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Effect of Technology-Mediated Dynamic and Static Visuals on Pre-Service Biology Teachers' Retention in Colleges of Education in North Central, Nigeria

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Abstract
This study investigated the effects of technology-mediated dynamic and static visuals on pre-service biology teachers' retention in Colleges of Education in North Central, Nigeria. The study adopted a pre-test post-test quasi experimental research design. Two research questions and two null hypotheses guided the study. The sample of the study consists of 354 NCE two biology students randomly selected from four colleges of education in North Central Nigeria. Two of the four colleges of education were assigned into Experimental Group I (students were taught using Technology-mediated Dynamic Visuals); and the remaining two were assigned Experimental Group II (students were taught using Technology-mediated Static Visuals). Forty Multiple Choice Questions named Biology Retention Test was used for data collection at pretest and posttest after being validated by experts and subjected to reliability check. The reliability coefficient 0.78 was obtained which shows that the instrument is reliable for the study. In the process of data collection, pre-service teaches were taught for two hours every week for the period of six weeks. After the administration of pretest and posttest, there was an interval of two weeks before the administration of retention test (DSVGRT). The data was analyzed using mean and standard deviations in answering research questions while Analysis of Covariance (ANCOVA) was used to test the hypothesis at 0.05 level of significance. Findings revealed that there is a statistically significance difference $F_{(2,352)} = 17.696$, P-value = 0.000 at $P < 0.05$, in the mean retention scores of pre-service Biology teachers taught Genetics using technology-mediated dynamic and static visuals. Partial eta squared; ($\eta_p^2 = .04$), revealed a moderate effect size with approximately 4% of the variance in the outcome attributed to the independent variable. Similarly, there is a statistically significance difference $F_{(4,349)} = 9.625$, P-value = 0.000 at $P < 0.05$, ($\eta_p^2 = .07$) in the mean retention scores of male and female pre-service Biology teachers' taught Genetics using technology-mediated dynamic and static visuals. Partial eta squared revealed the presence of a medium effect size, suggesting that the observed differences have a moderate practical significance of approximately 7% of the variability in the outcomes attributed to the variables being studied. Based on these findings, it was recommended among others that instructors should consider a blended approach that combines dynamic and static visuals thoughtfully, optimizing their respective strengths to cater to diverse learning styles and preferences in Colleges of Education in North Central, Nigeria.

Key words: Visualizations, dynamic, static, retention, gender

Introduction

Visualizations denote pictures, computer-generated displays, three-dimensional models, geometrical illustrations, diagrams, simulations, animations and videos which help teachers to effortlessly transfer information to students (Connolly, 2019). Visuals gives students the ability to create pictures in their mind based on the images they see or the text they read. It is one of the skills that makes it possible for students to gain more knowledge through understanding of the images they see, and students can easily recall what they have seen with their eyes than a spoken word only. The purpose of this graphical display is to provide the viewer a visual means of processing information (David & Tomaz, 2017). It is important to note that for visuals to be effective it must draw upon the previous knowledge based on the viewer. Thus, If the viewer does not possess the knowledge to understand the graphical entities and the relations between them, visuals will not achieve its goal. The purpose of any visuals to be used in an educational context is to facilitate the learning of some knowledge, idea, fact, concept and computer-based visuals (Shaffer et al., 2017).

Recently, advances in computer-based visuals enabled the display of visual objects in a variety of media formats, including computer screens, interactive whiteboards and videos to help students create a pictorial connection between the contents they learnt through images and the power of recalling information (Ryoo and Linn, 2012). Furthermore, Mayer (2009) described instructional visuals as a visual-spatial representation intended to promote learning with variations along several dimensions to include; realism and dynamism. Realism; in which pictures vary from high realism (a photo or video) to low realism (a line drawing or an animated line drawing). While statism is where pictures are static (a drawing and photo) or dynamic (an animation or video) and delivery medium where pictures are presented on a page or screen.

Technology-mediated Dynamic Visuals (TDV) are animated graphics displayed on computer screen which gives students a mental ability to manage cognitive processing of the material more accurately while studying to avoid overloading in working memory. Ryoo and Bedell (2017) opined that dynamic visuals allow students to directly depict dynamic features of animated concepts in order to understand the complexities that existed among them. For instance, the genetic concepts such as phenotype, genotype, mutation, variation, dominant and recessive gene and chromosomes are difficult to understand with verbal explanation. However, the dynamic visuals have the capacity to describe the concepts live as they act in their natural environment in visual terms. Supporting this, Sung and Chen (2017) added that it also allows for segmenting the concepts in stages of sequence for students understanding.

