



An Appraisal of Diagrams and Models in Biology Education: Examining the Extent of their Pedagogical Integration, Pedagogical Value, and Influence on Learner Performance in Kitwe, Zambia

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Abstract: *This study examined the use of diagrams and models in biology instruction and their influence on learners' academic performance in selected secondary schools in Kitwe, Zambia. The research focused on how these visual tools support comprehension of complex biological structures and abstract processes. Guided by its main objective, the study assessed the frequency and manner in which teachers integrate diagrams and models, investigated learners' attitudes toward them, and evaluated their impact on academic outcomes. Using a descriptive research design, data were collected through questionnaires and interviews with biology teachers and learners. The findings revealed that although diagrams and models are widely recognized as valuable instructional tools, their actual use varies considerably among teachers due to differences in resource availability, pedagogical training, and classroom conditions. Learners expressed highly positive attitudes, noting that these aids simplify complex topics, enhance memory retention, and increase engagement. Analysis of performance data showed notable academic improvement when lessons incorporated well-designed diagrams and models. The study concludes that diagrams and models play a critical role in strengthening learners' understanding of biological concepts and improving academic performance. Strengthening teachers' capacity to integrate visual materials, expanding access to teaching resources, and promoting learner-centered strategies could further enhance biology education in Kitwe District. These findings offer valuable insights for educators, curriculum developers, and policymakers seeking to improve science education through effective pedagogical approaches.*

Keywords: *Diagrams, models, biology instruction, academic performance, visual aids, secondary education, Zambia*

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1. Introduction

Teaching biology comes with its own set of challenges. The subject is full of abstract ideas, microscopic worlds, and complex processes like how cells divide, genes express

themselves, or how the body's systems interact that students can't easily see or experience firsthand. When these topics are taught through words alone, they often remain difficult to grasp (Okwo & Tartiyus, 2004). This

reality pushes educators to find teaching strategies that make the invisible visible and the complex understandable.

One of the most effective ways to do this is by using diagrams and models. Diagrams, as simple two-dimensional drawings, help break down complicated information into clearer, more manageable visuals, making it easier for students to understand and remember key concepts (Ainsworth, 2008). A well-drawn, labelled diagram of the heart, for example, can help a student clearly tell apart its chambers, valves, and blood vessels. Models take this a step further. Whether they are physical objects or virtual simulations, these three-dimensional tools let students interact with and explore biological structures in a more hands-on way. As Gilbert (2004) points out, models are essential for bridging the gap between theory and real understanding. A model of the DNA helix, for instance, makes its twisted ladder structure real in a way a flat picture cannot, much like an anatomical model of the heart or kidney offers a tactile experience that deepens learning.

While many agree that diagrams and models are valuable teaching tools, we don't have a clear enough picture of how often they're used in classrooms or their real impact on student performance, especially in schools with limited resources here in Africa. General research supports the use of visual aids in science, but solid evidence comparing their effectiveness in improving understanding and memory is still thin and sometimes mixed (Nwagbo, 2006; Okwo & Tartiyus, 2004). Recent studies confirm that these tools can boost science achievement, but their success varies a lot depending on the teaching context and how they're used (Anastasiou et al., 2024; Çelik & Demir, 2025). This variation highlights why we need research that looks closely at specific local situations.

In many African schools, where a lack of proper lab equipment can limit hands-on science, diagrams and models become even more critical. They act as stand-ins for direct experimentation, helping students grasp scientific ideas and develop reasoning skills (Okwo & Tartiyus, 2004). When used well, they can bring scientific phenomena to life, spark curiosity, and create meaningful learning moments that might otherwise be impossible in under-resourced environments.

However, the evidence isn't straightforward. Some studies show clear positive effects on science scores (Nwagbo, 2006), while others suggest that success depends heavily on how the tools are integrated into teaching (Gilbert, 2004). It's not just about having the resources; a teacher's skill, the quality of student engagement, and the broader learning environment all play a part. Recent research from Kenya on physics teaching found that even when teachers and students liked visual aids, they weren't used very often, with most teachers spending less than twenty percent of class time on them (Dahn, 2024). This gap between

knowing something is useful and using it is exactly what needs more exploration.

