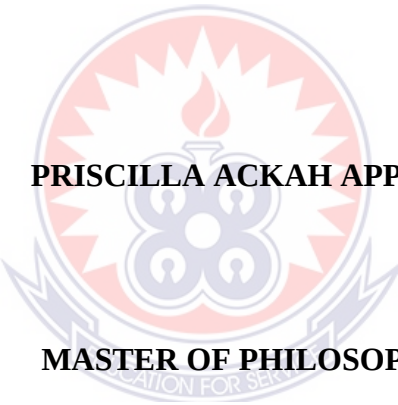


UNIVERSITY OF EDUCATION, WINNEBA

Investigating the effectiveness of multimedia assisted instructions on students' academic performance in some selected topics in Biology at Winneba Senior High School

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PRISCILLA ACKAH APPIAH

MASTER OF PHILOSOPHY

UNIVERSITY OF EDUCATION, WINNEBA

**INVESTIGATING THE EFFECTIVENESS OF MULTIMEDIA ASSISTED
INSTRUCTIONS ON STUDENTS' ACADEMIC PERFORMANCE IN SOME
SELECTED TOPICS IN BIOLOGY AT WINNEBA SENIOR HIGH SCHOOL**

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**A thesis in the Department of Science Education,
Faculty of Science Education, to be submitted to the
School of Graduate Studies in partial fulfilment
of the requirements for the award of the degree of
Master of Philosophy
(Science Education)
in the University of Education, Winneba**

SEPTEMBER, 2024

DECLARATION

Student's Declaration

I, Priscilla Ackah Appiah, declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and acknowledged, is entirely my own original work, and that it has not been submitted, either in part or whole, for another degree elsewhere.

Signature:

Date:

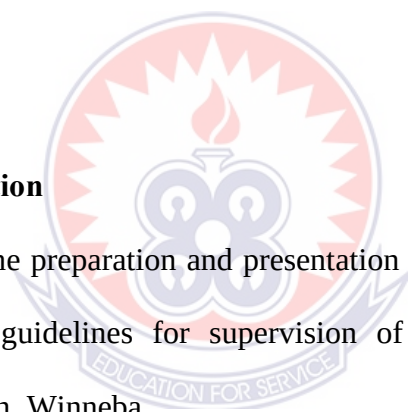
Supervisors' Declaration

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of thesis as laid down by the University of Education, Winneba.

Name of Supervisor: Stephen Twumasi Annan (Ph.D)

Signature:

Date:



DEDICATION

I dedicate this work to my husband Mr. Emmanuel Appiah, my children Angel Nana Appiah, Benevolence Nyameaye Appiah, Vanessa Mennkah Nhyira Appiah, Lora Obrimpong Sekyiwaa Appiah and Gabriella Estella Aky3dzepa Appiah and my lovely parent Madam Cecilia Asante and Mr Michael Aidoo.



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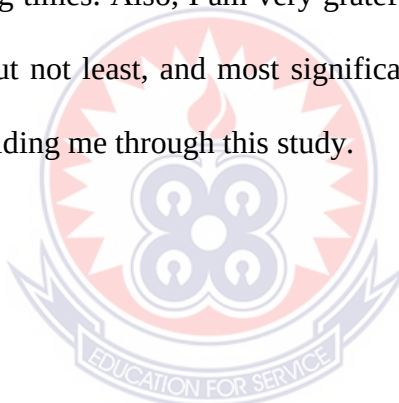


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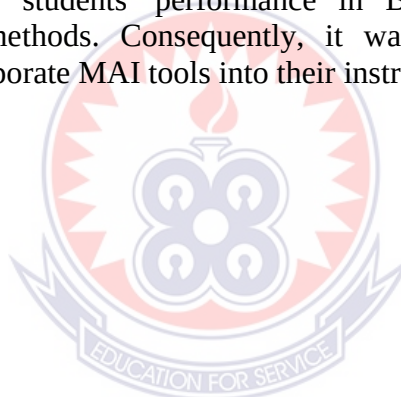
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ABSTRACT

The research examined the impact of multimedia-assisted instruction (MAI) on students' academic performance in selected Biology topics at Winneba Senior High, specifically when utilized as a complement to conventional teaching methods. An action research methodology was employed to collect data for this investigation. The study involved a single intact Form Two class consisting of 60 students from a public school in the Effutu Municipality. A cyclical approach to action design was implemented, along with a purposive sampling technique. Data collection methods included observation, interviews, and tests to gather both qualitative and quantitative information. The results indicated a notable improvement in students' performance in the selected Biology topics when MAI tools were incorporated into the teaching process. Additionally, the findings revealed that students exhibited a favorable attitude towards the use of multimedia-assisted instruction in Biology education. Furthermore, the study highlighted the challenges faced by students in utilizing MAI for their learning, which included limited access to devices, slow internet connectivity, software malfunctions, and environmental factors such as distractions, unsuitable classroom conditions, and inadequate time for the effective use of multimedia resources. The study concluded that the implementation of MAI tools significantly enhances students' performance in Biology when integrated with traditional teaching methods. Consequently, it was recommended that Biology educators should incorporate MAI tools into their instructional practices.



CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter provides an overview of the study's background, articulates the problem statement, outlines the study's objectives, and poses the research questions. Additionally, it discusses the significance of the study, as well as its delimitations and limitations. The chapter concludes with an operational definition of terms, along with the abbreviations and acronyms used in the study, and details the organization of the research.

