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MULTIMEDIA INSTRUCTION: AN INNOVATIVE TOOL FOR ENHANCING STUDENTS' ACHIEVEMENT AND RETENTION IN CELL BIOLOGY

Odunukwe, Charity Ngozi;[1] Ofoegbu, Theresa[2] & Nwanya, Darlington Uzoma[3]
[1&2]Faculty of Education, University of Nigeria Nsukka
[3]Government Secondary School Owerri

***Correspondence:** Odunukwe, Charity Ngozi

Abstract **-** The study investigated the effect of two modes of multimedia instructional package on undergraduate students' achievement and retention in cell biology Two research questions and null hypotheses guided the study. The research design was quasi-experimental research design. The population consisted of 191 first year students (43 males, 148 females) of Biology Education in five federal universities in South-East Nigeria. The sample consisted of 127 students (31 males, 96 females) from two federal universities in the population of study. Simple random sampling technique was used to assign the federal universities to two experimental groups for the study. The treatment instrument was a Computer Animation Instructional Package. Instrument used for data collection was Cell Biology Achievement Test (CBAT). The instrument was validated by experts and trial tested. Reliability coefficient of 0.8 was established for CBAT using Kuder Richardson (KR-20) formula. Research questions were answered using mean and standard deviation while Analysis of Covariance was used to test the null hypotheses at 0.05 level of significance. The result revealed that both the Animation with Narration (AN) and Animation with Text (AT) modes of the instructional media had significant positive effect on undergraduate students'achievement and retention in cell biology. The AT mode was more effective in enhancing students achievement while the AN mode is more effective in enhancing students' retention of learned concepts. In conclusion, the researchers propose that the AN and AT modes of multimedia instructions be adopted by university lecturers in teaching cell division and other complex science topics.

Keywords: Multimedia instruction, achievement, retention, cell biology

Introduction

Innovative pedagogies and media are required for a meaningful teaching and learning of cell biology. This is because; the study of cell biology is an important impetus for survival of life on earth. Cell biology is an aspect of biology that deals with the study of cells at both the microscopic and molecular level. On a broader view, it is the study of the structure and functions of a cell, from the most general properties shared by all cells, to the unique, highly intricate and complex functions particular to specialized cell (Bisceglia, 2014). Cell biology is therefore one of the important, if not the most important aspect of biology. Cell biology is a topic in senior secondary school biology curriculum in Nigeria (Luwoye, Bello & Adeoye, 2021). It is also offered as a stand-alone course in colleges of education (NCCE, 2014). However, in federal universities, it is a topic in a foundational course for biology education students. The aims of learning cell biology is enshrined in the goals and objectives of biology curriculum in Nigeria which are to: 1. prepare students to acquire adequate laboratory and field skills in biology; 2. have meaningful and relevant knowledge in biology; 3. possess the ability to apply scientific knowledge to everyday life in matters of personal/community health and agriculture, and 4. acquire reasonable and functional scientific attitudes (Federal Ministry of Education Nigeria, 2014). So, biology

curriculum in secondary and tertiary institutions in Nigeria is meant to provide solid foundation for students in biological sciences. It also aims at equipping students with the necessary knowledge they require for future academic and professional pursuits in the field of cell biology.

