.D	df	R	t	P-Value
Conventional	68	16.18	2.46	1	.988	-51.767	0.00**
Experimental	74	29.18	4.72	73			

***Significant at 0.05-Rejected*

The descriptive statistics show that the experimental group, taught using the explicit multimedia learning strategy, achieved a mean performance score of 29.18 (SD = 4.72), compared to 16.18 (SD = 2.46) for the control group taught with conventional methods. The mean difference of 13.00 favors the experimental group, with an average standard deviation indicating additional consistent scores. The t – value of -51.767 and p value 0.00 < 0.05 confirmed that students taught using EMLS perform better than those taught using conventional method. This supports the premise of Mayer's Cognitive Theory of Multimedia Learning (2005, 2020), which suggests that presenting information through dual channels (verbal and visual) enhances understanding and recall. Studies by Akinbadewa (2020) and Sakiyo et al. (2020) similarly reported improved achievement in science subjects when multimedia strategies were applied. Abiola and Adekunle (2016) also found positive impacts in Agricultural Science using computer-based multimedia presentations. However, the moderate size of the difference in this study contrasts with the larger effects reported by Rajendra and Sudana (2017), which could be due to contextual limitations such as variations in technology access and teacher proficiency (Aboyade, 2018; Pant-Naithani & Devi, 2024).

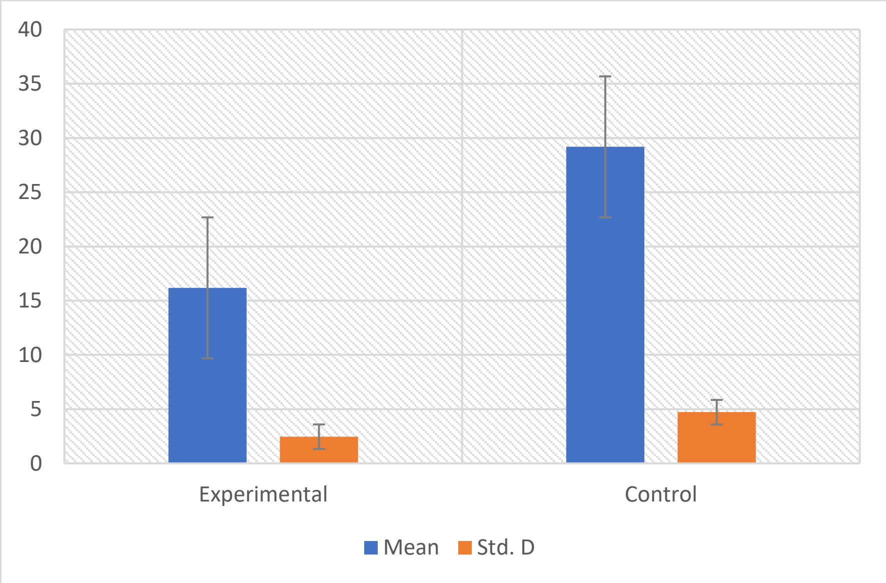

Figure 1: Chart of mean performance scores of students between the experimental and control groups.

The histogram visually confirms that the experimental group consistently outperformed the control group, with a higher mean score (29.18 vs. 16.18) and a smaller spread, as indicated by the narrower distribution of scores. This compact clustering in the experimental group suggests more uniform learning outcomes, aligning with Mayer's (2020) assertion that multimedia instruction enhances cognitive integration and supports consistent achievement. The wider spread in the control group mirrors findings from Aboyade (2018) that conventional methods often yield more varied outcomes due to differences in individual learning pace and engagement. Similar histogram trends were reported by Akinbadewa (2020) in biology classes where multimedia strategies tightened score distributions.

Assess the effect of EMLS on student retention in Agricultural Science.

This research question was raised to know whether there is an improvement in the retention ability of the learners taught plant nutrient cycles using an explicit multimedia learning strategy. To answer this question, the posttest and post posttest scores of the learners were compared, and the independent sample t-test score was computed as presented in Table 2.

Table 2: Related sample t-test of the Posttest and Post-Posttest Mean Retention Scores of Students in The Experimental Group.

