

Visualizing the Cell: The Impact of Multimedia Instruction on Students' Academic Performance

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Citation: Khalid, S. B., Muhammad, R., & Samaila, K. (2026). Visualizing the Cell: The Impact of Multimedia Instruction on Students' Academic Performance. *Equity Journal of Innovative Research in Education*, 3(1), 145-157: ISSN 2814-2187

ABSTRACT

Cell biology involves abstract and microscopic concepts that many students find difficult to understand through traditional teaching method. This study investigated the impact of multimedia instruction on senior secondary school students in cell biology class. To determine whether the use of multimedia instruction such as videos, audios, images, and pictures improve students' test score compared to traditional instruction, a quasi-experimental design was adopted. Two groups of students were used. An experimental group (N = 55) taught with multimedia instruction and control group (N = 52) taught with tradition method. Pre-test and post-test score were collected and analyzed using t-test to compare the mean score. Findings indicated that students exposed to multimedia instruction achieved significantly higher post-test scores and demonstrated better conceptual understanding of cell structure than the control group. The visual and interactive nature of multimedia materials enhanced achievement. Therefore, teachers and curriculum planners and should incorporate multimedia-based learning activities into the secondary school biology curriculum, especially for abstract topics like cell biology.

ARTICLE HISTORY

Received 30 April 2026

Accepted 30 May 2026

KEYWORDS:

Cell, Biology,

Multimedia, Instruction

1. Introduction

Biology is a branch of science that encompasses diverse field including botany, conservation, genetics, medicine, marine biology, molecular biology, micro biology, physiology and zoology. The government emphasizes that biology is a science subject that strives to give pupils the necessary scientific understanding for all of life's challenges. It is one of the core subjects in Nigerian secondary school curriculum that was introduced to students at senior secondary school level as a preparatory ground for human development, where career abilities are groomed, and potentials and talents discovered and energized (Samaila et al., 2022). Biology has some topics that trip up most students because they are abstract, math-heavy, or just unintuitive. For example,

genetics and cell are believe to be among the difficult topics in biology because it sits at the intersection of “too small to see” and “too many moving parts”.

The cell is the fundamental units of life, that all living things are composed of one or more cells, and that all cells arise from preexisting cell through cell division. Most cells are very small, with diameters ranging from 1 to 100 micrometers and are therefore only visible under a light or electron microscope. The cell is a key concept, and accurate knowledge of it is essential for understanding many phenomena and biological processes, as well as the overall functioning of living beings (Osuafor, & Okonkwo, 2013). Having sufficient knowledge of the cell is important because it's the basic unit of life. Everything living is made of cells, and everything living does happens because of what cells do. Teaching cell in secondary schools helps students understand cellular processes like photosynthesis and respiration, building a better understanding of energy flow in ecosystems and global environmental systems (Ezechi & Mercy, 2022). Students need solid cell biology because almost every other life science topic sits on top of it. Without it, you are memorizing disconnected facts instead of understanding how life actually works (Piwuna, & Mangut, 2023). The goal of biology curriculum in senior secondary School is to instill in students scientific process and attitude.

The cell is abstract in nature because is relatively small in size and this situation makes the cell concept difficult to explain and understand (Snezana, et al., 2011). According to Olutola (2020) many students reported that some biology topics such as cell and genetics were boring, abstract, and difficult to understand. Consequently, Biology, particularly cell consistently records low levels of interest, and low achievement levels across all internal and external assessments (Okwonkwo & Emanalom, 2012). However, many students struggle with the cell biology, resulting to poor examination performance and a lack of interest in furthering their studies in biology. Nigerian students do not find cells hard because they are “dull.” They find it hard because we often teach an invisible, dynamic 3D system using 2D drawings, with no lab, in a second language, under examination pressure.

