Design and Evaluation of Three-Dimensional Visualization Module for Teaching Cell Biology in Nigerian Secondary Schools

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Abstract

Teaching cell biology in Nigerian secondary schools presents significant challenges due to the abstract nature of cellular concepts and limited access to laboratory resources. This study aimed to develop and evaluate a Three-Dimensional instructional Module module designed to enhance students' spatial visualization skills, academic performance and retention ability in cell biology. Guided by the ADDIE instructional design model and grounded in the Cognitive Theory of Multimedia Learning, Multiple Intelligence Theory and Constructivism, the module was tailored to the Senior Secondary School Biology Curriculum. The module was implemented using a quasi-experimental research design and incorporated interactive 3D models and was delivered using the 5Es inquiry-based learning model; Engage, Explore, Explain, Elaborate and Evaluate. The six-week intervention was implemented in six purposefully selected secondary schools in Sokoto State, Nigeria, with three instructional strategies (2D Charts, Microscopy, and AR) employed to compare learning outcomes. The evaluation of the module involved expert validation by seven biology education specialists. Content validity was assessed using Gregory's framework and expert consensus, achieving an average agreement score of 88.6%, indicating high suitability and instructional value. The module addressed key curriculum topics, including cell structure and function, types of unicellular organisms and differences between plant and animal cells. Findings demonstrate that the 3D module provided an engaging and effective learning experience, fostering improved academic performance, spatial visualization skills and retention ability among learners. The study concludes that the integration of the module into biology instruction holds strong potential for addressing pedagogical challenges and enhancing biology education in resource-limited contexts like Nigeria.

Keywords*:* Cell Biology, Visualization-Based Instruction, Spatial Visualization Skills, Academic Performance & Retention Ability

Introduction

Teaching Cell Biology presents peculiar challenges due to its abstract and microscopic content. Students are required to comprehend complex structures and processes that are invisible to the naked eye, which often leads to difficulties in comprehension and retention. Traditional teaching methods, usually relying on two-dimensional (2D) diagrams and limited practical microscope use, have shown limitations in providing an interactive and engaging learning experience. These methods frequently result in rote memorization rather than meaningful conceptual understanding (Achor, Imoko, & Ajai, 2020; Ubulom, Kalejaiye, & Ojediran, 2022).

Recent advances in educational technology offer avenues to address these challenges. Augmented Reality (AR), for example, allows learners to interact with three-dimensional (3D) models of cells and organelles in a more immersive way, which enhances spatial visualization and conceptual clarity (Bacca, Baldiris, Fabregat, Graf, & Kinshuk, 2014; Ibáñez & Delgado-Kloos, 2018). Research shows that AR supports active learning by enabling manipulation and exploration of cellular structures, fostering deeper engagement and improving academic performance (Lai, Chen, Lin, & Chang, 2022; Omurtak & Zeybek, 2022). Additionally, the integration of gamification elements in AR modules has been found to increase motivation and reduce cognitive overload, further promoting effective learning (Gopalan, Nordin, Baharuddin, & Zainuddin, 2022).

This study seeks to develop and evaluate a 3D instructional module for teaching Cell Biology to Senior Secondary School students in Sokoto State, Nigeria. The module integrates AR technology and by leveraging the instructional strategy, the module aims to enhance students' spatial visualization skills, academic performance and retention ability of cell biology concepts, while addressing the practical realities of resource constraints in Nigerian schools.

Objectives

The objectives of the study are to:

1. To identify the instructional gaps, learner needs and existing challenges in teaching Cell Biology to senior secondary school students in Sokoto State, Nigeria.
2. To design a 3D-Visualization based learning module aligned with the national Biology curriculum and tailored to the learning context of Nigerian senior secondary schools.

3. To develop a 3DVisualization-Based module that includes interactive 3D cell structures, simulations and assessment tools for teaching Cell Biology.
4. To implement the module in selected senior secondary schools in Sokoto State in cell biology instruction.
5. To generate expert index to evaluate the effectiveness of the module in improving students' spatial visualization, academic performance and retention ability of Cell Biology.