Technology-mediated Static Visuals (TSV) are illustrations, drawings, photos, diagrams, maps, graphs, charts, figures, tables displayed on screen. The mode of presentation of static visuals includes displaying content all at once or in sequence on the screen. Stromme and Mork (2020) remarked that multiple static pictures may be presented either sequentially, that is, one after another at the same position on the screen so that earlier pictures can be replaced by later ones, or simultaneously, that is, all together on one page. The two presentation formats, namely sequential and simultaneous presentation of multiple static pictures, can be characterized by different benefits and drawbacks for learning. Though, all the two modes of presentation add value to students' learning outcome. However, understanding which of the mode of presentation of visuals add more value to students' learning outcome is yet to be confirm because, little research has been conducted regarding the comparison of different types of visuals on genetic concepts especially at Colleges of Education in North Central, Nigeria.

Additionally, Koc-Januchta et al. (2020) commented that these different presentation formats of static visuals all serve as objects of comparison for dynamic visuals because, the presentation of static pictures can vary with respect to different aspects. For example, the number and the size of pictures shown may be different; the duration of the presentation of single pictures may vary with the content; and of course, the presentation format of static visuals regarding their sequence can be different. Thus, the temporal position of visual elements of genetic concepts are easier in a sequential presentation due to almost identical spatial positions (Stromme and Mork, 2020). However, a sequential presentation of multiple static visuals is more similar to a dynamic presentation, because it is still transitory (Hegarty, 2004 and McElhaney et al., 2015).

Science related disciplines like Biology, Chemistry and Physics require that students understand the complex nature of their interrelations and changes that occur over time in order to inform future practices. However, the content in these subjects seems to be challenging and abstract especially in specific content areas like genetics of which students often fail to understand their complexity. Biology is one of the science subjects that is more inclined to human life in which science students cannot do without it. It is a science of life which help students to have an idea about their genetic makeup; understanding the

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concepts of Biology qualifies them to become scientist. According to Rieper (2018), the knowledge of Biology in its applied form has established varied application in industries such as food manufacturing, processing and preservation. Biology serves as a major driving force of economic power in the 21st century, especially in the pharmaceutical and beverage industries where materials are converted into drugs, syrup, chemicals and other by-products which are useful household equipment made available to man (Treagust & Tsui, 2018)

Nigeria depends to a large extent on products manufactured by biological scientists, Biochemists and microbiologists such as; drugs, antibiotics, cosmetics beverages and other food products for human survival and economic wellbeing. The beginning journey of these professionals is at tertiary institution like universities, polytechnics and colleges of education where they specialize in areas like botany, zoology, dermatology, reproductive Biology and plant science with meaningful and relevant knowledge in Biology and adequate laboratory and field experiences. The National Commission for Colleges of Education (NCCE) curriculum (2012) ensured that students are furnished with never-ending experience in skills of critical and logical thinking in order to identify problems and finding possible solutions.

The study of Biology is divided into Branches; Zoology, Ecology, Embryology, Botany and Genetics in which Zoology focuses on the study of animals' life, Ecology deals with the interrelations of organisms with their environment, Embryology is also a branch of Biology that is related to the formation, development and growth of the embryo, Botany focuses on the study of plants life. Genetics is a branch of Biology that deals with the heredity and variations of organisms. Biology has many important achievements especially in the area of Applied Biology with few of these achievements surrounding the development of vaccines and drugs for the prevention and cure of diseases, organ transplant, population control through family planning, disease control in the medical field and conservation of ecosystem among others. Brooks (2021) stated that learning about biological concepts and processes in the human body can be challenging since many biological processes are not visible to the naked eye. The intricate nature of genetics poses a unique challenge as it remains imperceptible to the naked eye, demanding a teaching approach that transcends the conventional reliance on verbal instruction typically employed in schools and colleges. The complexity of genetic concepts, such as the intricacies of DNA and gene interactions, necessitates a shift towards more practical and experiential teaching methods. While verbal explanations play a crucial role in conveying information, the abstract and microscopic nature of genetic phenomena often proves elusive to students when presented solely through words.