1.1 Background to the Study

The incorporation of multimedia-assisted instruction (MAI) in educational settings has gained recognition as an effective means of improving students' academic outcomes (Abdulrahman et al., 2020). With the swift progress of technology, educators are now equipped with a range of multimedia tools, including videos, animations, interactive simulations, and educational software, which can enhance traditional teaching approaches (Nicolaou et al., 2019).

The application of these resources has the capacity to render learning more engaging and accessible, accommodating various learning styles and requirements (Putra, 2018). In the realm of biology education, which frequently encompasses intricate concepts and processes, multimedia-assisted instruction can prove to be especially beneficial (Akinbadewa & Sofowora, 2020).

By visualizing biological processes that are challenging to convey through conventional methods, MAI can facilitate students' comprehension of abstract concepts (Hayes & Kraemer, 2017). For example, animations depicting the mitosis

process or the operation of the human heart can significantly improve students' understanding and retention of these subjects.

However, despite the known advantages of MAI, its effectiveness in improving academic performance is still a subject of ongoing research, particularly in specific educational settings. In Ghana, the adoption of multimedia tools in senior high schools has been gradual, and many schools are still in the early stages of integrating technology into their classrooms (Bordoh et al., 2024).

Winneba Senior High School, like many other schools in Ghana, faces challenges such as large class sizes, limited resources, and varying levels of technological infrastructure. These factors can influence the effectiveness of MAI and its potential to improve students' academic outcomes. Additionally, students at this level often have diverse backgrounds and learning preferences, making it crucial to explore instructional methods that cater to their needs.

1.2 Statement of the Problem

The instruction and acquisition of biology, especially within the context of senior high schools in Ghana, pose considerable pedagogical challenges. Numerous biological concepts are fundamentally abstract, necessitating a significant degree of cognitive processing that frequently surpasses the capabilities of traditional teaching methods (Bayeldeng, 2022). As a result, a large proportion of students find it difficult to grasp essential biological processes, which contributes to ongoing learning challenges and underperformance in national examinations.

In spite of the increasing evidence that supports the effectiveness of multimedia-assisted instruction (MAI) in improving conceptual comprehension and student engagement, the majority of senior high schools in Ghana—including Winneba Senior High School—still predominantly depend on traditional teaching

methods (Adu-Gyamfi et al., 2016). These methods, which are generally marked by rote memorization, lecture-centric delivery, and reliance on textbooks, may not adequately address the varied cognitive requirements of students in a subject as conceptually challenging as biology (Fleischner et al., 2017).

The ongoing inadequate performance of students in biology, as emphasized in the repeated reports from the Chief Examiners of the West African Examinations Council (WAEC), highlights the critical necessity to reevaluate teaching strategies (Bayeldeng, 2022). These reports indicate persistent difficulties in students' comprehension of essential topics, implying that current instructional approaches may not sufficiently promote profound learning and knowledge retention.

In light of this situation, it is essential to examine the efficacy of multimedia-assisted instruction as a potential alternative or supplementary teaching strategy. This research aims to investigate whether the incorporation of multimedia tools into biology education can improve students' academic outcomes by rendering abstract concepts more accessible, engaging, and meaningful.

1.3 Purpose of the Study

The purpose of the study was to investigate the effect of Multimedia Assisted Instruction on students' academic performance in selected topics in biology at Winneba Senior High School.

1.4 Objectives of the Study

The objectives of the study were to;

1. Determine the effect of Multimedia Assisted Instruction (MAI) on students' attitude towards the study of biology.
2. Assess the effect of Multimedia Assisted Instruction (MAI) on student' academic performance in selected topics in biology at Winneba Senior High School.
3. Examine the challenges faced by students' in employing Multimedia Assisted Instruction (MAI) in learning Biology.

1.5 Research Questions

The study sought to answer the following questions:

1. What is the effect of multimedia assisted instruction on students' attitude towards the study of biology concepts?
2. What is the effect of multimedia instructional approaches on student' academic performance in selected topics in biology at Winneba Senior High School?
3. What are the challenges faced by students' in employing Multimedia assisted Instruction (MAI) in learning Biology in Winneba Senior High?

1.6 Significance of the Study

The results of the study will offer valuable insights to biology educators, enabling them to effectively incorporate MAI into the teaching and learning of biological concepts at Winneba Senior High School. Additionally, the outcomes of this research will be advantageous for biology students at Winneba Senior High School, as they will have access to various learning mediums through digital media.

Furthermore, Winneba Senior High School may contemplate the integration of MAI into their educational strategies as a method to improve biology education.

1.7 Delimitations

The scope of the study included Form two General Science 3 students from Winneba Senior High School in the Effutu Municipal district in the Central Region. The study adopted the use of Multimedia Assisted Instruction as an intervention to teach some selected topics in biology. Moreover, the study only used five topics to test the learners.

1.8 Limitations of the Study

The study was undertaken at only Winneba senior high school and as such the findings were not generalizable to other schools since various schools may have different educational environments, resources, and student demographics that could influence the outcomes.

1.9 Abbreviations

1. **MAI:** Multimedia Assisted Instruction
1. **2.SHS:** Senior High school
2. **GES:** Ghana Education Service
3. **WAEC:** West African Examination Council

1.10 Operational definition of Terms

1. Multimedia-Assisted Instruction: A dynamic instructional approach that integrates multimedia elements into the curriculum, such as text, graphics, audio, videos, animations, and interactive simulations (Vijayalakshmi & Kumar, 2020).