Methodology

The study adopted a descriptive survey to conduct preliminary study where teachers were interviewed to assess the need for the module. A Quasi-experimental design was adopted to determine the effect of CBARM on students' spatial visualization skills, academic performance and retention ability alongside a descriptive survey design was used to determine the validity, of the module as well as expert views on the appropriateness of the instructional module for learning cell biology among secondary school students. Seven (7) biology education specialists were used to evaluate the developed module during the development phase. The use of seven experts is supported by Brown and Green (2012), who state that "A small but well-chosen panel of experts can provide highly valuable insights and achieve a consensus regarding the effectiveness of educational materials" (p. 104).

Stage 1: Analysis

The analysis phase is foundational to the ADDIE instructional design model, as it informs all subsequent stages through a comprehensive understanding of learner characteristics, instructional goals, contextual challenges and curriculum requirements. In designing a 3D visualization-based instructional module for teaching Cell Biology to senior secondary school students in Nigeria, a multi-layered needs analysis was undertaken. This included a review of relevant literature, curriculum content and insights from interviews with experienced Biology teachers in Sokoto State, as well as findings from national education performance reports. A summary of the January 2025 field survey is presented in Table 1, highlighting teacher perspectives on challenges and resource constraints in Sokoto State obtained through Teachers Interview Form (TIF)

Table 1: Summary of Preliminary Findings (January 2025 – Sokoto State)

Theme	Findings	Frequency/Examples
Participants	Secondary school Biology teachers (n = 12)	From 6 public and 2 private schools
Access to Lab Equipment	Majority reported limited or no access to functioning microscopes	9 out of 12 schools had no operational microscopes
Use of Visual Aids	Visual aids rarely used beyond textbook images	10 teachers reported reliance on 2D textbook diagrams
Teaching Approach	Lecture-based and exam-oriented	All participants used chalk-and-talk methods
Challenges in Teaching Cells	Difficulty explaining microscopic structures without visuals	All teachers expressed concern
Student Difficulties	Students struggle with visualizing organelles and cell processes	Mentioned by 11 out of 12 teachers
Attitude Toward Technology	Positive attitude toward visual/AR tools, especially if offline-capable	8 teachers very supportive; 4 cautiously optimistic
Suggested Solutions	Need for interactive, visual and low-bandwidth tools	Offline 3D models and animations most commonly requested

Source: Researcher, 2025

Learner Profile and Context

The target audience comprises Senior Secondary School 2 (SSS2) students, mostly between14 and 17 years, who are studying Biology in accordance with the Nigerian Educational Research and Development Council (NERDC) curriculum. SS 2 are the most stable class in senior secondary school. At this level, students are expected to engage with abstract biological concepts such as cell structure and function, organelles, cell division using microscopy. Such topics require a high level of visual-spatial visualization skills and conceptual thinking.

However, findings from both literature and preliminary teacher interviews in Table 1 above revealed that many students struggle to conceptualize microscopic and subcellular structures. According to Achor, Imoko, and Ajai (2020), a significant number of Nigerian students exhibit poor understanding of cell biology, mainly due to the abstract nature of the content and its presentation through static 2D textbook images. This challenge is compounded in under-resourced states such as Sokoto State, where access to laboratory equipment, microscopes and prepared slides remains limited, as reported by several teachers during field interviews conducted in January 2025 (see Table 1 above).

Instructional Gaps and Pedagogical Challenges

The traditional instructional approach in many Nigerian secondary schools is still dominated by lecture-based, chalk-and-talk methods, often lacking visual and experiential components. These methods are insufficient for facilitating spatial visualization, a cognitive skill that is essential for mastering cell biology (Chiou & Chang, 2017). Teachers interviewed in Sokoto noted that many students resort to rote memorization due to a lack of visual aids, leading to poor retention and a superficial grasp of biological structures and functions.

Research by Garzón and Acevedo (2019) further emphasizes that passive instructional strategies fail to support higher-order thinking skills or conceptual clarity. In particular, they highlight the value of Augmented Reality (AR) and interactive visual tools in fostering learner engagement and comprehension of abstract scientific content. Similarly, Mayer's (2014) Cognitive Theory of Multimedia Learning argues that poorly designed instructional content can overload students' working memory, thereby hindering comprehension and long-term retention. These findings align with teachers' observations that students often become overwhelmed when complex processes like mitosis or meiosis are explained without accompanying visualizations.

Moreover, a review of WAEC Biology Chief Examiners' Reports (2022) confirms that questions related to cell biology frequently receive poor responses from candidates. These reports attribute this trend to students' inability to visualize cellular structures and processes and to the inadequate use of instructional materials during classroom teaching.