This conventional teaching approach, heavily reliant on verbal communication, may inadvertently hinder students' retention and comprehension of genetic principles. The abstract nature of genetics demands a multi-sensory teaching strategy that incorporates hands-on activities, laboratory experiments, and visual aids to provide a holistic and immersive learning experience. By engaging students in practical applications, educators can bridge the gap between abstract genetic concepts and tangible, real-world examples, fostering a deeper understanding and enhancing retention.

The concept of retention, defined as students' ability to recall knowledge acquired after the learning process, holds particular significance in the context of teaching complex subjects like genetics. As elucidated in the previous discussion, the imperceptible nature of genetic principles necessitates a departure from conventional, verbally dominated teaching methods to more practical and experiential approaches. The challenge lies not only in conveying genetic information effectively but also in ensuring its lasting impact on students' retention over time. Treagust and Tsui (2018) highlight the importance of retention as a precondition for students' progress in learning. They emphasize that the information received, be it from teachers or learning mediums, undergoes a transformation within the minds of individuals, manifesting in various forms such as text, graphics, words, or other symbolic representations. This transformation is integral to the process of retention, shaping how students internalize and recall genetic concepts.

Furthermore, Doan (2019) posits that knowledge retention (KR) is a critical factor for sustaining performance in schools, emphasizing the interconnected nature of knowledge. In the realm of genetics, where one genetic concept builds upon another, retention becomes the cornerstone for the acquisition and application of subsequent genetic knowledge. The continuity of learning in genetics relies on the traces of previously acquired knowledge, forming a cohesive and interconnected framework. Importantly, the link between students' interest in a course of study or subject and their achievement and retention cannot be understated. As highlighted in the broader discussion, a diversified and interactive pedagogical approach, incorporating practical experiences and engaging teaching methods, is essential for overcoming the challenges posed by the abstract nature of genetic concepts. The interplay between retention, teaching methodologies, and students' interest highlights the need for a dynamic and immersive learning environment, especially in the intricate domain of genetics. The incorporation of practical experiences not only facilitates comprehension but also cultivates a lasting impact on students' retention and gender variable, thereby fostering a more effective and sustainable approach to genetic education.

Gender, as the classification of students into males and females within the educational context, holds significant implications for classroom dynamics. In the realm of genetics education, the correlation between gender, learning style, and student engagement has been highlighted by Yu (2021). This assertion emphasizes the importance of considering gender as a factor in the design of courses, particularly when integrating instructional visuals. A contentious debate surrounds the role of gender in education, delving into the nuanced similarities and differences between male and female students in terms of achievement, retention of learned concepts, and the pedagogical approaches adopted by educators. The discourse extends beyond mere controversy to explore the potential application of visual approaches in teaching genetics concepts to Biology education students in colleges as reviewed in the literature.

Angelos and Rabindra (2021) explored the efficacy of using video games to teach microbiological concepts, specifically comparing interactive learning biology video games to traditional assignments. They utilized the infection defense video game, focusing on the immune system, and found that video game-based learning led to improved comprehension and engagement in scientific concepts, with significant differences in knowledge improvement and retention. Similarly, Laurentiu et al. (2021) investigated inclusive learning for quantum computing through a computer software called Quantum Odyssey. The study involved 30-minute play sessions with students aged 11 to 18, demonstrating that the visual and interactive methods of Quantum Odyssey efficiently conveyed complex quantum computational logic. Participants, even without prior knowledge, quickly grasped difficult concepts in an intuitive way, retained the information, and solved problems traditionally presented at the Masters' level in a mathematical format.

In another study, Stolk et al. (2021) explored the multifaceted and dynamic situational responses of women and men in college STEM courses. Analyzing data from over 5000 unique responses across 72 introductory-level STEM courses, they found significant differences in motivation between genders, particularly in lecture-based courses. Courses employing active learning showed more similar and positive motivational response profiles for both genders. Sudatha and Simamora (2021) investigated the effectiveness of using dynamic visuals in natural science learning for junior high school students. Their study, involving 36 males and 28 females, demonstrated that dynamic visuals significantly improved students' comprehension of transportation systems and excretion in organisms. Additionally, the use of dynamic visuals was found to be attractive in instruction, and students' retention varied based on gender. The reviewed studies collectively contribute insights into the effectiveness of dynamic visuals, gender differences, study design, and methods of data analysis. These findings provide a foundation for understanding how interactive and visual learning methods impact comprehension, motivation, and retention in various educational contexts.