Variable	Tests	N	Mean	St.D	Df	R	t	P-Value
	Posttest	74	28.18	4.42	1			
Retention Ability	Post- posttest	74	32.05	4.23	73	.998	51.971	0.00

In the experimental group, the mean retention score increased from 28.18 (SD = 4.42) in the posttest to 32.05 (SD = 4.23) in the post-posttest, yielding a mean difference of 3.87. The slightly smaller standard deviation in the post-posttest suggests both improvement and increased consistency in retention over the two weeks. The t-value of 51.971 and p value of $0.00 < 0.05$ confirmed a significant relationship between EMLS and academic performance. This finding aligns with the conclusions of Anunobi et al. (2016) and Pius et al. (2021), who observed that multimedia-enhanced instruction promotes long-term retention of concepts. Mayer (2009) attributes this to reduced cognitive overload and better integration of knowledge in long-term memory. Similar patterns were found in Ayodeji (2021), where mathematics students retained learned material longer under multimedia instruction. However, some studies, such as Bacon and Stewart (2006), note that retention gains can diminish over time without reinforcement, indicating that continued practice is key to sustaining performance.

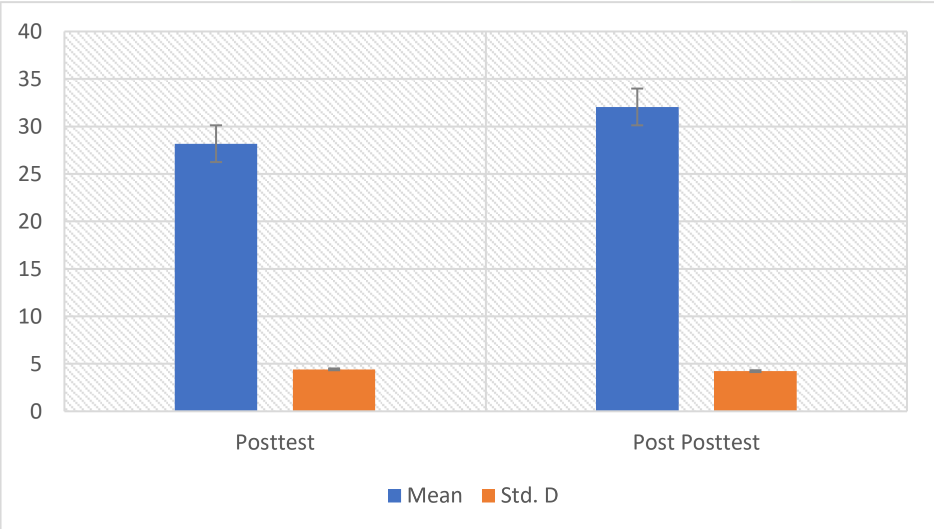

Figure 2: Chart of the mean retention score of students in post-test and post-posttest in the experimental group.

The retention histogram shows an upward shift in the entire distribution from posttest to post-posttest, reflecting a mean gain of 3.87 points and indicating that most students improved over the two-week interval. The similarity in spread between the two assessments suggests stable consistency in performance across time. This visual pattern aligns with Anunobi, Gambari, Abdullahi and Alabi (2016) and Pius, Abumchukwu and George (2021), who observed that multimedia strategies help maintain and even build upon acquired knowledge over time. The overall upward shift also supports Bacon and Stewart's (2006) claim that active reinforcement during learning phases contributes to stronger retention curves.

What are the gender differences in academic performance among students exposed to EMLS?

This research question was raised to know whether there is gender difference in the academic performance of the learners taught nutrient cycles and organic components using an explicit multimedia learning strategy. To answer this question, the gender-based posttest scores of the learners were compared, and the independent sample t-test score was computed as presented in Table 3.