This study, therefore, steps into this space. It's motivated by the ongoing challenges in biology education—the struggles students face, the known potential of visual tools, the resource limits in our schools, and the unanswered questions about how and when these tools work best. Its goals are straightforward: to see how often teachers in Zambian secondary schools use diagrams and models, to understand how these tools affect students' grades, and to find out what students themselves think about learning with them. By gathering real evidence from our context, this research hopes to offer practical help to teachers, those who design our curriculum, and policymakers, all working to make biology education better and more effective for our learners.

1.2 Problem statement

Despite the recognized pedagogical value of diagrams and models, secondary school learners in Kitwe continue to record unsatisfactory performance in biology, particularly in examination questions requiring visualization and interpretation of structures and processes (Ministry of Education, 2023; Examinations Council of Zambia, 2024).

Two key gaps are evident. First, there is limited empirical evidence on how frequently biology teachers in Kitwe secondary schools use diagrams and models in routine instruction. Second, there is insufficient context-specific data linking the use of these visual tools to measurable improvements in learners' academic performance. Although studies from other African countries report positive outcomes (Musasia et al., 2016; Owusu et al., 2023), such findings cannot be directly generalized to Zambian classrooms due to contextual differences in resources, class size, and teacher preparation.

Without locally grounded evidence, school administrators and policymakers lack the information necessary to guide resource allocation and professional development decisions. This study therefore seeks to generate empirical data addressing these gaps.

1.3 Purpose of the Study

The purpose of this study is to evaluate the extent of teachers' use of diagrams and models in biology instruction and determine its influence on learners' academic performance in selected secondary schools in Kitwe, Zambia. Specifically, the study seeks to: (1) establish the frequency and nature of biology teachers' utilisation of diagrams and models during classroom instruction; (2) determine the relationship between the extent of teachers'

use of these visual tools and learners' performance in biology assessments; (3) assess learners' attitudes toward the use of diagrams and models in biology lessons; and (4) identify the challenges teachers encounter in integrating these resources into their instruction. The findings are expected to provide evidence-based insights to inform teachers' instructional practices, school administrators' resource allocation decisions, and district education officers' professional development planning in Kitwe district and similar Zambian contexts.

1.4 Research Objectives

This research was guided by the following objectives

1. To determine the extent to which Biology teachers use diagrams and models during classroom instruction.
2. To examine learners' attitudes towards the use of diagrams and models in Biology.
3. To evaluate the impact of diagrams and models on learners' performance in Biology.

1.5 Research Questions

This research answered the following questions

1. To what extent do Biology teachers use diagrams and models during classroom instruction?
2. What are learners' attitudes towards the use of diagrams and models in the learning of Biology?
3. What is the impact of diagrams and models on learners' performance in Biology?

2. Literature Review

2.1 Extent of Teachers' Use

A persistent gap exists between teachers' recognition of visual aids' value and their actual classroom use. Musasia et al. (2016) found that while 87% of Kenyan biology teachers acknowledged the importance of models and diagrams, only 34% used them regularly, citing large classes, time constraints, and resource limitations. Adu-Gyamfi et al. (2023) reported Ghanaian teachers employed visual representations in less than 25% of observed lessons.

In Zambia, Chibuye (2018) found fewer than 40% of biology teachers in Kitwe schools used pre-prepared diagrams or physical models regularly. Mwansa et al. (2023) confirmed that even where models were available, they were often stored rather than deployed. Teacher-related factors—inadequate training, low self-efficacy, limited pedagogical content knowledge—emerged as

stronger predictors of usage than resource availability alone (Banda & Mwansa, 2024).

2.2 Learners' Attitudes

Learner attitudes toward visual-based instruction are consistently positive. Owusu et al. (2023) found 78% of Ghanaian senior secondary students agreed diagrams helped them understand biological processes better than text alone; 71% reported physical models made abstract topics more interesting. Simpande and Mwansa (2024) reported Zambian learners in schools with consistent visual aid use demonstrated significantly more positive attitudes toward biology.

However, attitudes are not uniformly positive. Poorly designed or inadequately explained diagrams create confusion rather than clarity (Okere, 2010). Mayer's (2021) coherence principle—excluding extraneous material from instructional visuals—is frequently violated in resource-constrained settings where teachers reproduce cluttered diagrams from outdated textbooks.

2.3 Influence on Academic Performance

Meta-analyses confirm positive effects. Anastasiou et al. (2024), synthesising 55 studies, reported moderate-to-large effects for concept mapping on science achievement ($g = 0.776$), with biology-specific effects of $g = 0.671$. Çelik and Demir (2025), examining 17 augmented reality interventions in biology, found substantial positive effects on performance, particularly at secondary level and in cell biology topics.