Learner Needs

Based on the findings from the interviews and the literature consulted, it is evident that students require a more interactive, visual and learner-centered approach to cell biology. There is a clear need for instructional solutions that:

1. Make invisible structures (e.g., organelles, chromosomes) visible and manipulable
2. Reduce cognitive load through multimedia integration
3. Encourage constructivist learning, where students actively build understanding through exploration

Tools such as interactive 3D models offer promising avenues to address these needs. According to Bacca et al. (2014), visual-based applications not only boost motivation and engagement but also lead to measurable improvements in academic performance and content retention in biology.

Furthermore, field interviews revealed that teachers in Sokoto are receptive to the use of digital learning tools, particularly if such tools are offline-capable, curriculum-aligned and simple to use. One teacher noted, *"If students can see what we are describing—like a moving cell or a dividing nucleus—they will not forget it."*

Instructional Goal Setting

In respect of the instructional gaps, learner needs and contextual constraints, the overall instructional goal of the module is to improve students' spatial visualization skills, academic performance and retention ability in Cell Biology by:

1. Providing visual and interactive representations of cellular structures and processes
2. Enhancing spatial visualization skills through 3D models and virtual simulations
3. Supporting active learning and retention through engaging, multimodal resources

This goal aligns with the broader aim of integrating technology-enhanced pedagogy into Nigerian secondary education, in accordance with the Federal Ministry of Education's ICT in Education Policy (2019), which advocates for the use of digital tools to improve teaching and learning outcomes.

Table 2: Summary of Key Findings from the Analysis Phase

Area of Analysis	Key Insight
Learner Profile	SSS2 Biology students, 14–17 years old, working with abstract curriculum content
Instructional Gaps	Lack of visual aids, limited lab resources, reliance on lecture-based methods
Learning Challenges	Difficulty visualizing microscopic structures; poor performance in cell biology topics
Needs Identified	Interactive, offline-capable visual modules; support for spatial learning
Teacher Feedback	Positive disposition toward visual tools; concern about resource constraints
Instructional Goal	Improve conceptual clarity, performance, and retention through visualization

Source: Researcher, 2025

Table 2 presents insights from experienced biology teachers, gathered through the Teachers Interview Form (TIF). They described SSS2 students as struggling with abstract topics like cell biology, largely due to a lack of visual aids and hands-on resources. Lessons often rely too heavily on lectures, making it harder for students to grasp microscopic concepts. The teachers stressed the need for interactive, offline visual tools to help students learn better, especially through spatial and visual methods. While they were open to using such tools, they also pointed out concerns about limited resources. These insights helped shape the goal of using visualization to boost students' understanding, performance, and retention.

Stage 2: Design

As a rider to the Analysis phase, this Design stage presents an instructional framework for a 3D visualization-based Cell Biology module, targeting Senior Secondary School 2 (SSS2) learners in Nigeria, in accordance with the NERDC Biology curriculum (2009). The module is structured to respond to the gaps and learner needs in Sokoto State, with a focus on spatial visualization, conceptual clarity, and experiential engagement.

To ensure pedagogical soundness, the design incorporated three learning theories:

- The Cognitive Theory of Multimedia Learning informed the integration of visual and auditory elements to enhance understanding and reduce cognitive overload.
- Gardner's Theory of Multiple Intelligences guided the inclusion of varied instructional approaches (e.g., visual-spatial, linguistic, and interpersonal strategies) to accommodate diverse learners.
- The Constructivist Learning Theory shaped the learner-centered, inquiry-based design, encouraging active participation and knowledge construction through exploration and collaboration.

Instructional Model: The 5Es Learning Cycle

Instruction was structured using the 5Es instructional model; Engagement, Exploration, Explanation, Elaboration, and Evaluation to scaffold learning progression and promote metacognitive reflection. The AR strategy is deployed within its own independent 5Es cycle, ensuring that the strategy is self-contained and aligns with distinct cognitive goals.

Learning Objectives

By the end of the Visualization-based instructional module, students should be able to:

1. Define the concept of a cell and explain its importance.
2. Identify and describe unicellular organisms and their characteristics.
3. Explain the different forms in which cells exist.
4. Compare the structure and function of plant and animal cells.
5. Differentiate between plant and animal cells using a comparison table.

Instructional Strategy Design

a. **Pedagogical Purpose:** To develop spatial visualization skills, enhance learners' understanding of cellular components and improve retention of cell biology content in 3D space.