The study of cell biology is vital for the obvious reasons. It provides students with wealth of knowledge on the molecular and scientific basis of life. In other words, it is essential for scientific literacy and understanding of metabolic processes in life (Ndirika & Anidu, 2021). Another benefit is that it enables students to gain meaningful understanding of the cellular basis for healthy growth and diseased conditions. Lukow (2021) asserts that many cellular diseases of global concern today are basically as a result of uncontrolled or unchecked cellular processes in the body, example, cancer disease. Hence, to fight the menace of cancer and other cellular diseases, a deep and intense study of cell biology from cradle is required. Research studies in cell biology have also been reported to enhance diagnoses, treatments, and cures of diseases (Lukow, 2021). By implication, meaningful learning of cell biology will enable biologists working in animal, plant and medical sciences to develop new vaccines and more effective medicines. It will also enable undergraduate students' to effectively teach and transfer appropriate knowledge of cell biology to other students after university graduation. Despite the importance of learning cell biology, students tend to show poor understanding and poor mastery level of the contents. This has led to their poor achievement and retention of learned concepts in it (Bichi, Ibrahim & Ibrahim, 2019). The ugly situation has been attributed to a lot of factors such as, the use of traditional media to describe and explain the abstract and time-dependent motions of cell biology (Murtonen, Nokkala & Södervik, 2020). As a result, students perceive cell biology as an abstract and difficult topic that should be avoided and ignored. Affirming this, Odunukwe (2024) reported that undergraduate students in Nigeria perceive some contents in cell biology to be complex and difficulty to understand. Such contents include mitosis and meiosis (cell division). This phobia and misconception may have contributed to their consistent poor performances in faculty examinations. Abdulrahman, Yusuf, Arinde and Muhammad-Thani (2022) also revealed that number of students who passed cell biology at credit level (A-C) was consistently less than 30% for the years (2013-2019) in a tertiary institution used for a case study.

Achievement is an important learning outcome in education. It is a measure of students' academic standing or performance outcomes after completing an instructional task. According to Herrera, Al-La and Mohamed (2020), achievement is the final grades of students in school subjects. Achievement in cell biology (biology) can therefore be stated as the extent to which a student attained educational goals in biology when measured, tested or assessed on a pre-determined scale. So, achievement in biology can be expressed in terms of scores from various assessments in biology curriculum content, including classroom tests and external examinations. Several researchers have reported student' poor achievement in biology. The worrisome situation was observed in both secondary (Ali, Toriman & Gasim, 2014) and and tertiary institutions (Abdulrahman, Yusuf, Arinde & Muhammad-Thani, 2022). A number of reasons have been attributed to this. Some researchers argue that biological processes such as cell division are naturally abstract and complex in nature making it difficult for most student to understand and perform well (Chukwuemeka & Dorgu, 2019). Other studies attributed the poor achievement to poor teaching methods (Mamalanga, & Awelani, 2014), non-use and unavailability of modern instructional facilities and resources (Daworiye, Alagoa, Enaregha & Eremasi, 2015) and poor teacher competency and motivation (Agboghoroma

& Oyovwi, 2015). Other possible factors may include students' background and physiological variables. Most of these factors are being studied in a bid to see ways of enhancing students learning and achievement in cell biology. It is believed that when students' achievement is enhanced, it will improve their retention of learned concepts.

Retention is another important attribute in learning. It is very essential in the application and recall of knowledge learned. Retention can be explained as the ability to remember things learned after some period of time. According to Onyenma and Olele (2020), it is the process of moving new information from short-term memory to your long-term memory. In order words, the ability to make new knowledge stick in memory for longer time and for future use. Teachers want their students to retain and recall details rather than memorizing facts for exam. However, students tend to show poor retention of learned concepts in cell biology (Bello, 2014). This problem may be attributed to students' lack of proper understanding and construction of knowledge about cell biology (cell division). Study by Ozcan (2021) showed that students' poor understandings and poor mastery level for cell division results in their low retention of concepts in cell biology. However, proper understanding and construction of knowledge about cell biology depends on students' visualization of the chromosomes movement during mitosis and meiosis. Visualization may also help their meaningful understanding and retention of the complex process. Studies revealed that multimedia instructional packages facilitate visualization, meaningful learning and understanding of abstract processes (Bamidele & Yoade, 2017), enabling coding of information in both the visual and verbal mental codes. However, multimedia instructional packages can be presented in different modes during teaching and learning sessions.