2. Learning - It is a multifaceted process that entails the acquisition of new knowledge, skills, behaviors, or understanding through study, experience, or instruction (Bereiter & Scardamalia, 2018).

3. Teaching The practice involves employing a range of techniques and methods to impart values, information, and skills to students (Griffin & Care, 2014).

4. Collaborative Learning- Through collaborative learning, students work together in groups to achieve a common educational goal (Andreu-Andrés, 2016).

5. Software- It is occasionally called a program or application; it consists of a set of data and instructions that direct a computer on how to perform specific tasks (Wolf, 2012).

6. Multimedia- Content that combines various forms of media, such as text, audio, images, animations, and videos, to convey ideas or share information is known as multimedia (Vijayalakshmi & Kumar, 2020).

7. Effect: The impact of Multimedia aided instruction on students' achievement, self-efficacy, and interpersonal skills in Biology (Atiyah et al., 2020).

8. Constructivism: The individual acquires knowledge independently; learning is an engaging process that is collaborative and rooted in real-world situations (Saleem et al., 2021).

1.11 Organization of the Research

There are five chapters in this research study. Introduction, a problem statement, the study's goal, research objectives, and research questions are all included in the first chapter. This chapter covers the significance of the study, delimitation, limitation, and research organization. Primary reviewed literature that is relevant to the topic is included in chapter two of this research study. Concept theories were examined in relation to the study questions. The methods used for the study is covered

in chapter three of the publication. It described the target population, the data collection process, the research instrument, the sample and sampling technique, the analytical and presentation tools utilized for the study, and the research design. A thorough summary of the results and recommendations is provided in Chapter 4. It covered the researcher's examination of the answers to the issues that needed to be addressed. The overview of the results, conclusions, ideas for additional research, and recommendations are covered in chapter five



CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.0. Overview

This chapter examined relevant research that may shed light on the application of MAI in the classroom. The theoretical framework, conceptual framework of the study was displayed in this chapter as well as other relevant literatures.

2.1 Background on Multimedia in Education in Ghana

The Ministry of Education (2015) indicates that over a decade, the Ministry, along with its development partners and various business sector organizations, collaborated to integrate multimedia into the educational landscape. This initiative was primarily facilitated through the GES. In Ghana, the incorporation of multimedia in education is acknowledged as an essential tool for enhancing teaching and learning experiences. As technology and digital resources become increasingly accessible, educators in Ghana are investigating the use of multimedia to engage students, improve educational outcomes, and accommodate diverse learning styles. Numerous studies have underscored the significance and efficacy of multimedia-assisted instruction within the Ghanaian educational framework. Initiatives have been implemented at both pre-tertiary (public and private schools) and post-tertiary levels. The establishment of ICT laboratories and the provision of computers have been the primary methods for promoting multimedia development in these institutions. Nevertheless, access remains below the necessary levels or quantities. While there have been some improvements, challenges persist within tertiary institutions. Gbordzekpor et al. (2023) examined the availability and accessibility of multimedia resources for teaching and learning biology in Senior High Schools (SHS) in Ghana. The study also investigated how SHS biology teachers perceive their capability to

utilize multimedia resources in their teaching practices. This research highlights the significance of resources and teacher perceptions in effectively leveraging multimedia for educational purposes in Ghana.

Furthermore, Kyei-Arthur (2022) highlighted the difficulties and coping mechanisms of low-fee private schools in Ghana during the COVID-19 pandemic, with a particular emphasis on online learning resources. The research underscored the significance of technology and multimedia resources in facilitating education during difficult periods, stressing the necessity for effective use of digital tools for learning. A study conducted by Gupta et al. (2024) pointed out that the incorporation of multimedia in education is in line with global trends in digital learning and highlights the importance of utilizing technology to foster dynamic and engaging learning environments. Numerous positive outcomes were reported. Initiatives led to a greater number of students and teachers gaining digital skills and cultivating strong interests in digitalization and Science. However, another study by Vagg et al. (2020) regarding Multimedia in education has demonstrated that it enhances students' learning experiences by offering interactive and engaging content that accommodates various learning styles and preferences. The findings indicate that the application of multimedia resources can render learning more dynamic, interactive, and enjoyable for students, resulting in heightened engagement and motivation.

Moreover, research conducted by Vijayalakshmi (2020) demonstrated that multimedia-assisted instruction can enhance student performance across various subjects and tasks. This research confirmed that by integrating multimedia elements into teaching, educators can assist students in comprehending complex concepts more effectively, retaining information better, and applying their knowledge in practical situations, which ultimately results in improved academic performance. The schools

participating in these initiatives were encouraged to expand the project and/or acquire additional multimedia equipment; several public and private partners, including Parent Teachers' Associations and civil society, collaborated in these efforts. Additional studies indicate that educators can engage students' interest and sustain their attention, thereby creating a positive learning environment that promotes active participation and enthusiasm for learning.

Furthermore, additional research indicates that multimedia resources facilitate personalized learning experiences tailored to the unique needs and preferences of individual students (Alamri et al., 2021). However, another study highlighted that by offering interactive and adaptive content, educators can address diverse learning styles, abilities, and interests, allowing students to learn at their own pace and in ways that align with their learning preferences, thus providing innovative solutions to educational challenges (Haleem et al., 2022). Another study illustrates that the integration of multimedia in education represents a novel approach to tackling educational challenges and enhancing traditional teaching methods. The findings suggest that by utilizing technology and digital resources, educators can eliminate barriers to learning, ensure access to quality educational content, and create dynamic learning environments that promote creativity, critical thinking, and collaboration among students (Aljawarneh, 2020).