Statement of the Problem

Despite the potential of visuals to facilitate a clearer understanding of complex genetic concepts among pre-service Biology teachers, particularly by bridging the gap between pictorial mental models and practical visualization, there exists a notable gap in the dissemination of this concept, especially within the study area. Consequently, pre-service teachers continue to encounter challenges in assimilating genetic concepts in Biology. Although visuals strategies, such as Animations, Charts, Concept Maps, and Analogy, have been employed by researchers to address this issue, poor retention persists among pre-service Biology teachers. The weaknesses identified in the semester examination reports from 2017 to 2021 at Niger State College of Education Minna (2022) specifically highlight pre-service teachers' struggles with a poor grasp of genetic concepts. This struggle is attributed to the teaching strategies adopted by lecturers, which place more emphasis on texts rather than incorporating visuals. While attempts have been made to salvage the problem through various strategies, including the aforementioned visuals, the challenge of poor retention persists. To address this persistent issue, the researcher proposes the use of technology-mediated visuals, both dynamic and static, as potential solutions. The study aims to assess the effectiveness of these technology-mediated visuals in enhancing pre-service Biology teachers' retention of genetic concepts in Colleges of Education in North Central, Nigeria. This research thus seeks to fill the existing gap in retention strategies, particularly focusing on the impact of technology-mediated visuals on the learning outcomes of pre-service Biology teachers.

Objectives of the Study

The aim of this study is to investigate the effect of technology-mediated dynamic and static visuals on pre-service biology teachers' retention in Colleges of Education in North Central, Nigeria.

The specific objectives of this study are;

1. To investigate the effect of technology-mediated dynamic and static visuals on pre-service Biology teachers' retention in genetics.
2. To find out the influence of gender on the retention of pre-service Biology teachers' taught genetics using technology-mediated dynamic and static visuals.

Research Questions

The following research questions are raised to guide the study

1. What is the difference in the mean retention scores of pre-service Biology teachers taught Genetics using technology-mediated dynamic and static visuals?
2. What is the difference in the mean retention scores of male and female pre-service Biology teachers taught Genetics using technology-mediated dynamic and static visuals?

Research Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance;

H_{O1}: There is no significant difference in the retention scores of pre-service Biology teachers taught Genetics using technology-mediated dynamic and static visual.

H_{O2}: There is no significant difference in the retention scores of male and female pre-service Biology teachers' taught Genetics using technology-mediated dynamic and static visuals.

Methodology

The research design adopted for this study is quasi-experimental design using the pretest, posttest non-equivalent control group design. According to Shadish and William (2002), quasi-experimental design also known as nonrandomized design is used when it is not feasible to conduct randomization in a sampled population. The population of the study comprised of 5,935 pre-service teachers offering Biology in Colleges of Education in North Central, Nigeria. The target population focused on

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NCE II (200 level) students of 2022/2023 academic session. A sample size of 354 pre-service Biology teachers was captured in the intact class of NCE II students of the four (4) selected Colleges of Education using simple random sampling technique. The choice of 200 Level students was based on the biology course synopsis derived from Nigeria Certificate in Education Minimum Standards for General Education. The instrument used was the Dynamic, Static Visuals Genetic Retention Test which consisted of 40 objectives test items with four options (A-D) with only one correct option and three detractors. The instrument was already validated by experts a pilot test was conducted in a school that was part of the population but not included in the samples selected for the study. To establish the correlation coefficient value, the test scores were gathered and subjected to reliability analysis using Pearson Product Moment Correlation Formula (PPMC). The output of the analysis yielded a coefficient value of 0.78 and tested for reliability. The data was collected from two groups: Experimental Group I (students were taught using Technology-mediated Dynamic Visuals); and Experimental Group II (students were taught using Technology-mediated Static Visuals). The data was analyze using ANCOVA, Sidak Post-hoc analysis with partial eta squared η_p^2 used as a follow-up with effect sizes of the significant values. The analysis was conducted using Statistical Package for the Social Sciences (SPSS) version 23.0.

Results

Research Question One: What is the difference in the mean retention scores of pre-service Biology teachers' taught Genetics using technology-mediated dynamic and static visuals?

Table 1: Posttest and Retention Test Scores of Experimental Group I and II Exposed to Genetics using Technology-Mediated Dynamic and Static Visuals

Group Descriptions	N No. in Samples	Posttest $\bar{X}$	SD	Retention $\bar{X}$	SD	Mean Gain/Loss Loss
Experimental Group 1	158	78.75	14.170	61.34	18.670	-17.41
Experimental Group 2	196	72.38	20.295	52.86	16.669	-19.52

Key: $\bar{X}$ = Mean, SD= Standard Deviations, N= Number in samples.