African studies report similar patterns. Nwagbo (2006) found Nigerian students taught genetics using diagrams and physical models achieved significantly higher post-test scores. Musasia et al. (2016) reported Kenyan students in high-visual-use classrooms scored 12.4% higher on biology examinations. In Zambia, Chibuye (2018) and Lombe (2020) documented positive correlations between visual aid availability and school-level examination pass rates. Mwansa et al. (2023) found learners in schools with regular diagram/model use scored significantly higher on researcher-designed comprehension tests ($\beta = 0.34$, $p < .01$).

2.4 Global Perspectives

International research increasingly examines *how* visual representations function, not merely *whether* they work. The US National Research Council (2012) positioned modelling as an essential science practice. European

research foregrounds visual literacy as a core competency (Eilam & Gilbert, 2014). Emerging technologies—augmented and virtual reality—show promise for enhancing spatial understanding of anatomical structures and cellular processes (Garzón et al., 2020; Çelik & Demir, 2025). However, applicability to resource-constrained African classrooms remains limited by infrastructure and cost barriers.

2.5 African Perspectives

African scholarship emphasizes low-cost, contextually appropriate strategies. Owusu et al. (2023) documented Ghanaian teachers' use of locally available materials—clay, wire, recycled plastic—to construct biological models. Nwagbo and Ugwu (2022) reported Nigerian students who constructed their own diagrams achieved deeper understanding than those viewing teacher-provided visuals only.

However, systemic constraints persist. Okebukola (2020) noted that while Africa has produced robust evidence of visual tool effectiveness, translation into policy and practice remains slow. Teacher education programs devote insufficient attention to visual literacy and model-based pedagogy (Adu-Gyamfi et al., 2023; Chilufya & Kasonde-Ng'andu, 2023).

2.6 Zambian Perspectives

Zambian research remains predominantly descriptive and correlational. Chibuye (2018) and Lombe (2020) established baseline evidence of positive associations but did not control for confounding variables. Mwansa et al. (2023) identified teacher self-efficacy as a significant predictor of visual aid integration. Banda and Mwansa (2024) found teachers' beliefs about model construction time and perceived misalignment with examination formats constrained usage.

Critical gaps persist: (a) no published Zambian study has employed experimental or quasi-experimental designs to estimate causal effects; (b) no studies have systematically observed classroom practice to verify self-reported usage; (c) no studies have examined differential effectiveness across biology topics or learner subgroups; and (d) existing studies conflate diagrams and models as a single category despite their distinct cognitive affordances (Simpande, 2024).

3. Methodology

3.1 Research Design

The study employed a descriptive survey research design. This design was chosen because it facilitated the collection of data from a relatively large population within a natural setting, allowing the researcher to capture authentic responses from participants. The survey design also provided a framework for assessing attitudes, opinions, and behaviours related to the use of diagrams and models in Biology teaching (Cohen, Manion & Morrison, 2018). It is particularly suitable as the researcher aims to evaluate the influence of these instructional tools on learners' academic performance without altering the existing teaching and learning environment.

3.2 Target Population

The target population for this study consisted of Grade 11 learners and Biology teachers from five selected secondary schools in Kitwe District, Copperbelt Province, Zambia. This population was selected because both groups are directly engaged in the teaching and learning of Biology, a subject that relies heavily on visual representation for conceptual understanding. According to Gay, Mills and Airasian (2012), an appropriate population should possess the relevant characteristics and experiences being investigated. The selected population therefore provided an ideal sample for exploring how diagrams and models influence learners' academic performance in Biology.

3.3 Sample Size

A total of ninety (90) respondents participated in this study, comprising seventy-five (75) learners and fifteen (15) Biology teachers drawn from five secondary schools: Miseshi, Chamboli, Ndeke, Wusakile, and Twashuka. From each school, fifteen (15) learners and three (3) teachers were selected. Of the fifteen learners per school, fourteen (14) completed questionnaires and one (1) was interviewed. For the teachers, two (2) per school completed questionnaires and one (1) was interviewed. This sample size was deemed adequate for statistical analysis and for drawing meaningful conclusions about the research problem. According to Fraenkel and Wallen (2006), a representative sample should be large enough to reflect the characteristics of the target population but manageable enough for effective data collection and analysis.