Researchers have examined student's challenges in learning biology and identified some factors that contribute to student's poor performance in Biology, some of which includes lack teachers, lack of educational teaching resources, an overloaded syllabus, laziness, poor attitude, a lack of interest on the part of the students, a lack of interest on the part of the teacher, a large class size, a student to teacher ratio, and students family background (Cimer, 2012; Usuafor & Ifeoma, 2013). Similarly, Olutola, (2020) pointed out that test anxiety and ineffective use of instructional aid affect student performance. According to Ismail and Lukman, (2022), secondary school student struggle in Biology due to lack of adequate and occasionally possible instructional materials. Other factors include students' aversion to science and the mistaken belief that biology is a difficult subject. In addition, inadequate teaching methods, a lack of practical experience, and a paucity of competent teachers are all factors that might contribute to this problem (Imroz, 2023).

Traditional teaching methods adopted by the most biology teachers at senior secondary school level in Nigeria, have been identified as one of the major factors contributing to poor performance of students in biology (Asuzu & Okoli, 2019). This method is classroom-based and consists of lectures and direct instructions conducted by the teacher (Samaila & Al-Samarraie, 2023). It is a teacher-centered method that emphasizes learning through the teachers' guidance at all times (Masood et al., 2022). Students are expected to listen to lectures and learn from them (Allan, et al., 2019). Moreover, it one-way communication method that allows for little or none

audience participation thereby leading to students' misunderstanding, loss of information, and poor retention (Samaila et al., 2021). Majority of teachers in science classrooms still use traditional teaching techniques, which have repeatedly presented difficulties for both students and teachers over time (Samaila et al., 2024).

Teaching the cell using multimedia instruction will give students the lens to understand life, health, and half the news headlines. With cheap video techniques and light microscope, students can see onion cells, cheek cells, stomata. That one lab where they see their own cells often becomes a core memory. It moves biology from abstract to "that's me". Apps and animations now let students fly through a cell in 3D. You do not need a university lab to make it stick anymore. Multimedia instruction in this study involves the use of various forms of media, including text, audio, images, animations, and videos, to facilitate teaching and learning of cell biology (Bello, et al., 2022). The instruction is affecting the educational landscape and has been labeled as a tool that can enhance effective and efficient teaching and learning.

However, while it is increasingly used in many developed countries, its application in developing countries such as Nigeria to teach secondary school students is still a thing of novelty (Akinbadewa 2020). According to Maricic et al (2020), opined that a multimedia enabled classroom allows the teacher to engage student in the teaching process and make them more active, this process is no longer based exclusively on teacher lecturing, but become supported by various media, books, magazine, audio visuals, television and computers. According to Mahawar et al. (2022) one of the reasons why multimedia instruction may enhance learning is that videos tend to be engaging, which fosters student learning; videos lead to higher acceptance and satisfaction among students. Mayer (2003), claims that learning using multimedia (videos, images, animations and words) allows learner to easily understand the content. For multimedia instruction to meet both students and teacher's needs, then, instruction should move from passive, teacher centered classroom to active students centered one.

1.2 Statement of the problem

In many Nigerian secondary schools, the teaching of abstract topics like cell biology still relies heavily on traditional lecture and textbook methods, with limited use of visual aids or technology, contributing to students' poor comprehension, low interest, and persistent underperformance in Biology as reflected in WAEC and NECO results. In addition, students' performances in the terminal examination have over the years been poor as reflected in the WAEC and NECO results. The chief examiners have consistently lamented the poor performance in cell Biology for some years. (WAEC & NECO, 2022, 2023, 2024). The poor performance is product of several factors, prominent among them includes: poor class attendance, poor class managements /engagement, poor students' behavior, lack of resources, ineffective teaching method (Ntaila & Mbarak, 2023). According to the Piwuna and Mankik (2023) the lack of implementing the recommendations from chief examiner's report could be responsible for continuous low motivation and consequent poor students' performance in Biology.

The above issue can be tied to poor instructional teaching strategies. Multimedia instruction is one of the teaching strategies that can minimize and improve students' performance in teaching science subjects. The multimedia instruction allows teachers to use videos and modern microscopic to engage the students and make classroom active. The use of multimedia presentations support visual and verbal format supplemented with pictures, animations, text and

narrations that could overcome the limitation of traditional teaching method. Several studies conducted to investigate the effect of multimedia instruction on students' mastery of ecological concepts and photosynthesis. The results showed that multimedia instruction had positive impact on students' performance. However few studies or no studies were conducted to improve students' mastery of cell concept using multimedia. Failure to improve students' performance in cell biology may perpetuate rote learning, widen the achievement gap, and undermine efforts to produce scientifically literate graduates. To fill the existing gape, hence it is necessary to investigate the effectiveness of multimedia instruction on students' performance in cell biology.