Table 1 displays the means and standard deviation of experimental group one treated with technology-mediated dynamic visuals and experimental group two treated with technology-mediated static visuals at posttest and retention test. The mean retention scores of students for experimental group one was lower (*M* = 61.3, *SD* = 18.7) than the posttest scores (*M* = 78.8, *SD* = 14.2). The mean loss was -17.4 indicating a substantial loss in their retention. For experimental group two, the mean retention scores were also lower (*M* = 52.9, *SD* = 16.7) than the posttest scores (*M* = 72.4, *SD* = 20.3). The mean loss was -19.5 indicating a substantial loss in their retention. The finding revealed that there is a difference in the mean retention scores of pre-service Biology teachers' taught Genetics using technology-mediated dynamic and static visuals with students exposed to dynamic visuals retaining higher than those in the static visual group. Additionally, the retention of the groups was graphically presented in figure 4.2.

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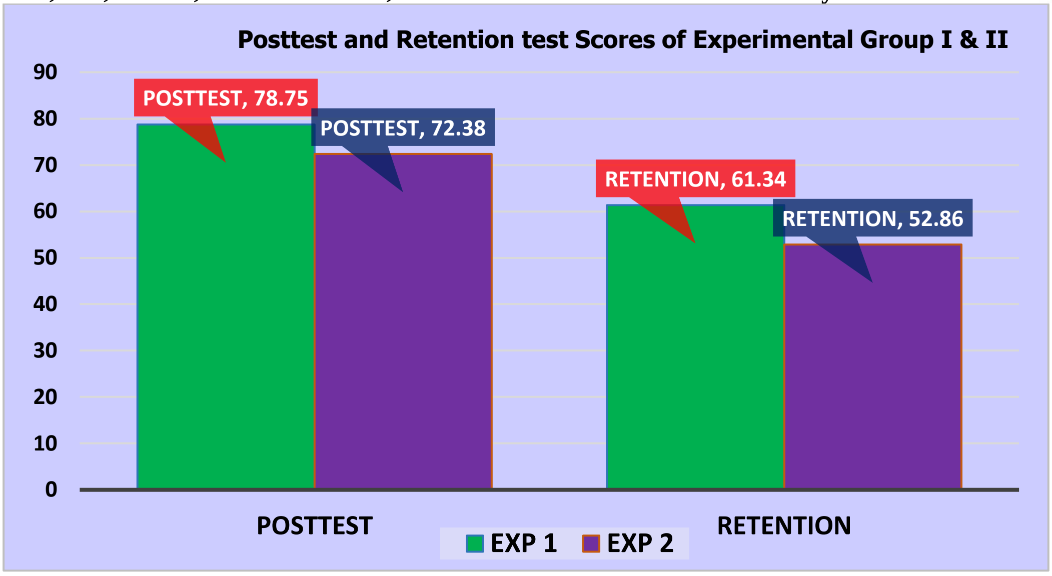

Figure 4.2: Posttest and retention test of experimental group I and II

Figure 1 showed the mean and standard deviation of experimental group I and II at posttest and retention test. In experimental group one, the taller bar represents the posttest while the shorter bar represents the retention test with a gradual decline in the height indicating a loss of information from the posttest scores. In experimental group two, the taller bar was also higher representing posttest while the shorter bar was lower representing retention test. The shortness in the second bar indicates a loss of information. This means that the groups retained almost all the knowledge gained at posttest to retention test.

Research Question Two: What is the difference in the mean retention scores of male and female pre-service Biology teachers' taught Genetics using technology-mediated dynamic and static visuals?

Table 2: Pretest and Posttest Retention Scores of Male and Female Students Taught Genetics using Technology-Mediated Dynamic and Static Visuals

Groups Descriptions	N Samples	Posttest Gender $\bar{X}$	SD	Retention $\bar{X}$	SD	Mean Loss
Technology Mediated Dynamic Males	73	82.92	8.535	66.41	15.413	-16.51
Technology Mediated Dynamic Females	85	75.16	16.873	56.99	20.159	-18.17
Technology Mediated Static Males	81	65.65	23.265	51.79	16.387	-13.86
Technology Mediated Static Females	115	77.11	16.430	53.61	16.896	-23.5

Key: $\bar{X}$ = Mean, SD= Standard Deviations, N= Number in samples.