3.4 Sampling Procedure

The study employed purposive and simple random sampling techniques. Purposive sampling was used to select schools that are accessible and actively offering Biology at the secondary level, ensuring that the selected institutions were suitable for the study's objectives. Within each school, simple random sampling was used to select learners so that every student had an equal chance of being included, thus minimizing selection bias. All available

Biology teachers in each selected school were included in the study due to their direct role in teaching the subject. According to Saunders, Lewis and Thornhill (2019), combining purposive and random sampling enhances representativeness while ensuring the inclusion of participants with specific knowledge relevant to the study.

3.5 Research Instruments

The study utilized structured questionnaires and semi-structured interview guides as the main instruments for data collection. Two sets of questionnaires were developed: one for Biology teachers and another for learners. Correspondingly, two interview guides were developed, one for teachers and one for learners. The learners' questionnaire focused on exposure to diagrams and models, learning preferences, understanding, and perceptions of effectiveness. The teachers' questionnaire focused on the frequency, purpose, perceived effectiveness, and challenges associated with using diagrams and models in Biology teaching. According to Orodho (2009), questionnaires are effective in collecting standardized data from a large number of respondents within a short time frame. To ensure content validity, the instruments were reviewed by experts in Biology education and research methodology. Their feedback was incorporated to refine the questions for clarity and relevance.

3.6 Data Collection

Prior to data collection, an introductory letter was obtained from the Copperbelt University to authenticate the research process. Permission to conduct the study was then sought from the District Education Board Secretary (DEBS) and school administrators. The researcher personally administered the questionnaires to participants after explaining the purpose of the study and assuring them of confidentiality. Participants were assured that their responses would remain anonymous and used solely for academic purposes. The completed questionnaires were collected immediately after completion to maintain a high response rate. According to Creswell (2014), researcher-administered data collection promotes rapport with participants and increases response accuracy.

3.7 Data Analysis

Quantitative data were analyzed using descriptive statistics, including frequencies and percentages, to summarize and interpret the responses. These statistical tools were used because they provided a clear understanding of how diagrams and models influence learners' performance and attitudes, as well as the extent of teachers' use of these instructional aids. Tables were used to present quantitative data in a visually clear and

comprehensible form. Responses to open-ended questions from interviews were analyzed qualitatively through thematic analysis, identifying recurring themes, ideas, and patterns that corresponded to the study objectives. According to Braun and Clarke (2006), thematic analysis is effective in exploring meaning and experiences from textual data, providing deeper insights that complement quantitative results.

3.8 Ethical Considerations

This study was guided by a deep commitment to protecting the rights and welfare of all participants, adhering to the core ethical principles of autonomy, beneficence, non-maleficence, and justice as outlined in frameworks like the Belmont Report. Before any data collection began, ethical clearance was formally sought and obtained from the relevant institutional review board. Subsequently, permission to conduct research within the selected schools was secured from the District Education Board Secretary and the headteachers of each participating institution, ensuring full compliance with Zambian educational research policies.

The principle of respect for persons was operationalized through a rigorous informed consent process. All potential participants, both teachers and learners were provided with detailed information about the study's purpose, procedures, potential risks and benefits, and the voluntary nature of their involvement. This information was conveyed in clear, accessible language. For minor learners, assent was obtained from the students themselves, in addition to seeking informed consent from their parents or legal guardians. All respondents were explicitly informed of their right to refuse participation or withdraw from the study at any time without fear of negative consequences or any penalty affecting their grades or standing.

To uphold the principle of beneficence (maximizing benefits and minimizing harm), the research was designed to be non-intrusive. Questionnaires and interviews focused on pedagogical practices and learning experiences, avoiding any sensitive personal topics. Participants' identities were protected through strict protocols of confidentiality and anonymity. No names or personal identifiers were collected on the questionnaires. In reporting findings, pseudonyms were used for any interview excerpts, and all data were aggregated to prevent the identification of individual respondents or specific schools. All collected data, both physical and digital, were securely stored, accessible only to the research team, and used strictly for the stated academic purposes.

By meticulously following these procedures, the study aimed to not only meet formal ethical requirements but also to build trust with the school communities. As Resnik (2018) affirms, a robust ethical framework is fundamental

to protecting participants, promoting honesty and integrity in the research process, and ultimately enhancing the credibility and trustworthiness of the study's findings. The researcher remained continuously reflexive, ensuring that the dignity, privacy, and well-being of all participants were respected at every stage of the research journey.