2. Literature Review

2.1 Traditional Method

Traditional teaching method focus on the teacher as the only source of information in the classroom, it embraces the idea of teacher centered method, involving face to face interaction, mainly from the teacher to students. It is very common in education especially at university level, the traditional method ignore students consequently the mental level of interest of students. It involves coverage of content and rote memorization on the part of the students (Khalid & Azeem 2012). In the traditional method of teaching, the teaching happens between the four walls of the classroom, the teacher is the sole source of information, and it promotes supremacy of teacher in the classroom. In this method, students learn through repetition and memorization, there is little or no space for critical thinking. It mainly relies on textbooks, emphasizes on basic skills, and learning assessment. The traditional teaching and learning method make the lecturer/yutor in charge of the classroom/theatre, write entity on the number of study hours, rather than on lecturing hours (Samaila et al., 2024).

According to (Ogunniyi, & Jegede, 2012) poor performance of senior secondary school students in biology can be attributed to a combination of factors including inadequate teaching, insufficient facilities students' negative attitude the subject and lack of interest in the subject. The shortage of teaching materials and resources such as textbook, laboratory equipment and visual aids can limit the effectiveness of biology instructions and negative impact towards students' performance, (Ogunniyi & Jegede 2012). From the perspective of Okwonkwo and Emenalom (2012), biology teachers in Nigeria lack the necessary training and qualifications to teach the subject effectively, this in turn can lead to poor teaching practice and a lack of interest among students.

2.2 Multimedia Instruction

Multimedia refers to audio, visual, audio visuals text chart that are used in conveying information. Multimedia refers to content that uses a combination of different forms of media such as text, audio, video, graphics, and animation to deliver information or entertainment to the audience." Mayer (2014) defined multimedia as the presentation of learning media using both preferential and verbal forms such as spoken and printed texts. This instruction allows for the integration of various types of media content to create a more engaging and interactive experience for the audience (Clark & Mayer, 2016). This kind of medium allows information to be easily transformed from one location to another. It is an interactive instruction that represents information to the user in a

powerful manner (Dhar et al., 2023). The use of multimedia in an educational setting offers numerous benefits to teachers and students, it improves engagement and motivation, improved comprehension, catering to diverse learning style and interactivity (Imroz, 2023).

Multimedia instruction refers to the use of various forms of media, such as text, images, audio, video, and interactive elements, to deliver educational content (Akinbadewa & Soforow, 2020). It is a method of instruction that engages multiple senses and learning modalities to enhance understanding and retention of information. According to Clark & Mayer (2016), "Multimedia instruction refers to any instructional method that uses multiple modes of presentation to promote learning. These modes can include words printed on the screen, graphics, animations, videos, narrations, and interactive elements." The goal of multimedia instruction is to enhance learning by presenting information in a more visual and immersive way making it easier for learners to understand and retain material. Multimedia instruction is commonly used in e-learning platforms, educational software, and online courses to provide a more interactive and engaging learning experience for students (Samaila, Dauda, et al., 2021).

In search to replace traditional teaching approach, researchers employ multimedia instruction to improve students' performance. Literature shows that multimedia instruction was tactically used to improve students learning outcome, performance, motivation, and engagement. For instance, Dubey (2012) conducted a study to assess the impact of multimedia package on achievement of science of VIII class students. The finding revealed that training with multimedia package is genuinely better than conventional teaching method for science (Biology) subject. It equally showed that male and female students of Class VIII do not differ genuinely in respect of their science achievement. Similarly, a consistent failure of students in digestive system classroom motivated researcher to compare the effect of multimedia instruction with traditional method on students' performance. Results revealed that students who taught with multimedia instruction had higher mean score compared to their counterpart.