Table 2 displays the means and standard deviation of male and female students in experimental group one treated with technology-mediated dynamic visuals at covariate posttest and retention test. The mean retention scores for male group were lower (*M* = 66.4, *SD* = 15.4) than the covariate posttest scores (*M* = 82.9, *SD* = 8.53). The mean loss was -16.5 indicating a substantial loss in their retention. For the female group, the mean retention scores were also lower (*M* = 56.9, *SD* = 20.2) than the posttest scores (*M* = 75.2, *SD* = 16.9). The mean loss was -18.3 indicating a substantial loss of information in their retention. This implies that there is a difference in the mean retention scores of male and female pre-service Biology teachers' taught Genetics using technology-mediated dynamic visuals favouring males. Likewise, the means and standard deviation of male and female students in experimental group two treated with technology-mediated static visuals at covariate posttest and retention test were displayed. The mean retention scores for male group were lower (*M* = 51.8, *SD* = 16.4) than the covariate posttest scores (*M* = 65.7, *SD* = 23.4). The

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mean loss was -13.9 indicating a minimum loss in their retention. For the female group, the mean retention scores were also lower (*M* = 53.6, *SD* = 16.9) than the covariate posttest scores (*M* = 77.1, *SD* = 16.4). The mean loss was 23.5 indicating a substantial loss of information. This implies that there is a difference in the mean retention scores of male and female pre-service Biology teachers' taught Genetics using technology-mediated static visuals favoring females.

Hypothesis One There is no significant difference in the retention scores of pre-service Biology teachers' taught Genetics using technology-mediated dynamic and static visuals.

To answer hypothesis one, ANCOVA analysis was used as shown in table 3

Table 3: ANCOVA of Mean Retention Scores of Pre-Service Biology Teachers' Taught Genetics Using Technology-Mediated Dynamic and Static Visuals

Source	Sum of Squares	df	Mean Square	F-value	P-value	Partial Eta Squared
Corrected Model	6878.650a	2	3439.325	11.144	.000	.060
Intercept	49490.854	1	49490.854	160.360	.000	.314
Covariate (Achievement)	581.041	1	581.041	1.883	.171	.005
*Retention	5461.247	1	5461.247	17.696	.000	.048
Error	108326.503	351	308.623			
Total	1251032.000	354				
Corrected Total	115205.153	353				

S = Significant at 0.05 level

Table 3: ANCOVA statistic was run to examine the difference between the retention scores of pre-service Biology teachers taught Genetics using technology-mediated dynamic and static visuals in experimental group I and II at posttest. The table revealed that $F_{(2,352)} = 17.696$, *P*-value = 0.000 at $P < 0.05$, indicating a significant difference in the mean retention scores of pre-service Biology teachers taught Genetics using technology-mediated dynamic and static visuals. Consequently, hypothesis two was rejected. The effect size was assessed using partial eta squared; ($\eta_p^2 = .04$), revealing a moderate effect size. This indicates that approximately 4% of the variance in the outcome can be attributed to the independent variable. In practical terms, the medium effect size suggests that the utilization of technology-mediated dynamic and static visuals in teaching Genetics to pre-service Biology teachers has a meaningful influence on their mean achievement scores. The finding implies that students taught Genetics using technology-mediated dynamic and static visuals differ significantly in their mean retention with moderate effect size.

Hypothesis Two: There is no significant difference in the retention scores of male and female pre-service Biology teachers' taught Genetics using technology-mediated dynamic and static visuals.

To answer hypothesis five, ANCOVA analysis was used as shown in table 4.

Table 4: ANCOVA of Mean Retention Scores of Male and Female Pre-Service Biology Teachers' Taught Genetics Using Technology-Mediated Dynamic and Static Visuals

Source	Sum of Squares	df	Mean Square	F-value	P-value	Partial Eta Squared
Corrected Model	10112.685a	4	2528.171	8.396	.000	.088
Intercept	50795.770	1	50795.770	168.687	.000	.326
Covariate (Achievement)	171.015	1	171.015	.568	.452	.002
*Gender (Retention)	8695.282	3	2898.427	9.625	.000	.076
Error	105092.467	349	301.125			
Total	1251032.000	354				
Corrected Total	115205.153	353				