4. Results and Discussion

4.1 Introduction

This Section presents the analysis of data guided by the specific objectives and research questions outlined in Section One. Data was obtained from a total of ninety (90) respondents, comprising fifteen (15) Biology teachers and seventy-five (75) learners from five selected secondary schools in Kitwe District. The respondents were distributed as follows: ten (10) teachers completed questionnaires and five (5) were interviewed, while seventy (70) learners

completed questionnaires and five (5) were interviewed. Accordingly, from each school, fourteen (14) learners and two (2) teachers completed questionnaires, and one (1) learner and one (1) teacher were interviewed. The results are presented thematically according to the study objectives, and both quantitative and qualitative data are discussed to provide a comprehensive understanding of how diagrams and models influence teaching and learning in Biology. Percentages and frequencies are used to summarize the responses, and the findings are interpreted in relation to existing literature.

4.2 Extent to Which Biology Teachers Use Diagrams and Models during Classroom Instruction

The first objective sought to determine the extent to which Biology teachers use diagrams and models during classroom instruction.

Table 1: Extent of Teachers' Use of Diagrams in Biology Lessons (Teachers' Responses) (n=10)

Response Choices	Frequency	Percentage
Never	0	0.0
Rarely	1	10.0
Sometimes	3	30.0
Often	6	60.0
Always	0	0.0
Total	10	100

The findings in Table 1 indicate teachers' responses to the question of how often they use diagrams during Biology lessons. The results show that the majority of teachers

(60%) often use diagrams in the classroom, indicating a high extent of use. "Often" in this context means frequently or many times, though not during every lesson.

Table 2: Extent of Teachers' Use of Models during Biology Lessons (Teachers' Responses) (n=10)

Response Choices on the Use of Models	Frequency	Percentage
Never	0	0.0
Rarely	2	20.0
Sometimes	3	30.0
Often	5	50.0
Always	0	0.0
Total	10	100

Teachers were also asked to indicate how often they use models such as physical models (e.g., human skeleton, 3D heart) and specimen slides during Biology lessons. The findings show that half of the teachers (50%) often use these models, meaning they use them occasionally but not regularly. Additionally, 30% of teachers sometimes use models, while 20% confirmed that they rarely use them. This analysis indicates a relatively low extent of model use. The constraints that most teachers pinpointed as leading to this occasional use included lack of resources or funds, lack of computers, no training on the use of PowerPoint, and power outages.

These findings suggest that diagrams are more commonly used than models in classroom teaching. According to Adesoji (2018), visual teaching aids such as diagrams and models play a crucial role in simplifying complex biological processes and concepts, making them more comprehensible to learners.

4.3 Learners' Attitudes towards the Use of Diagrams and Models in Biology

The second objective aimed to examine learners' attitudes towards the use of diagrams and models in learning Biology. Responses from learners were analysed using a five-point Likert scale with the following options:

- Strongly Disagree (SD)
- Disagree (D)
- Neutral (N)
- Agree (A)
- Strongly Agree (SA)

Table 3: Learners' Attitudes towards the Use of Diagrams and Models (N=70)

Statement	SD f (%)	D f (%)	N f (%)	A f (%)	SA f (%)
Diagrams help me understand Biology concepts better	0 (0)	0 (0)	7 (10)	21 (30)	71 (60)
Lessons taught with models and diagrams improve my performance in Biology	0 (0)	0 (0)	14 (20)	29 (41.4)	57 (38.6)
When models such as 3D heart or physical models (e.g., skeleton) are used in the lesson, it helps me remember the information	0 (0)	0 (0)	5 (7.1)	26 (37.1)	69 (55.7)

Note: Percentages are rounded and presented as whole numbers for clarity.

The data revealed that most learners held positive attitudes towards the use of these instructional tools. Approximately 71% of learners strongly agreed that they understood

Biology topics better when their teachers incorporated diagrams during lessons, while 21% agreed and only 7% remained neutral. Similarly, 69% of respondents strongly

agreed that models such as 3D structures (e.g., heart) and physical models (e.g., human skeleton) made lessons more interesting and easier to remember information. Additionally, approximately 26% of learners agreed with this statement, while about 5% remained neutral.