2.1.1 Vision, mission and overall, policy goals

The necessity for a nationally recognized multimedia integration within the Education Policy of Ghana has become increasingly pressing. With the Government's heightened commitment to establishing a technologically advanced and inclusive educational framework that utilizes multimedia resources to improve teaching and learning experiences, stimulate innovation, and enable students to thrive in a digital

era, new plans and initiatives are being introduced almost daily (Asabere, 2017). Nevertheless, it has been acknowledged that without a national policy and comprehensive sector coordination, such efforts will persist in a disorganized manner, leading to a greater likelihood of duplication and the misallocation of limited resources that fail to adequately meet the educational goals and priorities of the sector (Mashi et al., 2019).

Furthermore, a study conducted by Hobbs (2017) indicated that multimedia equipment should support educational processes rather than dictate them, and that by incorporating multimedia resources into teaching and learning methodologies, digital literacy skills among students and educators can be promoted and enhanced, fostering critical thinking, creativity, and digital fluency. Additionally, assisting educators in the effective integration of multimedia tools and technologies into their teaching practices, encouraging innovative instructional methods, and improving student engagement, motivation, and learning outcomes is essential. This also includes facilitating personalized and interactive learning experiences that empower students to take charge of their education, explore a variety of content, collaborate with peers, and cultivate vital 21st-century skills (Asabere et al., 2017).

The utilization, enhancement, and advancement of multimedia to expedite the socio-economic progress of the nation is encapsulated in the Ghana ICT for Accelerated Development (ICT4AD) policy document (Awuku, 2018). The research indicates that the primary objective is to "transform Ghana into an information-rich, knowledge-based, and technology-driven high-income economy and society." This document is already recognized as a crucial strategic pillar.

Nevertheless, a separate study conducted by Conrads et al. (2017) sought to promote personalized, engaging, and interactive learning experiences that

accommodate various learning styles and empower learners to realize their full potential. This study also aimed to articulate the significance, accountability, and efficacy of employing multimedia in the education sector, with the intention of addressing existing challenges in the sector and equipping Ghanaian learners, students, teachers, and communities to meet the national and global demands of the 21st Century. The primary goal of the policy was to ensure that the Ghanaian education sector offers sufficient opportunities for Ghanaians to acquire the essential skills, irrespective of their educational levels (both formal and non-formal), to fully benefit from the digital society.

In light of this context, the primary objective of the Policy was to empower graduates from both formal and non-formal Ghanaian educational institutions to utilize multimedia tools and resources with confidence and creativity. This would enable them to acquire the essential skills and knowledge required to actively engage in the global knowledge economy at all times, while also employing suitable multimedia to support and align with the policies, objectives, and strategies of the sector Ministry. This is particularly relevant to ensuring equitable access to education, enhancing the quality of education, improving educational management, advancing science and technology, and addressing labor market needs. Furthermore, the aim is to create a dynamic and inclusive learning environment that leverages multimedia resources to enrich teaching and learning experiences, foster innovation, and prepare students for success in a digital landscape (Awuku, 2018).

Additionally, a study conducted by Bonney (2022) examined the mission of this policy, which was to clarify the significance, accountability, and efficacy of incorporating multimedia in the education sector. This initiative seeks to tackle existing challenges within the sector and equip Ghanaian learners, students, teachers,

and communities to meet the national and global demands of the 21st Century. The core aim of the policy was to guarantee that the Ghanaian education sector offers sufficient opportunities for individuals to cultivate the necessary skills, irrespective of their educational background (formal or non-formal), thereby enabling them to fully benefit from the digital society. Consequently, the overarching policy goal was to empower graduates from Ghanaian educational institutions—both formal and non-formal—to confidently and creatively utilize multimedia tools and resources to acquire the essential skills and knowledge needed to be active participants in the global knowledge economy at all times.

2.2 Theoretical Framework

This study is underpinned by a framework comprising Cognitive Theory of Multimedia Learning and constructivism.

2.2.1 Cognitive Theory of Multimedia Learning (CTML) by Mayer (2005)

The Cognitive Theory of Multimedia Learning, formulated by Richard Mayer, asserts that individuals learn more efficiently when presented with both words and images rather than words alone (Mayer, 2005). This theory is founded on three key assumptions: dual channels, limited capacities, and active processing. In the context of dual channels, learners assimilate information through two distinct pathways—one dedicated to visual or pictorial data and the other to auditory or verbal information. Multimedia instructional approaches (MAI), which integrate both visual and auditory components, can utilize these dual channels to enhance the learning experience (Mayer, 2005). The second assumption indicates that each channel possesses a finite capacity for processing information at any moment. Overloading these channels can hinder the learning process. Consequently, effective multimedia instruction must be

crafted to manage cognitive load, ensuring that students are not inundated with excessive information (Mayer, 2005).

Furthermore, the third assumption suggests that learning transpires when students actively participate in selecting, organizing, and integrating information (Akinbadewa & Sofowora, 2020). Multimedia resources can support this active processing by offering interactive features that motivate students to engage with the content in significant ways (Mayer, 2017). In applying the Cognitive Theory of Multimedia Learning to this research, MAI in biology education can assist students in grasping intricate subjects by delivering information in a manner that corresponds with the brain's information processing mechanisms (Cavanagh & Kiersch, 2023). For example, animations depicting cellular processes or videos illustrating ecological interactions can enable students to visualize and better understand these abstract ideas, ultimately enhancing their academic performance (Eberbach et al., 2021).