Table 3: Independent Sample t-test on post-test scores of explicit multimedia learning strategies students

Variable	Gender	N	Mean	SD	df	R	t	p-value
	Male	41	24.39	1.58				
Academic performance	Female	33	27.31	2.38	51.346	2.92	-6.001	0.000

Male students in the experimental group recorded a mean performance score of 24.39 (SD = 1.58), while females scored 27.31 (SD = 2.38), resulting in a mean difference of 2.92 in favour of females. The lower standard deviation for males suggests more consistent performance, while the slightly higher spread among females indicates greater variability. The t (51.35) = −6.00 and $p <$ .005. This small mean gap suggests that the explicit multimedia learning strategy is effective regardless of gender, aligning with findings by Ado et al. (2018) and Abiola & Adekunle (2016), who reported no significant gender-based differences in multimedia learning outcomes. These results also support the gender-neutral application of explicit instruction as outlined by Archer & Hughes (2011).

However, the female advantage in mean scores mirrors findings by Yusuf & Adigun (2010), who noted that gender may still play a role depending on subject matter and socio-cultural factors, indicating that while multimedia can level the playing field, subtle differences in engagement and learning strategies may persist.

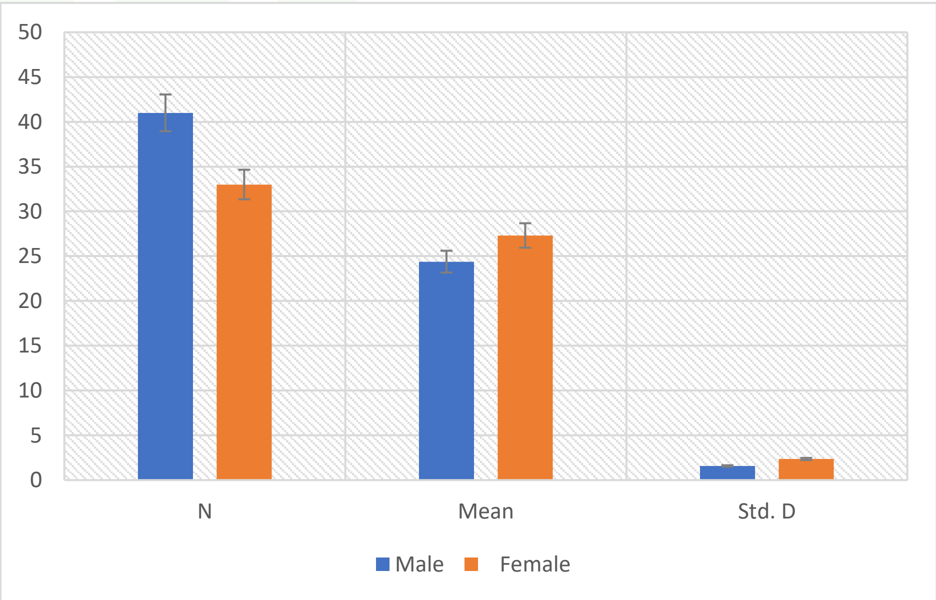

Figure 3: The differences between the mean performance scores of male and female students in the experimental groups.

The histogram comparing male and female performance shows slightly higher bars for females across score ranges, reflecting the 2.92 mean advantage observed in the table. The male distribution is more tightly clustered, while the female distribution is slightly wider, suggesting more variability in outcomes among females. These patterns corroborate Archer & Hughes' (2011) stance that explicit instructional strategies are gender-inclusive, producing broadly comparable outcomes. They also reflect the mixed results in Yusuf & Adigun (2010), where slight female advantages in average scores were noted but not statistically significant.

What are the gender differences in retention among students exposed to EMLS?

This research question was raised to know whether there is gender difference in the academic performance of the learners taught nutrient cycles and organic components using an explicit multimedia learning strategy. To answer this question, the gender-based

post posttest scores of the learners were compared, and the independent sample t-test score was computed as presented in Table 4.

Table 4: Paired Sample t-test on post-test and post-posttest scores of explicit multimedia learning strategies in the Experimental group.