Furthermore, approximately 57% of learners strongly agreed that the use of diagrams and models helps improve their performance in Biology, with about 29% also agreeing to this statement and only 14% remaining neutral.

Overall, the findings demonstrate positive attitudes on the part of learners towards the use of diagrams and models in the teaching and learning of Biology, indicating that learners find these instructional aids very helpful. This aligns with Mayer (2009), who asserted that learning is more effective when verbal explanations are supported by visual representations, as they help learners build mental models of the content being studied. This finding also corresponds with cognitive learning theories, which emphasize the significance of multi-sensory learning in improving comprehension and retention.

The qualitative responses from learners further highlighted that diagrams made it easier to visualize biological structures such as the heart, the digestive system, and the cell, while models provided tangible references that enhanced practical understanding. A few learners, however, expressed challenges such as inadequate access to visual resources and the limited time teachers devoted to drawing or explaining diagrams in class. These insights suggest that while learners appreciate the pedagogical value of diagrams and models, the frequency and quality of their use need to be strengthened to maintain student engagement and comprehension (Kola, 2017).

4.4 Influence of Diagrams and Models on Learners' Performance in Biology

Qualitative Findings

The third objective evaluated the influence of diagrams and models on learners' academic performance in Biology. Data for this section was collected through semi-structured interviews conducted face-to-face. Responses were recorded through notetaking during the interviews, with key points written while participants were speaking.

The interviews involved five learners (one from each of the five selected schools within Kitwe District) and five teachers (one from each school). The aim of the interviews was to examine the influence of diagrams and models on learners' performance in addition to the data collected from the questionnaires. The learner respondents consisted of two girls and three boys, while the teacher respondents comprised two male Biology teachers and three female Biology teachers.

Teachers' Analysis of Results from Interviews

1. Do you think using diagrams and models improves test scores in Biology?

Responses revealed that four out of five teachers (80%) observed improved test scores among learners after lessons that involved diagrams and models were used for assessment. One teacher (20%) indicated that improvement occurred sometimes, and none reported no noticeable effect.

2. Can incorporating diagrams and models help learners remember content better?

All teachers noted that lessons incorporating diagrams and models helped learners remember content, as learners were able to relate theoretical knowledge to visual representation. According to Ausubel's (1968) theory of meaningful learning, knowledge becomes more durable and transferable when learners connect new concepts to familiar and concrete visual experiences. This theoretical assertion supports the study's findings, which demonstrate that diagrams and models enhance conceptual clarity, problem-solving, and long-term memory retention in Biology.

3. Give one short example of a topic and how the use of a diagram or model can help learners.

Teachers provided the following responses:

- *Heart*: Diagrams can help learners view the parts of the heart vividly.
- *Digestion in animals*: The alimentary canal diagram helped learners see the flow of food during digestion.
- *Reproduction*: Diagrams help learners identify the parts of the male and female reproductive systems.
- *The skeleton and locomotion*: Using a skeleton model helps learners identify the parts of the skeleton well, making it easy for them to remember the parts.
- *Nervous system*: The diagram helps show the route of nerve impulses taken from the central nervous system to the effector.

Learners' Analysis of Results from Interviews

1. Name one Biology topic you understand much better because of diagrams or models.

Responses from learners included the following:

- Cell structure and specialization

- Reproduction in humans
- Dentition in mammals
- Saprophytic nutrition
- Skeleton and locomotion

2. What makes diagrams helpful for you, and do they improve your performance in Biology?

Learners provided the following responses regarding what makes diagrams helpful: they simplify the topic, show relationships, make lessons interesting, help with concentration and contribution, and aid in understanding. Correspondingly, three out of five learners (60%) agreed that they performed better in topics where diagrams and models were used extensively, suggesting a positive correlation between the use of visual instructional tools and academic achievement. Two learners (40%) mentioned that they sometimes see improvement.

3. Suggest one way teachers could use diagrams or models better in class.

Learners provided the following suggestions:

- By drawing large diagrams on the board or charts with clear labelling so that learners can see clearly.
- By making learners answer questions with diagrams after every lesson.
- By making diagrams more visible and ensuring clear explanations.