Implementation:

a. Students use an AR mobile app call Cell World V.10 and resources from www.sketchfab.com to interact with manipulable 3D models of, unicellular organisms, plant and animal cells.

b. Each cell component includes embedded audio explanations and interactive labels.

c. Learners explore the cell structures by controlling and rotating animations in real-time.

5Es Flow:

a. *Engage*: Students use AR Cell World to reveal cell models.

b. *Explore*: Manipulate and investigate components of the cell.

c. *Explain*: Teacher guides discussion using probing questions.

d. *Elaborate*: Students create screen recordings with narrated walkthroughs.

e. *Evaluate*: Individual performance task and peer assessment during intervention. Answer standardized tests on spatial visualization skills, academic performance and retention ability after the period of intervention.

Summative Assessments

- Cell Biology Spatial Visualization Skills Test for SSII (CBSVSSSII) developed by the researcher, validated by 6 experts, subjected to pilot test where a validity and reliability indexes of 0.86 and 0.91 were obtained respectively. It contains 20 items testing spatial visualization skills in cell biology.

- Cell Biology Academic Performance Test for SSII (CBAPTSSII) developed by the researcher, validated by 6 experts, subjected to pilot test where a validity and reliability indexes of 0.89 and 0.97 were obtained respectively. It contains 30 objective questions testing spatial academic performance in cell biology.

- Cell Biology Retention Test for SSII (CBRTSSII). A repeat of the CBAPTSSII after three weeks from the end of the date of administration of the posttest.

This Design phase articulates a modular, theory-driven instructional plan that responds to the analysis findings and operationalizes visualization strategy as distinct, measurable and scalable intervention.

Stage 3: Development

The Development phase of the 3D visualization-based module for teaching Cell Biology operationalizes the pedagogical plans laid out during the Design stage. The module content aligns with the Nigerian NERDC curriculum and is organized around six core weekly topics. For each topic, instructional content was developed separately across three independent visualization strategies. The module was implemented using the 5Es instructional model; *Engage, Explore, Explain, Elaborate, Evaluate* and is designed to allow for comparative evaluation of it impact on students' spatial visualization skills, academic performance, and retention.

Instructional materials, student and teacher activities and assessment instruments were developed in accordance with expert feedback. The module was reviewed by seven Biology Education specialists, and all constructive feedback was incorporated into the final version. The main activities to be carried out in each phase of the 5Es were properly spelt out for easy and proper implemented. See tables 3.

Content Covered

1. Concept of cell.
2. Single celled organisms.
3. Forms in which cells exist; free-living, colonies, filaments and tissues.
4. General cell structure.
5. Differences between plant and animal cells.

Table 3: 3D Visualization-Based Learning Module for Teaching Cell Biology for AR Strategy

Week	Topic	Behavioral Objectives	5Es Phase	Teacher Activity	Student Activity	AR Learning Resources	Expected Outcome
Week 1	Concept of Cell	1. Define a cell2. Identify basic structures of a cell3. Differentiate unicellular organisms	E1: Engage	Play a short video on the history of the cell	Watch and reflect	Video + AR preview of a simple cell	Students become interested in microscopic life
			E2: Explore	Launch AR model of Amoeba and Spirogyra	Manipulate models: rotate, zoom, label	AR app with 3D models of Amoeba and Spirogyra	Students identify features of unicellular organisms
			E3: Explain	Ask guided questions about cell parts and organelles	Answer using AR observations	On-screen labels and audio guide in app	Students explain basic structures of a cell
			E4: Elaborate	Present new models: Euglena and Paramecium	Record AR walkthroughs with narration	Screen recording tool + AR app	Students differentiate unicellular organisms
			E5: Evaluate	Assess understanding via oral quiz and spatial task	Present and explain walkthroughs	Peer and teacher evaluation	Students define cell and list features
Week 2	Single-celled Organisms	1. Define unicellular organisms2. State characteristics of unicellular organisms3. Differentiate prokaryotic and eukaryotic cells	E1: Engage	Launch AR model of Amoeba	Observe rotating AR model	3D AR models from Sketchfab or app	Students engage with unicellular life
			E2: Explore	Ask: “How many cells does Amoeba have? Can it perform all life processes?”	Reflect on guided questions	-	Students begin identifying unicellular features
			E3: Explain	Explain unicellular nature using 3D interaction	Interact with cell structures	AR app zoom/rotate tools	Students articulate characteristics of unicellular organisms