S = Significant at 0.05 level

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Table 4: ANCOVA statistic was computed to examine the difference in the retention scores of male and female pre-service Biology teachers' taught Genetics using technology-mediated dynamic and static visuals for experimental groups I and II. The table revealed that $F_{(4,349)} = 9.625$, P-value = 0.000 at $P < 0.05$, indicating a significant difference in the retention scores of male and female pre-service Biology teachers' taught Genetics using technology-mediated dynamic and static visuals. Therefore, hypothesis five was rejected. Furthermore, the assessment of effect size was carried out utilizing partial eta squared, denoted as ($\eta_p^2 = .07$). The analysis revealed the presence of a medium effect size, suggesting that the observed differences have a moderate practical significance. This implies that approximately 7% of the variability in the outcomes can be attributed to the variables being studied, highlighting a noteworthy impact beyond statistical significance. These differences were further examined using a pairwise comparison analysis as presented in table 5.

Table 5: Sidak Pairwise Comparison of the Posttest Means Achievement Scores of Male and Female Pre-Service Biology Teachers' Taught Genetics Using Technology-Mediated Dynamic and Static Visuals

(I) Gender	(J) Gender	Mean Difference (I-J)	Std. Error	Sig.[b]
Dynamic Males	Dynamic Females	9.107*	2.801	.008
	Static Males	13.918*	2.952	.000
	Static Females	12.566*	2.616	.000
Dynamic Females	Dynamic Males	-9.107*	2.801	.008
	Static Males	4.811	2.743	.395
	Static Females	3.459	2.484	.660
Static Males	Dynamic Males	-13.918*	2.952	.000
	Dynamic Females	-4.811	2.743	.395
	Static Females	-1.352	2.592	.996
Static Females	Dynamic Males	-12.566*	2.616	.000
	Dynamic Females	-3.459	2.484	.660
	Static Males	1.352	2.592	.996

Table 5 presents the results of the analysis examining gender-related differences in mean scores. The findings indicate statistically significant mean differences between certain gender groups. For instance, among Dynamic Males and Dynamic Females, a significant mean difference of 9.107 was observed with a p-value of .008. Similar patterns are seen between Dynamic Males and Static Males (mean difference = 13.918, p < .001) and between Dynamic Males and Static Females (mean difference = 12.566, p < .001). Interestingly, these significant mean differences are also reflected in the reverse comparisons. For instance, Dynamic Females compared to Dynamic Males showed a mean difference of -9.107 (p = .008), and Dynamic Females compared to Static Males exhibited a mean difference of -4.811 (p = .395). Static Males compared to Dynamic Males showed a substantial mean difference of -13.918 (p < .001), and the comparison between Static Males and Dynamic Females resulted in a smaller mean difference of -1.352 (p = .996). Similarly, Static Females exhibited a significant mean difference when compared to Dynamic Males (mean difference = -12.566, p < .001), and when compared to Dynamic Females, the mean difference was -3.459 (p = .660). The finding highlights gender-related variations in mean scores and suggests that these differences are statistically significant for specific gender pairings. The reported mean differences provide insights into the extent to which gender influences the measured outcomes.

Discussion

The findings of research question one on the mean retention scores of pre-service Biology teachers' taught Genetics using technology-mediated dynamic and static visuals discovered that there is a difference in the mean retention scores of pre-service Biology teachers and the null hypothesis indicated that the difference was significant. Thus, the mean retention scores of pre-service Biology teachers taught Genetics using technology-mediated dynamic and static visuals has a moderate effect size accounting for approximately 4% of the variance in the outcome. The observed differences in the mean retention scores of pre-service Biology teachers taught Genetics using technology-mediated dynamic and static visuals can be attributed to various factors inherent in the use of these instructional methods. The distinct characteristics of technology-mediated dynamic and static visuals play a crucial role in influencing how information is retained by students over time.

Technology-mediated dynamic visuals, such as interactive simulations and animations, offer a dynamic and immersive learning experience. These visuals often involve real-time manipulations, allowing students to engage actively with the genetic concepts they are learning. This active involvement promotes deeper cognitive processing and a more comprehensive understanding of the subject matter. As a result, students exposed to dynamic visuals may have retained the genetic concepts more effectively due to the hands-on and interactive nature of the learning process. On the other hand, technology-mediated static visuals provide visual representations without the same level of interactivity. While they can effectively convey certain genetic concepts, they may not offer the same depth of engagement as dynamic visuals. Consequently, students exposed to static visuals might not have experienced the same level of active participation and cognitive processing, potentially leading to slightly lower retention scores compared to their counterparts exposed to dynamic visuals.