Variable	Gender	Test	N	Mean	SD	*df*	R	T	p-value
Retention Ability	Male	Post test	41	24.39	1.58	71	4.82	-2.846	0.000
		Post Posttest		29.21	3.38				
	Female	Post test	33	27.31	2.38		4.13		
		Post Posttest		31.44	3.20				

For males, the mean retention score of male students increased from 24.39 (SD = 1.58) to 29.21 (SD= 3.38) while from 27.31 (SD= 2.38) to 31.44 (SD = 3.20) for female students, with a mean difference of 4.82 and 4.13 respectively. The $t(71) = -2.85$, $p < 0.05$ indicate that multimedia strategy is gender neutral in terms of improving retention ability among students. This aligns with findings from Umar et al. (2020) and Salisu (2015), which showed that multimedia instruction improved retention across genders. The results also correspond with Mayer's (2014) principle that well-designed multimedia instruction supports diverse learners by appealing to multiple cognitive channels. Contrarily, research by Iwanger (2018) in Basic Science found slightly greater retention gains among male students, suggesting that subject area and cultural context may influence retention outcomes.

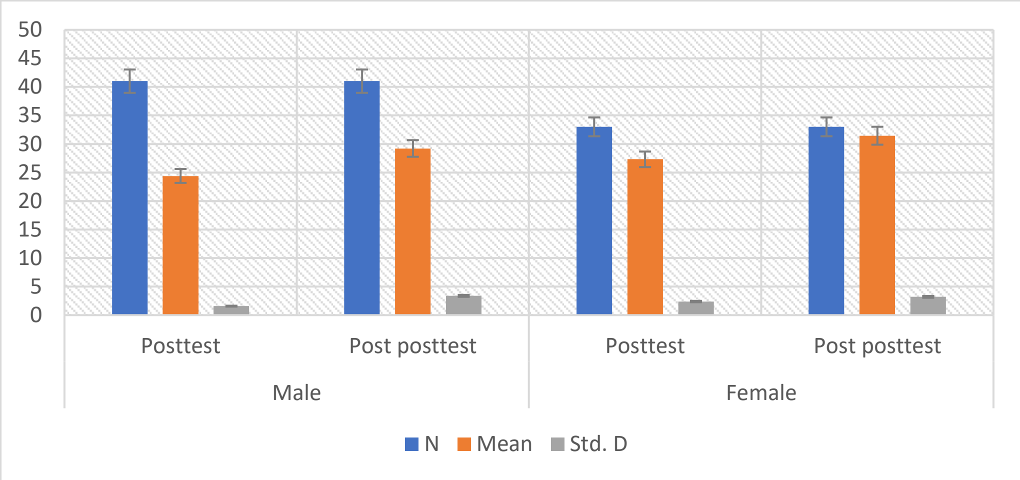

Figure 4: Chart of the posttest and post-posttest retention scores of male and female students in the experimental groups.

Retention histograms for males and females show parallel upward shifts from posttest to post-posttest, indicating similar learning gains (7.83 vs. 8.13 mean differences). However, males' post-posttest distribution is more spread out, while females' scores become more tightly clustered, reflecting greater uniformity in female retention performance. This pattern supports Ayodeji (2021) and Umar, Ossom and Egbita (2020), who found that multimedia instruction promotes consistent retention across learners, but also mirrors Bacon and Stewart's (2006) caution that retention gains may vary more among certain subgroups, possibly due to differences in motivation and engagement. **Conclusion/Recommendations**

The findings of this study demonstrate that the explicit multimedia learning strategy is an effective instructional approach for enhancing students' academic performance and retention. Students exposed to the multimedia strategy consistently outperformed their peers taught through conventional methods, not only achieving higher mean scores but also exhibiting greater consistency in their performance. Retention gains over the two-week interval further underscore the lasting impact of the approach, with both male and female students benefiting almost equally, affirming the gender-neutral nature of the strategy. These outcomes echo the principles of Mayer's Cognitive Theory of Multimedia Learning and are reinforced by earlier studies (Akinbadewa, 2020; Sakiyo et al., 2020; Abiola & Adekunle, 2016), while also highlighting the potential of technology-enhanced pedagogy to bridge performance gaps and sustain learning over time. Based on these findings, it is recommended that:

1. Teachers should adopt multimedia strategies to enhance instructional delivery in Agricultural Science.
2. Katsina state government should provide training and infrastructure to support multimedia use in secondary schools across the state.

3. Curriculum planners should incorporate multimedia tools and techniques in pedagogical guidelines.

4. Further studies should assess EMLS across other science subjects and regions to generalize findings.

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