Modes of multimedia instructional package denote various ways, format or approaches by which multimedia instructional package are presented to learners. It comprises of different formats or presentations of words and pictures in a multimedia learning environment (Mayer, 2017). Words can be presented in multimedia learning as written text or spoken text (audio/narration) while pictures might be presented as illustrations, photos, graphics, video or animation. Consequently, modes of multimedia instructional package may consist of different combinations of animation with text or with audio. There are three different modes of multimedia presentations and they all have root on Mayer's principles of multimedia learning. Basically, the modality principle and redundancy principle. According to modality principle, multimedia mode of animation + narration (AN) is more effective for learning than that of animation + text (AT) (Castro-Alonso & Sweller, 2021). According to the redundancy principle, the multimedia mode of animation + narration (AN) is more effective for learning than that of animation + narration + text (ANT)(Mayer, 2017). However, empirical studies and evidences on the effectiveness of different modes of multimedia instructional package on students learning is inconclusive.

For example, studies by Oberfoell and Correia (2016) and AbuSaad, Lee and Fong (2013) revealed that students who received instruction using the AN mode had more effective learning than those taught with AT mode. In another study, Bamidele and Yoade (2017) emphasized the efficacy of ANT mode over other modes and conventional teaching method in the learning of biology. However, other studies such as that by Liu (2019) presented contrarily report. It showed no significant difference in the effectiveness of different modes of multimedia instructional package in learning and knowledge transfer scores of students. So, empirical evidences on effectiveness of different modes of multimedia instructional package on students learning are conflicting. The conflicting

evidences informed the need to verify the assertions, by undertaking this study which examined the effectiveness of two multimedia learning modes in enhancing undergraduate students' achievement and retention in cell biology.

The study of biology has remained an important impetus for the survival of life on earth. However, the learning of cell biology has been a challenge to students in Nigeria, including undergraduate students in tertiary institutions. Evidence have shown that students' achievement and retention in the topic appears unsatisfactory over the years. Previous studies attributed this challenge to the use of traditional media to describe and explain the abstract concepts and time-dependent motions of cell biology. Hence, the need to employ innovative approaches using multimedia learning modes in teaching cell biology. However, there are conflicting evidences on the effectiveness of different multimedia learning modes on undergraduate students' achievement and retention of learned concepts in biology. The conflicting evidences informed the need for this study which examined the effectiveness of two multimedia learning modes in enhancing undergraduate students' achievement and retention in cell biology. The purpose of this study was to examine the effectiveness of two multimedia learning modes in enhancing undergraduate students' achievement and retention in cell biology.

Research Questions

The following research questions guided the study:

1. What is the mean achievement scores of students taught biology using multimedia learning modes?
2. What is the mean retention scores of students taught biology using multimedia learning modes?

Hypotheses

This study investigated the following hypotheses, which were tested at a significance level of 0.05.

Ho_1: There is no significant difference in the mean achievement scores of students taught cell biology using animation with narration (AN) and animation with text (AT).

Ho_2: There is no significant difference in the mean retention scores of students taught cell biology using animation with narration (AN) and animation with text (AT).

Methodology

The research design was quasi-experimental research design, specifically pretest, post-test design. The population of the study consisted of 191 first year undergraduate students (43 males, 148 females) of Biology Education in the five federal universities in South-East Nigeria.. The sample consisted of 127 first year students (31 males, 96 females) of biology education drawn from two federal universities in the population of study. Two federal universities offering degree programme in education were randomly sampled for the study. The treatment instrument was a multimedia instructional package in two modes namely: Animation with Narration (A+N) mode and Animation with Text (A+T) mode. Instrument used for data collection was Cell Biology Achievement Test (CBAT). The instrument was validated by experts and trial tested on students with homologous characteristics with the sample. Reliability coefficient of 0.8 was established for CBAT using Kuder Richardson (KR-20) formula. Research questions were answered using mean and standard deviation

while Analysis of Covariance (ANCOVA) was used to test the null hypotheses at 0.05 level of significance.

Results

Table 1: *Students' Mean Scores and Standard Deviations in WAEC in Biology*

Year	Mean Score	Standard Deviation
2014	29.00	12.37
2015	18.00	10.49
2016	21.00	10.34
2017	31.00	11.79
2018	27.00	10.34

Source: Statistics Section; West African Examination Council (WAEC) National Office, Lagos Nigeria.