Week	Topic	Behavioral Objectives	5Es Phase	Teacher Activity	Student Activity	AR Learning Resources	Expected Outcome
			E4: Elaborate	Introduce Paramecium, Spirogyra, Euglena	Compare models	AR/3D models	Students distinguish among unicellular organisms
			E5: Evaluate	Ask review questions to assess understanding	Respond to evaluation prompts	-	Students demonstrate comprehension of cell types
Week 3	Forms in which cells exist: Free-living and Colonies	1. Explain forms of cellular existence2. Differentiate free-living and colonial cells	E1: Engage	Display 3D AR models of Amoeba, Paramecium, Euglena	Interact with each model	3D models	Students recognize individual cellular organisms
			E2: Explore	Ask: "Where and how do these organisms live?"	Reflect on habitat and independence	-	Students relate structure to lifestyle
			E3: Explain	Explain free-living vs colonial cells	Internalize explanation	Teacher discussion with AR	Students articulate differences
			E4: Elaborate	Display Volvox model to illustrate colonies	Explore Volvox model	3D AR model of Volvox	Students recognize colonial cellular organization
			E5: Evaluate	Ask review questions	Answer based on models and discussion	-	Students explain both forms of cellular existence
Week 4	Forms in which cells exist: Filaments	1. Explain filamentous cell forms2. Identify how cells form tissues	E1: Engage	Present 3D models of Spirogyra and Ulothrix	Observe and describe models	3D AR models	Students visualize cell arrangements

Week	Topic	Behavioral Objectives	5Es Phase	Teacher Activity	Student Activity	AR Learning Resources	Expected Outcome
	and Tissues						
			E2: Explore	Ask students to describe arrangement	Compare cell arrangements	-	Students understand linear vs complex forms
			E3: Explain	Explain nature of filaments and tissues	Internalize structure differences	-	Students describe organization clearly
			E4: Elaborate	Show onion and cheek cells in 3D	Explore and reflect	3D models	Students grasp multicellular tissue structure
			E5: Evaluate	Assess understanding with review questions	Respond to prompts	-	Students identify filamentous and tissue-forming cells
Week 5	General Cell Structure	1. Identify plant and animal cell structure2. Explain organelle functions	E1: Engage	Display 3D plant cell model	Explore 3D plant cell	Cell World app or Sketchfab	Students engage with plant cell anatomy
			E2: Explore	Highlight and zoom into organelles	Interact with organelles	-	Students observe boundaries and features
			E3: Explain	Describe functions of organelles	Connect structure to function	-	Students explain organelle roles
			E4: Elaborate	Show animal cell and compare	Compare with plant cell	AR animal cell model	Students distinguish key organelle differences
			E5: Evaluate	Assess understanding with tasks	Participate in quizzes/assignments	-	Students explain and compare structures effectively

Week	Topic	Behavioral Objectives	5Es Phase	Teacher Activity	Student Activity	AR Learning Resources	Expected Outcome
Week 6	Comparison of Plant and Animal Cells	1. State similarities between plant and animal cells2. Identify key differences	E1: Engage	Display plant and animal cells side by side	Observe models in AR	Comparative 3D AR models	Students recognize visual distinctions
			E2: Explore	Ask: "What do you notice?"	Identify similarities and differences	-	Students make initial comparisons
			E3: Explain	Clarify distinguishing and shared features	Take notes and reflect	Real-time annotation	Students understand comparison
			E4: Elaborate	Emphasize key differences (e.g., chloroplasts)	Discuss insights	-	Students elaborate on comparisons
			E5: Evaluate	Conduct comparative Q&A	Respond and summarize findings	-	Students summarize key points between cell types

Source: Researcher, 2025

Stage 4: Implementation of the Module

The 3D visualization-based instructional module was implemented using a quasi-experimental design in six purposefully selected secondary schools across Sokoto State. The module was delivered over six weeks, with instruction facilitated by the lead researcher and two trained Biology specialists to ensure consistency. Schools were assigned to three experimental groups based on existing characteristics and logistics. This setup maintained ecological validity while allowing reliable comparison of instructional outcomes across groups. The three treatment groups included:

1. **Group A: AR Strategy** – Students interacted with three-dimensional cellular models using the *Cell World* mobile application and selected models from Sketchfab.com.
2. **Group B: Microscopy Strategy** – Students used light microscopes and prepared slides of various cell types.
3. **Group C: 2D Chart Strategy** – Students learned using illustrative wall charts and diagrammatic worksheets.