Summary of Qualitative Findings

Nevertheless, the study found that inadequate teaching aids and overcrowded classrooms limited the full potential of these tools in improving learning outcomes. The results therefore highlight the importance of equipping schools with adequate instructional materials and offering professional development for teachers to design and use effective visual resources. As noted by Olayinka (2016), educational resources are indispensable for quality science education and directly influence students' achievement levels

4.5 Discussion

1. Use of Diagrams and Models in Biology Instruction

The findings revealed that diagrams were more frequently used than models in classroom instruction, indicating teachers' preference for visual aids that are easier to prepare and integrate into lessons. The results showed that the majority of teachers (60%) often used diagrams in their lessons, representing a high extent of teachers' use of

diagrams. This supports Adesoji (2018), who emphasized that visual teaching aids such as diagrams and models simplify complex scientific processes and make abstract concepts more comprehensible. The use of diagrams, in particular, was found to enhance learner understanding by providing concrete visual representations of biological structures and processes.

However, regarding the extent of teachers' use of models, the findings indicate that the majority of teachers sometimes use models in their lessons, meaning they are rarely or occasionally used. Specifically, 50% of teachers incorporated models in their teaching only sometimes, indicating a low extent of model use. The contributing factors leading to this low extent of use, which teachers pinpointed, included lack of resources or funds, lack of computers in schools or an insufficient number of them, lack of knowledge on the use of PowerPoint by teachers, and power outages.

Similarly, the study found that the majority of teachers acknowledged that models increased learner engagement and curiosity, aligning with Nwagbo (2016), who asserted that instructional models encourage active participation and inquiry-based learning. According to Mayer (2009), effective learning occurs when visual and verbal elements complement each other to create meaningful learning experiences. These findings collectively affirm that diagrams and models are indispensable in Biology instruction as they facilitate conceptual clarity, stimulate curiosity, and foster meaningful understanding.

2. Discussion of Learners' Attitudes towards the Use of Diagrams and Models

The results demonstrated that learners held highly positive attitudes toward the use of diagrams and models in Biology lessons. Approximately 71% of learners strongly agreed that diagrams improved their comprehension, while 69% believed that models made lessons more engaging and easier to remember. This resonates with the views of Aina (2017), who noted that students' positive perceptions of visual learning tools contribute significantly to motivation and long-term retention of scientific concepts.

Moreover, 57% of learners reported better academic performance in topics taught using diagrams and models, confirming that visual instructional aids not only improve understanding but also enhance examination outcomes. According to Bruner (1966), learners construct knowledge more effectively when they engage with tangible representations of abstract ideas. This supports the finding that models, through hands-on and visual learning, strengthen learners' ability to relate theoretical knowledge to practical applications. Hence, learners' positive attitudes toward these aids reflect their appreciation for

participatory, visual, and interactive learning environments.

3. Discussion of the Influence of Diagrams and Models on Learners' Performance in Biology

The third objective sought to determine the influence of diagrams and models on learners' academic performance, and the results were analysed from the semi-structured interviews. Findings revealed that 80% of teachers observed improved test scores following lessons involving diagrams and models, while the majority of learners (60%) confirmed similar outcomes. This evidence underscores the pedagogical value of visual aids in improving learning achievement. The results are consistent with the Cognitive Theory of Multimedia Learning proposed by Mayer (2009), which asserts that learning is more effective when information is presented through both visual and verbal channels.

According to Jegede and Okebukola (2018), the use of models and diagrams enables learners to visualize microscopic structures and dynamic biological processes that are otherwise difficult to grasp. This strengthens their ability to recall and apply knowledge in assessments. The positive correlation between visual aids and academic performance demonstrates that when learners are exposed to interactive, well-illustrated lessons, their comprehension deepens and performance improves. The study therefore confirms that diagrams and models are not mere supplementary tools but integral components of effective Biology instruction.

The teachers also provided practical examples of how diagrams and models helped simplify topics for better understanding by learners. During the interviews, learners similarly mentioned specific topics which they understand better with the help of diagrams and models. Additionally, learners gave brief explanations on how instructional aids such as diagrams and models influence their learning in Biology, which in turn helped to improve their performance. Among the positive influences mentioned by learners were helping them to concentrate, aiding in understanding Biology concepts, building interest in learning Biology, and simplifying the topics or lessons in Biology.

4.6 Implications of the Findings

The findings of this study carry significant implications for teaching practice, curriculum development, and educational policy. Firstly, the results indicate that incorporating diagrams and models into Biology instruction enhances learners' comprehension, engagement, and performance. This calls for teacher training institutions and education ministries to prioritize visual instructional techniques as part of pedagogical

preparation. According to UNESCO (2021), effective science education depends on teachers' ability to use appropriate instructional media that promote conceptual understanding and critical thinking.