The Cognitive Theory of Multimedia Learning serves as a foundational element for this research by offering a framework that elucidates how multimedia-assisted instruction (MAI) can enhance students' academic performance in biology. The subject of biology frequently encompasses complex structures, abstract processes, and intricate systems that are challenging to comprehend through conventional text-based instruction alone. By incorporating visual elements (such as diagrams, animations, and videos) alongside auditory components (including narration and sound effects) into the educational experience, MAI aligns with the dual-channel processing assumption of CTML, thus promoting deeper learning (Almasseri & AlHojailan, 2019).

Furthermore, by crafting multimedia content that is cognitively optimized and does not overwhelm learners with excessive or irrelevant information, the study

adheres to the limited capacity principle. For example, breaking down instructional materials into smaller, more manageable segments and employing signaling techniques to emphasize key information are strategies that alleviate cognitive load and enhance comprehension, which are vital to the efficacy of MAI (Allan et al., 2019).

The third assumption, active processing, holds particular significance in the context of this research. Multimedia-assisted instruction frequently incorporates interactive elements such as quizzes, simulations, and guided tutorials that motivate students to engage actively with the content. This is consistent with CTML's assertion that learners must mentally organize and integrate information for meaningful understanding to take place (Chakraborty, 2019). In conclusion, CTML not only provides a rationale for the incorporation of multimedia in biology education but also presents specific design principles that inform the creation and execution of effective instructional materials. This theory acts as the conceptual foundation of the study, ensuring that the multimedia interventions utilized are based on empirically-supported cognitive principles that improve learning outcomes.

2.2.2 Constructivism by Bruner (1966)

Constructivism is a theory of learning that posits learning as both an active endeavor and a personal interpretation of the world (Efgivia et al., 2021). In a similar vein, (Zajda & Zajda, 2021) assert that constructivism is a learning theory which maintains that the most effective method for acquiring knowledge is through active mental engagement and reflection. Thompson (2002) characterizes knowledge as the formation of concepts within the learner's mind. Students acquire knowledge by contemplating what is being taught and developing an interpretation informed by their past experiences, personal beliefs, and cultural context (Brookfield, 2017). The

Constructivist approach to multimedia-assisted instruction highlights the importance of active learning, wherein students generate knowledge through their engagement with multimedia resources. This methodology is consistent with the notion that learners enhance their understanding by linking new information to their pre-existing knowledge and experiences.

A research conducted by Sasan (2022) emphasizes the potential of Constructivist learning theory to improve students' learning experiences through the use of multimedia resources.

By incorporating Constructivist principles into multimedia-assisted teaching, educators can develop engaging and interactive educational settings that facilitate deeper comprehension and retention of knowledge (Sasan, 2022). This methodology aids students in cultivating critical thinking skills, enhancing problem-solving capabilities, and fostering a greater appreciation for the subject matter (Samat & Chaijaroen, 2012).

The constructivist theory related to multimedia-assisted instruction is crucial for enhancing student learning by encouraging active participation, critical analysis, and the construction of knowledge (Sasan, 2022). This strategy motivates students to link new information with their existing knowledge and experiences, thereby promoting a more profound understanding of the subject matter (Samat & Chaijaroen, 2012). By embedding constructivist principles into multimedia instruction, educators can establish vibrant learning environments that enable students to take charge of their educational journey, resulting in enhanced academic performance and knowledge retention (Sasan, 2023). The Constructivist theory can be divided into three primary categories: Cognitive Constructivism, Social Constructivism, and Radical Constructivism.

2.2.3 Cognitive constructivism

This theory emphasizes the construction of individual knowledge through mental processes and the development of schemas. According to this theory, learners actively create their understanding of the world by integrating new information into their existing cognitive frameworks (Mohammed & Kinyó, 2020). Cognitive constructivism underscores the significance of internal mental processes, including perception, memory, and problem-solving, in the learning process (Neo & Neo, 2010). By involving students in activities that stimulate their thinking and promote reflection, cognitive constructivism seeks to enhance higher-order thinking skills and foster deeper understanding (Le & Nguyen, 2024). This approach highlights the necessity of scaffolding learning experiences to assist students in constructing meaning and effectively developing their cognitive skills.

2.2.4 Social constructivism

Social constructivism, as articulated by Fosnot (2013), underscores the importance of culture and context in understanding societal dynamics and in the formation of knowledge based on this comprehension. Minor (2023) asserts that the objectives of instruction, the significance of the home language, the selection of instructional materials, classroom management, student interactions, community relationships, teaching methodologies, and assessment practices will collectively enhance literacy learning for students from diverse backgrounds within the framework of social constructivism. Knowledge is created or generated by humans. Language and writing systems serve as cultural instruments that various societies have developed and made accessible. It is essential to encourage learners from all backgrounds to utilize their native languages as a foundation for literacy advancement in educational settings. In a social constructivist learning environment, teachers should not abandon students

to navigate their learning independently; instead, they must evaluate what is necessary for genuine understanding of the subject matter and actively engage with students to facilitate the enhancement of their conceptual frameworks. The educator's role is to aid students in making the concepts to be learned relevant and meaningful at their individual levels.