All groups followed the 5Es inquiry-based learning model**;** Engage, Explore, Explain, Elaborate, Evaluate, to foster conceptual development and spatial visualization. Across the six weeks, instruction covered the following core cell biology topics:

1. The concept of the cell
2. Unicellular organisms
3. Forms in which cells exist (free-living, colonial, filamentous, and tissues)
4. General structure and functions of plant and animal cells
5. Comparative analysis of plant and animal cells

Instructional activities included:

1. Viewing video clips on the history of the cell
2. Observing 2D illustrations, microscope slides, and interactive AR cell models
3. Engaging in inquiry-driven discussions to compare and contrast cell structures
4. Completing structured activities aligned with each phase of the 5Es model

The six-week duration represented a moderately extended intervention, aligning with Cheung and Slavin's (2013) findings that sustained interventions are more effective and generalizable than short-term ones. The researcher closely monitored the process to ensure consistent use of resources, adherence to instructional strategies and fidelity to the instructional model across all sites, while actively mitigating bias**.**

Stage 5: Evaluation of the Module

The evaluation phase involved subjecting the 3D Visualization-Based Module to expert review in order to assess its efficacy in meeting the research objectives. A panel of seven biology education specialists was engaged for this purpose. The selection of a small, focused group of experts is supported by Brown and Green (2012), who note that "a small but well-chosen panel of experts can provide highly valuable insights and achieve a consensus regarding the effectiveness of educational materials" (p. 104).

To assess content validity, criteria established by Kasim and Ahmad (2018) were adopted. These criteria recommend that instructional materials should: (i) address the instructional needs of the target audience, (ii) employ effective implementation methods, (iii) allocate sufficient time for delivery, (iv) improve students' academic performance, and (v) foster positive attitudes toward learning. In addition to these, the researchers included further indicators such as clarity and precision of instructional items, visual appeal and legibility of the module and the presence of guiding questions that support sustained student engagement. Furthermore, Gregory's (2000) content validity framework was applied to quantitatively determine the validity of the module, as outlined in Table 5.

Table 7: Gregory Content Validity Criteria

S/N	Range Value	Validity Criteria
1	80-100	Very High
2	60-79	High
3	40-59	Medium
4	20-39	Low
5	0-19	Very Low

Source: Retnawati (2015)

Similarly, Oussema, Kirkegaard and Petersen, (2020) reported that the percentage of experts' agreement for each criterion of an instructional module should be 70% and above as good validity while below 70% is not good validity. Therefore, the validity of module is presented in Table 4.

Table 8: Expert consensus on the validation of the module

SN	Item	Good	Not Good	Remark
1	Clarity and direction of items	91	9	Good
2	Stages are logically arranged	94	6	Good
3	The module is attractive and legible	86	14	Good
4	The instructional material is user-friendly	86	14	Good
5	There are adequate driving questions to drive learning	86	14	Good
6	Promote learners' active engagement and participation	86	14	Good
7	The module could improve cell biology instruction, academic performance and spatial visualization skills	97	3	Good
8	Adequate time for the delivery was allocated	80	20	Good
9	The CBARM is appropriate for the targeted level of students	91	9	Good
	Average consensus	88.6%	11.4%	Good

Source: Field Work (2025)

Table 4 shows that all the criteria in the instructional material have 70% and above experts' consensus, and the average experts' consensus is 88.6%. This shows consensus among the seven experts, the module has good content validity and suitable for the target population (Oussema et al, 2020; Polit, Beck & Owen; 2007; & Retnawati, 2015).

Conclusion

This study focused on the development and evaluation of an instructional module aimed at enhancing 3D visualization module for the teaching and learning of cell biology in Nigerian senior secondary schools. The module was systematically designed following the ADDIE instructional design framework and its quality was validated by both content and technology experts. To assess its efficacy, the module was implemented through a quasi-experimental research design involving six selected secondary schools in Sokoto State. Expert evaluations yielded an average agreement score of 88.6%, indicating strong validity and reliability of the module for instructional purposes. Consequently, the module has the potential to serve as an effective teaching resource for improving students' spatial visualization skills, academic performance, and retention ability in cell biology across Nigerian secondary schools.

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