Research on the impact of interactive multimedia instruction revealed that the use of interactive multimedia provide a good value of effectiveness in mastering students cell concept compared with learning using conventional method (Akinbadewa, 2020). Gambari, et al. (2013) carried out a research to assess the role of multimedia in students' academic achievement. The findings shows a significant difference in the achievement posttest between the two groups, the experimental group (multimedia instruction) have higher score than the control group, the study concludes that the multimedia instruction should be adopted for better teaching and learning.

In a related study conducted by Kareem, (2019) on the effect of multimedia on performance of senior secondary school students. A quasi-experimental design of pretest and post-test group was adopted. Performance test was the instrument used in the study. A sample of 200 students purposively selected. Mean, standard deviation and t-test are the statistical techniques used. One of the findings revealed there was significant difference between secondary school students exposed to multimedia on listening skill and those not exposed. In addition, a research was conducted and found that students in the multimedia group have significant higher mean score in term of both knowledge acquisition and retention in biology than the control group. Also students in the multimedia group exhibit more positive attitude towards biology compared to those in the control group. The study also recommends integrating multimedia tools and resources into biology instruction, particularly for teaching complex topic like cell concept.

Multimedia instruction improves student performance over traditional methods by leveraging how the human brain processes information. By combining words and graphics, it prevents cognitive overload, stimulates multiple senses, simplifies abstract concepts, and significantly boosts overall engagement and knowledge retention (Ugwu and Nzewi, 2015). Traditional lectures can lead to passive listening, whereas multimedia environments are inherently more interactive and stimulating. Incorporating audio, video, and animation maintains students' interest and curiosity, leading to better attendance and a positive attitude toward the subject matter (Ntaila & Mbaraka, 2023). The key advantages of multimedia instruction in biology is its ability to make the learning process more goal-oriented, participative, and adaptable to individual needs (Adegoke, 2011). Students have the flexibility to learn at their own pace and in their preferred learning environment, whether at home or in the classroom. Moreover, multimedia instruction transcends geographical barriers, allowing students to access learning resources regardless of their location.

By combining text, images, animations, and videos, multimedia instruction stimulates student interest and motivation, leading to enhanced learning outcomes (Rosamsi, et al., 2019). The impact of animation based instruction on student's achievement in cell biology. The findings shows that students taught with animation based instruction obtained a significantly higher achievement level compared to the control group. The study implies that the lecture-based animation method improves the learning of abstract concept and complex process that possess many understanding problems among students such as those in cell biology (Ezechi & Anyanwu, 2022). Moreover, the interactive nature of multimedia allows students to take control of their learning experience, promoting active engagement and collaboration with peers and teachers (Bello et al., 2022).

While numerous studies have established the positive effect of multimedia instruction on students' performance in science subjects, most of this evidence is derived from technologically advanced classrooms in developed countries, with limited empirical attention given to the Nigerian context where infrastructural deficits, large class sizes, and teacher readiness differ significantly. Existing local studies have largely focused on general ICT integration or compared multimedia to traditional methods in broad terms, but few have specifically isolated its effect on performance in abstract, visualization-dependent topics such as cell biology at the secondary school level. Moreover, prior research in Nigeria rarely accounts for moderating variables like school type, location, and students' prior exposure to digital tools, which are critical in a diverse educational landscape. This study is therefore unique in that, it examines the effect of tailored, curriculum-aligned multimedia instruction on students' performance in cell biology within public secondary schools in Nigeria, while also considering contextual constraints and resource availability. Hence, the following research objective and hypothesis were formulated:

Research Objective: To examine the differences in the performance mean scores (post-test scores) between students taught using multimedia instruction and those taught using the traditional teaching method

H01: There is no statistically significant differences in the performance mean scores (post-test scores) between students taught using multimedia instruction and those taught using the traditional teaching method

3. Research Methodology

3.1. Research Design

This study adopts quasi experimental design. It compares groups with different circumstances and treatments to find out the cause and effect of the treatment. Quasi experiment are studies that aimed to evaluate intervention but do not use randomization. The experiment was conducted in biology class at a secondary school. Before the experiment, three experts reviewed and approved the study protocol. A sample size of ninety six (107) students was calculated using the G*Power software from a total population 503 students. The population of this study cut across all Biology students in Kebbi State. There are six education zones in Kebbi State and this study could have selected a school from each Zone, but due to the growing insecurity in the state, a convenient sample technique was used to select a school from two zones.