Furthermore, the study suggests that resource allocation in schools should be improved to ensure the availability of teaching materials and model specimens. The observed challenges, such as large class sizes and inadequate preparation time, require administrative interventions to enable teachers to deliver learner-centred, visually supported lessons. As stated by Ogunniyi (2019), the integration of visual teaching aids contributes to inclusive learning by accommodating diverse learning styles and abilities. The findings, therefore, advocate for systematic investment in educational resources and continuous professional development for teachers to strengthen science pedagogy.

5. Conclusion and Recommendations

5.1 Conclusion

This section presents the major conclusions of the study in line with the research objectives and questions. The conclusions are grounded in the data presented in Section Four and discussed in Section Five, supported by relevant scholarly literature.

Extent to Which Biology Teachers Use Diagrams and Models during Classroom Instruction

The study concluded that Biology teachers widely use diagrams as part of their teaching strategies but employ models less frequently due to resource constraints. Teachers demonstrated awareness of the pedagogical value of visual aids, recognizing that diagrams and models make abstract biological concepts tangible and relatable. This conclusion supports Adesoji (2018), who emphasized that visual aids serve as vital tools in simplifying complex scientific ideas. The findings highlight that while teachers value the importance of these materials, their effective utilization depends largely on availability and institutional support.

Learners' Attitudes towards the Use of Diagrams and Models in Biology

It was concluded that learners exhibit highly positive attitudes toward the use of diagrams and models in Biology lessons. They perceive these instructional tools as engaging, motivating, and effective in promoting understanding and retention of content. This finding confirms Mayer's (2009) assertion that visual representations, when combined with verbal explanations, enhance cognitive processing and conceptual clarity. The results suggest that integrating diagrams and models into

lessons not only supports comprehension but also fosters learners' enthusiasm and interest in the subject.

Influence of Diagrams and Models on Learners' Performance in Biology

The study further concluded that the use of diagrams and models significantly enhances learners' academic performance in Biology. Both teachers and learners confirmed that topics taught with the aid of visual materials yielded better results compared to those taught without them. The findings corroborate Nwagbo (2016), who stated that instructional models promote interactive learning and reinforce students' understanding. Therefore, diagrams and models should be viewed not as supplementary teaching aids but as essential components of effective science instruction that improve learners' conceptual mastery and performance.

5.2. Recommendations

Based on the findings and conclusions of the study, the following recommendations are proposed:

1. Recommendations for Teachers

- Teachers should increase the use of diagrams and models in Biology lessons to make abstract concepts more tangible and relatable to learners.
- Educators should incorporate diverse visual teaching aids, including charts, specimens, and three-dimensional models, to promote interactive and engaging learning.
- Teachers should undergo continuous professional development to improve their skills in designing and utilizing visual materials effectively in line with curriculum objectives.

2. Recommendations for Educational Administrators and Policy Makers

- School administrators and the Ministry of Education should ensure adequate provision of teaching and learning materials, including models and diagrams, in all schools. Additionally, more workshops should be provided to educate teachers on the use of computers and PowerPoint presentations.
- Policies should be formulated to promote the integration of visual instructional resources into science curricula and teacher training programs.
- Educational authorities should reduce class sizes where possible to enable more effective use of interactive and visual-based instructional strategies.

3. Recommendations for Curriculum Developers

- Curriculum planners should emphasize the importance of visual aids in science education and include clear guidelines on their use in Biology syllabi.
- Learning outcomes should be designed to assess not only theoretical understanding but also learners' ability to interpret and apply knowledge gained through visual learning.
- Collaboration between curriculum designers, teachers, and educational technologists should be encouraged to develop affordable, locally produced models for Biology instruction.

5.3 Suggestions for Further Research

This study focused primarily on Biology education; therefore, further research could extend to other science subjects such as Chemistry and Physics to explore how diagrams and models influence learning outcomes across disciplines. Future researchers may also conduct longitudinal or experimental studies to establish the long-term impact of visual aids on learner retention and performance. Additionally, investigations into the integration of digital and virtual models, particularly in low-resource educational settings, would provide valuable insights into modernizing science education. Exploring gender-related differences in learners' responses to visual learning tools could also enrich understanding of their pedagogical effectiveness.

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