From table 1 above, the highest mean score from 2014-2018 is 31.00. This is not up to 50.00. It is a worrisome situation which has frustrated students efforts to gain admission into tertiary institutions in Nigeria. It has also impeded the actualization of the goals and objectives of biology education in the country. Narrowing down to states, Okoro and Oluwasegun (2023) reported WAEC analysis for Biology (2018-2021) in one of the educationally advantaged states in the country. According to the report, only 47.00 percent passed the subject in 2018, 48.70 percent in 2019, 49.00 percent in 2020 and 49.20 percent in 2021. Not up to 50 percent of the students passed biology within these years. The ugly situation has been a source of concern to stakeholders in the educational sector. However, scholars have noted that learning with multimedia instructional package can demystify abstract and complex academic concepts. Gambari, Yaki, Gana and Ughovwa (2014) reported that multimedia instructional package promotes students understanding of difficult academic contents. In other words, multimedia instructions are potent tools for making learning more meaningful and effective, as it enhances understanding of difficult and abstract concepts. When students' understanding of difficult concepts is enhanced, it will most likely enhance their achievement and retention of learned concepts.

Table 2: **Mean Achievement Scores and Standard Deviation of Students taught cell biology using Animation + Narration (AN) and Animation + Text (AT) Multimedia Learning Modes**

MEDIA	N	Pretest Achievement		Post-Test Achievement		Mean gain
		Mean	SD	Mean	SD	Mean
Animation + Narration	70	37.43	11.64	44.61	12.17	46.85
Animation + Text	57	49.05	13.99	50.91	16.77	48.50

Table 2 revealed that students taught with animation + narration had pretest achievement mean score and standard deviation of 37.43, 11.64; post-test achievement mean score and standard deviation of 44.61, 12.17, and adjusted mean of 46.85. Those taught with animation + text had pretest achievement mean score and standard deviation of 49.05, 13.99; post-test achievement mean score and standard deviation of 50.91, 16.77, and adjusted mean of 48.50. This shows that students taught with animation + text performed better than those taught with animation + narration in cell biology.

Table 3: **Mean Retention Scores and Standard Deviation of Students taught Cell Biology using Animation + Narration (AN) and Animation + Text (AT) Multimedia Learning Modes**

MEDIA	N	POST-TEST		RETENTION		MEAN GAIN
		X	SD	X	SD	X
Animation + Narration	70	44.61	12.17	62.66	10.94	64.69
Animation + Text	57	50.91	16.77	45.02	3.93	45.80

Table 3 revealed that students taught with animation + narration had post-test mean score and standard deviation of 44.61, 12.17; retention mean score and standard deviation of 62.66, 10.94, and adjusted mean of 64.69. Those taught with animation + text had post-test mean score and standard deviation of 50.91, 16.77; retention mean score and standard deviation of 45.02, 3.93, and adjusted mean of 45.80. This shows that students taught cell biology using animation + narration retained concepts better than those taught with animation + text.

Table 4: Analysis of Covariance of Students' Cell Biology Achievement Scores by Media

SOURCES OF VARIATION	Sum of Squares	df	Mean Square	f	Sig	PARTIAL ETA SQUARED
Covariates Pretest	7556.893	1	7556.893	53.965	.000	
Interest	14940.450	3	4980.150	35.564	.000	
Main Effects (Combined)	14484.532	2	7242.266	51.719	.000	.261
Media						
Model	23381.406	6	3896.901	27.829	.000	
Residual	23105.309	165	140.032			
Total	46486.715	171	271.852			

a. Posttest by Media with Pretest
b. Covariates entered first
Posttest by Media with Pretest
b. Covariates entered first

Result in Table 4 revealed a statistically significant main effect for media F(1,165) = 51.719, p = .000, partial η^2 = .261. Since P(0.000) is less than 0.05. The null hypothesis was rejected, indicating that there was a significant difference in the mean achievement scores of students taught cell biology using animation with narration (AN) and animation with text (AT). The effect size, calculated using partial eta squared, was .261. This means that 26% of the variation in the dependent variable is influenced by the independent variable.