3.2 Participant of the Study

A total of 96 students from the two selected secondary schools in Kebbi State participated in this research. In the multimedia instruction class, there were 55 students (57.3%), while in the traditional method class, there were 41 students (42.7%). There were 52 male participants (54%) and 44 female participant were (45%). Regarding school, majority of the participants come from government secondary school Jega, 55 students (57.3%), while the remaining participants were from government secondary school Gwandangwaji 41 students (42.7%).

3.3. Instrumentation

In this study, the research instrument was a Biology Performance Test (BPT). The researcher, in collaboration with experienced biology teachers, developed the instrument from biology syllabus of the SS2 Biology curriculum. The BPT comprised 20 multiple-choice items, each with four options labeled A–D. The items were constructed to align with curriculum objectives and to assess students' understanding of key concepts in cell structure and function. To ensure content validity, the draft instrument was subjected to expert review by biology educators and test-and-measurement specialists. Following validation, the items were deemed satisfactory and adequately covered the intended content domain. The reliability of the instrument was established using the Kuder-Richardson Formula 20 (KR-20), which yielded a coefficient of 0.89, indicating high internal consistency.

Experimental Procedure

The experimental procedure explains how the two instruction were conducted. In the first week, the researchers introduced and engaged all the students about the research. The students committed to participate in the research. Thereafter, a pre-test was administered to all the students (N = 107) in experimental and control groups.

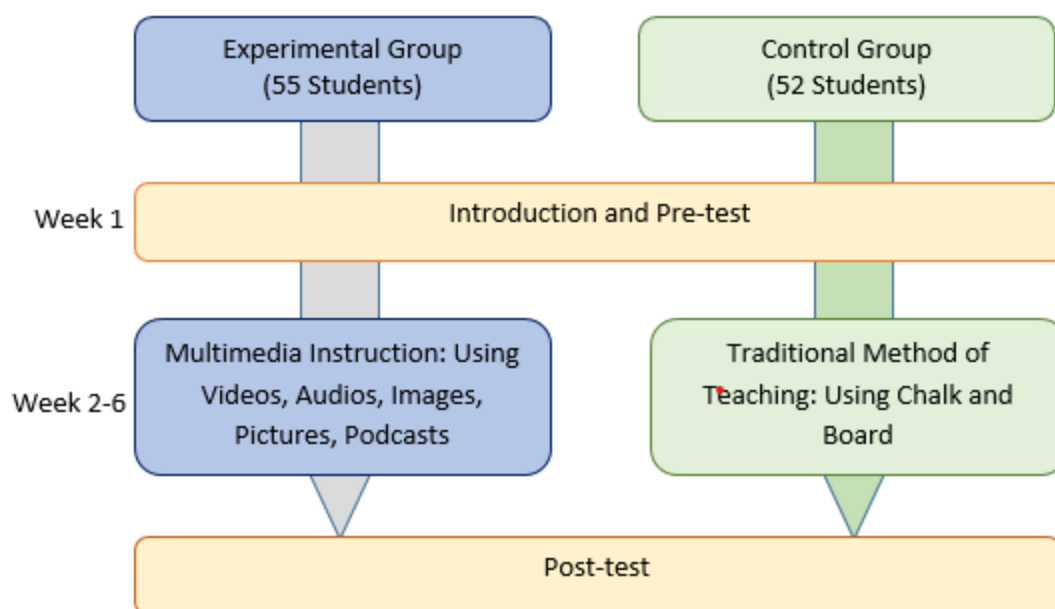


Figure 3 Experimental procedure

Figure 3 shows that from the second week to sixth week of the experimental procedure, students had been learning cell biology using different instructions. The experimental group's students taught using multimedia instruction where videos, audios, images, pictures and podcasts were being used. Students in the control group taught using traditional teaching method where teacher teach using chalk and board.

4. Results

4.1 Descriptive Statistics

There were a total of 96 valid respondents in this study. The experimental group consists of 55 (57.3%) students, while the control group of 41 (42.7%) students. There were 52 (54%) male student and 44 (46%) female students.