According to Minor (2023), enhancing school literacy for children from diverse backgrounds can be achieved if educators acknowledge the significance of students' native languages and view biliteracy as a realistic and commendable objective. Schools serve as socio-cultural environments where teaching and learning occur, alongside the application of cultural competencies such as reading, writing, mathematics, and specific forms of communication (Mogashoa, 2014). This concept implies that both theory and practice are influenced by prevailing cultural ideologies rather than emerging independently. Educators should utilize assessment techniques that reduce error sources and accurately reflect students' reading skills. Social constructivists assert that learning is inherently a social endeavor, and knowledge is a product of human interaction. Engagement with adults can significantly enhance the cognitive development of young children. From a social constructivist viewpoint, five factors contributing to the reading achievement gap are identified: linguistic differences, cultural variances, discrimination, insufficient education, and educational rationale (Minor, 2023). The collective social achievements of educational institutions, communities, teachers, students, and families play a crucial role in determining both success and failure in literacy education. In constructivism, communication or discourse processes are likened to construction processes. The focus is on generative actions, such as interpreting or creating texts. Key themes in constructivist literature include active participation in meaning-making processes, text comprehension as a

lens into these processes, and the diverse nature of knowledge, particularly knowledge that arises from belonging to a specific social group (Minor, 2023). Social constructivism posits that there is no objective foundation for knowledge claims, as knowledge is perpetually a human construct. The role of instructors, classmates, and family members in mediating learning, the dynamics of classroom teaching, and the organization of systems within which children learn or fail to learn are all explored in social constructivist literacy research Minor (2023).

2.2.5 Radical constructivism

A theory introduced by Ernst von Glasersfeld asserts that knowledge is actively constructed by learners based on their interpretations of the world, rather than merely reflecting an objective reality (Von-Glasersfeld, 2012). In the realm of multimedia-assisted instruction, radical constructivism indicates that learners interact with multimedia materials to develop their own understanding of the content, shaped by their distinct perspectives and experiences. This methodology underscores the subjective nature of knowledge construction and emphasizes the significance of learners' active involvement in interpreting information presented through multimedia resources (Tobin & Tippins, 2012). By integrating radical constructivist principles into multimedia instruction, educators can establish learning environments that motivate students to critically reflect on and interpret multimedia content in ways that are personally significant and pertinent to their educational journey.

Radical constructivism is crucial in education as it challenges conventional perspectives on knowledge acquisition and highlights the proactive role of learners in forming their understanding of the world. This theory advocates for a student-centered approach that appreciates individual perspectives, experiences, and interpretations. By recognizing the subjective nature of knowledge construction, radical constructivism

promotes critical reflection, metacognitive awareness, and the investigation of diverse viewpoints (Tobin & Tippins, 2012). Implementing radical constructivist principles in educational contexts can empower students to take charge of their learning process, stimulate creativity, and cultivate a deeper understanding of the intricacies of knowledge and reality. This approach can improve students' cognitive flexibility, problem-solving abilities, and capacity for independent thought, equipping them to navigate an increasingly complex and diverse world.

2.2.6 The Constructivist view of the role of the learner

The constructivist perspective on the learner's role underscores the significance of active participation, meaning-making, and the construction of knowledge. Learners are regarded as proactive contributors to their educational journey, developing understanding through their interactions with the environment, experiences, and social contexts. This viewpoint emphasizes the critical role of learners' prior knowledge, beliefs, and interpretations in influencing their educational outcomes. By actively engaging in the process of constructing their understanding of the world, learners cultivate critical thinking skills, problem-solving capabilities, and a profound appreciation for the intricacies of knowledge (Tobin & Tippins, 2012). Brau (2016) asserts that in a constructivist classroom, students are required to contemplate the content being presented and formulate an interpretation throughout the learning experience. The author further notes that students base their interpretations on their previous experiences, personal viewpoints, and cultural backgrounds. Additionally, students are encouraged to reflect on their newly acquired information following the interpretation. They are expected to engage and interact with their environment, peers, authorities, and instructional resources.

In a constructivist classroom, learners acquire knowledge and meaning by actively participating in activities, observing the interactions between concepts and ideas, and developing a cognitive framework to comprehend everything. Students are generally permitted to pursue their interests, provided they continuously challenge themselves and generate innovative ideas. There is no competition among students in a constructivist setting. Instead, students are encouraged to collaborate and exchange information and ideas. Often, students take on the role of a teacher in subjects where they possess particular expertise, assisting their classmates while simultaneously reinforcing their own knowledge.

2.2.7 The constructivist view of the role of the instructor

In constructivism, the instructor's role transitions from that of a traditional lecturer to a facilitator, guide, and co-learner. In constructivist pedagogy, educators establish learning environments that foster active engagement, critical thinking, and collaborative knowledge construction among students (Misra, 2020). Rather than simply delivering information, instructors promote exploration, inquiry, and reflection to assist students in building their understanding of concepts (Shi, 2024). This methodology highlights the significance of scaffolding learning experiences, offering guidance, and nurturing a supportive learning atmosphere where students can forge connections, question assumptions, and enhance their cognitive skills (Misra, 2020). From the constructivist perspective, instructors are viewed as facilitators who assist and support students in the active construction of their knowledge through meaningful experiences and interactions (Ritchhart et al., 2011). Instead of being the exclusive source of information, educators cultivate learning environments that stimulate exploration, collaboration, and critical thinking (Ritchhart et al., 2011). By embracing a learner-centered approach, instructors encourage student engagement, autonomy,

and a profound understanding of concepts (Misra, 2020). This transformation in the instructor's role from a knowledge provider to a learning facilitator empowers students to take charge of their learning journey and acquire vital skills for lifelong learning.