Table 5: Analysis of Covariance of Students' Cell Biology Retention Scores by Media

SOURCES OF VARIATION		Sum of Squares	df	Mean Square	f	Sig	PARTIAL ETA SQUARED
Covariates	Pretest	4711.462	1	4711.462	33.590	.000	
Interest							
Main Effects		14309.098	3	4769.699	34.005	.000	
(Combined)							
Media		14092.766	2	7046.383	50.236	.000	.301
Model		19125.181	6	3187.530	22.725	.000	
Residual		23143.726	165	140.265			
Total		42268.907	171	247.187			

a. Retention by Media with Post-test
b. Covariates entered first

Result in Table 5 revealed a statistically significant main effect for media $F(1,165) = 50.236$, $p = .000$, partial $\eta^2 = .301$. Since $p(0.000)$ is less than 0.05. The null hypothesis was rejected, indicating that there was a significant difference in the mean retention scores of students taught cell biology using animation with narration (AN) and animation with text (AT). The effect size, calculated using partial eta squared, was .301. This means that about 3% of the variation in the dependent variable is influenced by the independent variable.

Discussion

Findings from the study revealed that students taught cell biology with AT mode had higher achievement scores than those taught with AN mode. And the difference was statistically significant, implying that the actual difference in mean scores between the groups was substantial. This shows that the modality effect is no longer impacting learners as it was about twenty years ago. The rationale behind this change can be attributed to high experience level of the participants, not with content of the study but instead, with technology, online learning, and multimedia formats that include animation and text. The synchronized on-screen text did not impede learning; rather it reduced the cognitive load and enhanced learning and achievement of students in cell biology. This agrees with the study of Oberfoell and Correia (2016) who reported that animation with onscreen text was more effective for low-experienced learners than the narrated version. However, the findings are not in consonance with that of AbuSaada, Lee and Fong (2013) and Gambari, Ezenwa and Anyanwu (2014) who found that achievement of students in solid geometry with AN courseware mode was better than their colleagues who in AT mode. The result of the presnt study refutes Mayer's multimedia modality principle and the findings of Adegoke (2010) that multimedia based instruction involving animation with narration results in a more significant learning outcome than animation with onscreen text.

The study also revealed that students taught with AN mode had better retention in cell biology than those taught with AT mode. The rationale behind this can be explained using the modality principle of multimedia learning. According to the modality principle,

the multimedia mode of AN is more effective for retaining learned concepts than AT mode (Castro-Alonso & Sweller, 2021). This is because text presented with animation could constitute extraneous cognitive load and cognitive overload of the working memory, thereby undermining effective retention. It was assumed that the competition for cognitive resources in the visual channel from the simultaneous presentation of animation and text (AT) constituted extraneous cognitive load, which led to cognitive overload in the working memory of students in AT group. This must have led to their lower retention of learned concepts. While, animation presented with narration (AN) facilitated learning resulting to higher mean retention scores of students in AN. This particular finding validates Mayer's modality principle of multimedia learning. It also concurs with the findings of Castro-Alonso and Sweller (2021), Wang and Evans (2021) and Chretien (2020). They revealed that students who learned with AN mode had better retention and recall of details than those that learned with animation and text (AT) mode. However, the finding contradicts with that of Oberfoell & Correia (2016) who reported that learners who viewed a multimedia instruction that contained animation and onscreen text, had more effective retention and transfer of knowledge than learners that viewed the narrated (AN) mode. However, the fact that the two modes of CAIP enhanced students' retention of learned concepts in cell biology gave support to what was earlier found by Gambari, Falode and Adegbenro (2014) that students' retention can be improved through the use of animated-media tools in geography and mathematics respectively.

Conclusion

The study revealed that learning with the two different multimedia modes enhanced undergraduate students' achievement and retention in cell biology. Students taught with AT mode had significantly higher achievement while those taught with AN mode had better retention in cell biology. This indicates that AT mode is more effective in enhancing undergraduate students' achievement in biology while AN mode facilitates better retention of learned concepts. Based on these findings, the researchers advised that both the AN and AT mode be used in teaching and learning of cell biology at all levels of education. It can serve as a medium of improving undergraduate students' poor achievement and retention in cell biology.

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