The finding is consistent with the finding of Angelos and Rabindra (2021) who found that knowledge improves in all conditions. However, the gameplay condition is associated with marginally significant difference in knowledge improvement and retention. The finding was also consistent with Laurentiu et al. (2021) finding which shows that the Quantum Odyssey visual methods are efficient in portraying counterintuitive quantum computational logic in a visual and interactive form. This enabled untrained participants to quickly grasp difficult concepts in an intuitive way, retained the concepts and solve problems that are traditionally given Masters' level courses in a mathematical form.

The finding of research question two on the difference in the mean retention scores of male and female pre-service Biology teachers' taught Genetics using technology-mediated dynamic and static visuals discovered that there is a difference in their mean retention scores of male and female pre-service Biology teachers' taught Genetics using technology-mediated dynamic visuals favouring males. The finding of the null hypothesis indicated that there is a significant difference in the retention scores of male and female pre-service Biology teachers' taught Genetics using technology-mediated dynamic and static visuals. Further analysis revealed the presence of a medium effect size, suggesting that the observed differences have a moderate practical significance. This implies that approximately 7% of the variability in the outcomes is attributed to the variables being studied, highlighting a noteworthy impact beyond statistical significance. The finding of the pairwise comparison highlights gender-related variations in mean scores and suggests that these differences are statistically significant for specific gender pairings. The reported mean differences provide insights into the extent to which gender influences the measured outcomes. The observed disparities in the mean retention scores of male and female pre-service Biology teachers taught Genetics using technology-mediated dynamic and static visuals can be attributed to a combination of cognitive and instructional factors influenced by gender.

Cognitive differences between males and females may contribute to the variations in retention scores. Studies have indicated that males and females can process and retain information differently. The nature of technology-mediated dynamic visuals, with their interactive and engaging elements, might align more with certain cognitive preferences exhibited by males. This alignment could result in enhanced retention among male students when exposed to such visuals compared to their female counterparts.

Furthermore, instructional strategies and preferences could come into play. The propensity for males to respond more favorably to technology-mediated dynamic visuals might be related to their inclination towards hands-on and interactive learning experiences. These visuals cater for students' learning styles and bolster their retention. On the other hand, female students might prefer a different instructional approach that is better accommodated by technology-mediated static visuals, potentially contributing to the observed variations in retention scores.

The medium effect size observed indicates a moderate practical significance of the differences in retention scores. This sizeable effect suggests that approximately 7% of the variability in the outcomes can be attributed to the interplay of gender and instructional strategies. The impact extends beyond mere statistical significance, highlighting the substantial influence of gender on the measured outcomes.

The pairwise comparison analysis emphasizes the gender-related variations in mean scores, confirming that these differences are statistically significant for specific gender pairings. This emphasizes the complex interaction between gender and instructional methods, which contributes to variations in retention outcomes. The reported mean differences provide valuable insights into the degree to which gender influences the measured outcomes, shedding light on the intricate relationship between gender and instructional effectiveness.

This finding consistently supported the earlier finding of Sudatha and Simamora (2021) who showed that the mean of the comprehension test before the use of dynamic visuals differed significantly from that after the use of dynamic visuals and that dynamic visuals was attractive to be used in the instruction based on gender. Thus, dynamic visuals enhance students' understanding of both males and females. Similarly, Stolk et al. (2021) findings indicate a significant difference in lecture-based learning courses, with women reporting less self-determined motivations compared to men.

Conclusion

It was confirmed that technology-mediated dynamic visuals contribute to improved retention rates among pre-service Biology teachers compared to static visuals. The statistical significance of this difference, combined with the moderate effect size, emphasizes the benefits of dynamic visual elements for reinforcing and retaining genetic concepts, thereby enhancing the learning experience.

Recommendation

1. To address the gender-based differences in retention, the administration of colleges of education should actively promote gender-inclusive educational environments. This includes creating support mechanisms, mentorship programs, and safe spaces where students of all genders can thrive academically and personally.
2. Colleges of education should prioritize ongoing professional development for Biology lecturers. This training should encompass not only content knowledge but also pedagogical skills, including; the creation and incorporation of dynamic visual aids in Genetics curricula, the effective use of dynamic visuals, gender-responsive teaching practices, and strategies for maintaining student retention.

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