Table 1: Students' Population Based on Group and Gender

	Value label	N	%
Group	EXP	55	57.3
	CTR	41	42.7
Gender	Male	52	54
	Female	44	46

4.2 Research Hypothesis

A null hypothesis was tested to understand if there is no statistically significant differences in the performance mean scores (post-test scores) between students taught using multimedia instruction and those taught using the traditional teaching method.

Table 2: T-test analysis

Levene's Test		t-Test for Equality of Means			
	F	Sig.	T	Df	Sig. (2.tailed)
	3.557	.062	3.217	94	.002
Post-test			3.380	93.760	.001

The t-test analysis in table 2 on difference in performance mean scores (post-test) between in EXP group and CTR group shows that the p-value = .002 which is less than 0.05 level of significant. Therefore, hypothesis H₀₁ was rejected. This implies that there is a significant difference exists in students' learning achievement. Student in the EXP group (M = 19.2909) had performed better compared to the students in the CTR group (M = 17.6585). This indicates that multimedia learning approach had significantly influence students' ability to learn.

4.5 Discussion of Findings

This research was conducted to understand the impact of multimedia instruction on students' learning achievement in cell biology class. Results showed that students in multimedia class performed better and scored high marks. This implies that multimedia learning approach has significantly influence students ability to learn. Similarly, the results suggested that multimedia resources—such as animations, labelled diagrams and videos—enhanced students' comprehension of cell structures and processes. This finding is consistent with several studies previous studies. For example, Wang, (2022) found that multimedia instruction significantly improved secondary-school students' achievement in Biology compared to traditional teaching in Enugu State. Their study, which used a quasi-experimental design similar to this study, showed that students exposed to multimedia outperformed their counterparts in the control group. Similarly, Ntaila and Mbaraka (2023) reported that students taught with multimedia facilities in Cross River State performed better than those taught without multimedia.

This research noted that multimedia makes learning more interactive and helps teachers to present abstract biological processes more clearly. This aligns with the present study, especially because cell concepts require visualization of microscopic structures. The finding upholds the assertion of Mayer (2009) that students learn more deeply with words and pictures when combined than they could have with either words alone or pictures alone, and that multimedia is more effective when it is interactive and under the control of the learner. Further support comes from Rosamsi, et al. (2019) in Ethiopia, who hypothesis the effect of multimedia teaching strategies on secondary school students. It was established that multimedia instruction not only improve students' performance but give a room for students with different learning style. Those who are visualized were captured and those who were auditory were also had opportunity to learn according to their needs (Ezechi & Anyanwu, 2022). In addition, animations and simulations helped make invisible biological processes more concrete. This is directly relevant to the teaching of cell concepts and further validates the present study's findings (Bello et al., 2022).

Moreover, this research is strongly supported by Mayer's Cognitive Theory of Multimedia, which posits that students learn more effectively when they have different learning strategies in one lesson. For example, using videos, pictures, and images. Multimedia instruction provides opportunities for such active engagement, allowing learners to visualize microscopic cell structures, manipulate representations, and link new information to prior knowledge. Thus, the

higher achievement of the multimedia group aligns with other elements processed by the multimedia instruction like interaction, student-centered, and collaboration.

Conclusion

The use of videos, audios, animations, and diagrams helped students visualize abstract cellular structures and processes, leading to deeper understanding and improved performance. Overall, the results reported that students learn better when actively engaged through multiple sensory channels. Consequently, this study underscores the value of integrating multimedia resources into biology education as a means of improving students' understanding of complex concepts, enhancing their engagement, and ultimately boosting their academic performance.

Recommendations

1. Ministry of Education and school stakeholders should encourage biology teachers to integrate multimedia instruction (videos, audios, animations, and pictures) when teaching cell concepts to enhance students' achievement.
2. Government and school administrators should provide functional multimedia facilities such as computers, projectors, internet access and educational software in biology laboratories.
3. Government should organize workshops and professional development on regularly basis to improve teachers' proficiency in multimedia-based instruction.
4. Curriculum planners and should incorporate multimedia-based learning activities into the secondary school biology curriculum, especially for abstract topics like cell biology.

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