2.3 Multimedia Integration in Teaching and Learning

In numerous countries across the globe, Multimedia Assisted Instruction (MAI) has become a fundamental component of education. GebreYohannes et al. (2016) highlighted the influence of multimedia in the teaching of mathematics. Furthermore, Smith (2023) examined the integration of multimedia and virtual reality in online education. Abuhmaid (2011) also noted that instructors must possess the skills necessary to incorporate MAI into their teaching and learning activities, necessitating training in ICT competencies. As teachers become more adept with multimedia tools, the presence of MAI in classroom teaching and learning activities is expected to increase.

Multimedia Assisted Instruction (MAI) has significantly enhanced student engagement, improved comprehension of concepts, and facilitated personalized learning experiences, ultimately resulting in more effective and impactful educational outcomes while also enabling educators to align with global best practices. The conventional lecture method or traditional teaching techniques have been supplanted by technology-based teaching and learning tools and resources due to the preparation of teachers. Additionally, Chopade (2022) investigates the importance of multimedia teaching-learning methodologies and the application of machine learning for predicting results. This research highlights the role of multimedia technology in enhancing the learning experience in professional courses and underscores the

advantages of multimedia teaching methodologies in contemporary educational environments.

Moreover, Erbas (2019) explored the effects of augmented reality on students' academic performance and motivation within a biology course. The study offers valuable insights into the contribution of multimedia resources to enhancing student engagement and academic success (Erbas, 2019). According to the findings of the study, one of the key factors determining the success of digital and technology-based teaching and learning was the preparation of teachers in the use of MAI.

Furthermore, Mutua and Mwangi (2023) explored the integration of multimedia mathematical internet memes into mathematics education. He is a researcher based in Kenya who employed a quantitative study to examine the incorporation of mathematical internet memes within mathematics classrooms. This research illustrates the use of quantitative techniques to evaluate the effectiveness of innovative teaching methods in improving student learning outcomes in mathematics education. A survey method was utilized to gather data from 205 teachers through questionnaires. The results indicated that the usage of mathematical internet memes (MAI) by teachers was moderate, with a majority (65 percent) of the surveyed instructors regularly employing MAI in their classrooms. In other words, teachers utilized MAI to a moderate extent. Additionally, a study conducted by Nwafor et al. (2023) assessed teachers' competence in the use of digital instructional tools in upper basic schools in Cross River State, Nigeria. They found that a significant number of Biology teachers possessed the necessary MAI skills, although the utilization of available resources was far from optimal. Moreover, Wiggins et al. (2017) carried out a survey to evaluate students' perceptions of engagement in an active learning environment. This questionnaire was administered to 16 Biology instructors as part of

the study, which employed a survey methodology. According to the findings, teachers recognized the importance of MAI in the teaching and learning process. However, most of them refrained from using MAI to teach Biology due to insufficient multimedia infrastructure and power outages, which were identified as the primary obstacles in the classroom.

Bdulrahaman et al. (2020) explored the potential of multimedia technologies within the educational framework to improve the learning experience and foster students' creative skills. The research emphasizes the collaborative efforts among educators, researchers, and multimedia creators in refining educational methodologies. Conversely, Al Zboun et al. (2018) examined the influence of YouTube and Facebook on students' academic performance in geography courses, particularly in enhancing the achievement and retention of undergraduate students in environmental education.

Bhebhe et al. (2023) addressed the incorporation of techno-pedagogies in online teaching strategies for sustainable business education, particularly in light of the transition to fully online instruction during the COVID-19 pandemic. The study aimed to boost student engagement through innovative teaching techniques. It was found that educators who lacked expertise and confidence faced challenges due to limited access to resources and inadequate MAI support while implementing MAI in their classrooms.

Additionally, Chopade et al. (2022) investigated the importance of multimedia teaching-learning methodologies and the application of machine learning for predicting outcomes. This research highlights the contribution of multimedia technology to the learning of professional courses and underscores the advantages of multimedia teaching methods in contemporary educational environments. The

findings indicated that a significant number of respondents exhibited limited competence and confidence in utilizing MAI for the teaching and learning process. Furthermore, the results suggested that teachers believe MAI enhances the teaching and learning experience.

Furthermore, Calabuig-Moreno et al. (2020) examined the practical use of digital technology in physical education and training within the framework of the multimedia era. This study explores how digital technology can improve teaching effectiveness, enhance student motivation, and foster independent learning skills in the realm of physical education, highlighting the significance of integrating technology to transform conventional teaching methods. Nevertheless, as noted by Mulkeen (2009), educators in Anglophone Africa face challenges related to teacher supply, training, and management, as West African teachers do not utilize MAI in their classrooms to the extent possible. This issue may stem from several interconnected factors, one of which is the role of the teacher in the analysis of technological integration in teacher education in Ghana (Ohemeng, 2009). Research on the limitations of performance management systems in developing nations revealed that the challenges of MAI implementation in Ghana include a shortage of skilled human resources and various institutional factors (Ohemeng, 2009).

A descriptive survey design was employed across 12 secondary schools in Nairobi County to explore the potential and challenges affecting the integration of MAI in teaching and learning. According to the findings of the study, teachers encounter significant obstacles, such as the need to enhance their own technical skills and knowledge, as well as to engage in self-training for the application of CAI in their classrooms (Ohemeng, 2009). The development of teachers' competencies for MAI implementation in Ghanaian high schools is crucial (Akyeampong, 2014). However,

there is limited information regarding whether teachers at Winneba Senior High Schools receive training on the use of MAI in their classrooms. Consequently, this study has taken an interest in this matter (Asante, 2023).

2.4 Importance of MAI Utilization in Education

Multimedia Assisted Instruction (MAI) is increasingly significant in the educational field (Leow & Neo, 2014). Additionally, Galope (2013) examined multimedia-assisted instruction in the context of teaching Science and Health to fourth-grade students, focusing on its impact on students' performance and their attitudes towards the use of multimedia in the classroom. To grasp the significance of MAI in education, it is essential to comprehend its definition. MAI refers to educational strategies that integrate various multimedia elements, including videos, images, audio clips, simulations, animations, and interactive content, to enhance the teaching and learning experience (Vijayalakshmi et al., 2020). This research highlighted the influence of multimedia on motivation and knowledge retention. This instructional approach utilizes multimedia tools to convey information in diverse formats, accommodating different learning styles and engaging students through a mix of visual, auditory, and interactive elements. The goal of multimedia assisted instruction is to enhance understanding, retention, and overall educational outcomes by creating a dynamic and interactive learning environment for students (Vijayalakshmi and Kumar, 2020).

Additionally, Al-Rahmi et al. (2020) conducted research on digital communication as the application of Information and Communication Technology (ICT) for the sustainability of education. Moreover, Multimedia Assisted Instructions (MAIs) are utilized within an enclosing-rectangle scaffold through computer-assisted instruction to assist low-achieving students in understanding the area of basic

geometric shapes, thereby demonstrating the advantages of multimedia instructional strategies in promoting learning (Al-Rahmi et al., 2020). Furthermore, Multimedia Assisted Instruction is essential in enhancing teaching and learning experiences across diverse educational fields. Researchers have emphasized the importance of multimedia tools in boosting student engagement, understanding, and retention (Kao & Luo 2020). This study illustrates the effects of Multimedia-Assisted Learning on learning behaviors and student knowledge in physical education classes, using basketball game recordings as a case study.

In addition, MAIs are implemented in various settings such as homes, schools, and workplaces. The application of MAIs can significantly enhance teaching and learning processes in numerous ways. It has the potential to elevate the quality of teaching, learning, and management in educational institutions, facilitate virtual internationalization at universities, and present both opportunities and challenges, including the role of artificial intelligence in higher education and scientific research (Novoselova, 2023).

Multimedia Assisted Instruction is essential for enhancing teaching and learning experiences across various educational fields. Researchers have emphasized the importance of multimedia tools in boosting student engagement, understanding, and retention. MAI has contributed to the increasing use of multimedia tools for effectively delivering educational content. Consequently, the current study aimed to analyze the impact of Multimedia by creating a Multimedia Package for Instructional Purposes and implementing it in the classroom, thereby engaging learners and demonstrating the extent of the required learning achieved. Furthermore, Chakraborty et al. (2020) investigated the effects of Multimedia tools on teaching and learning processes. The findings indicated that most multimedia solutions used for educational

purposes are tailored to the pedagogical content of the subject matter and the target audience, while the effectiveness of various multimedia tools across different groups and subjects can be linked to the technologies and components integrated into their design.

Kirimi (2014) explored the influence of information communication technology on education. The research revealed that technology benefits not only school students but also facilitates office work. It enables a more efficient method for storing and distributing information. Recognizing the significance of technology in educational institutions and its successful implementation is crucial. The integration of technology in schools serves as a means to bridge the gap between the present and the future by evaluating the impact of educational videos on student engagement, critical thinking, and learning (Carmichael et al., 2018).

Bdulrahman et al. (2022) performed a systematic literature review regarding the advancements in Computer Assisted Instruction, with a particular emphasis on the rising utilization of multimedia for the effective delivery of educational content. Their research highlights the increasing popularity and efficacy of multimedia tools within instructional environments. In contrast, Carriedo et al. (2023) explored the influence of teachers' autonomy support on students' fundamental psychological needs, intrinsic motivation, and levels of moderate-to-vigorous physical activity.

Furthermore, Khamparia (2018) noted that multimedia has significantly influenced E-learning concepts, methodologies, tools, and applications. This research indicated that multimedia-based technologies have a profound effect on our daily learning activities, transitioning education from a teacher-centered approach to a learner-centered one. E-learning offers individuals the chance to enroll in online courses and creates a virtual classroom environment on the web, facilitating

interactions between teachers and learners, as well as the distribution of course materials through interactive multimedia. Interactive multimedia provides learners with various media formats to accommodate their learning styles and allows for personalized adaptive content delivery, thereby enhancing the effectiveness of learning.

However, Abdullahi (2014) discovered that Multimedia-Assisted Instruction (MAI) enhances students' intellectual characteristics by fostering higher-order thinking, improving communication skills, and developing problem-solving abilities, along with a comprehensive understanding of learning tools and content. In his investigation of MAI's application in teaching science education in schools, he further asserted that MAI cultivates a more effective interactive learning environment and equips students with the knowledge and skills related to MAI.

Lee et al. (2023) investigated the application of an enclosing-rectangle scaffold through computer-assisted instruction to assist low-achieving students in understanding the area of fundamental geometric shapes, showcasing the efficacy of multimedia instructional strategies in enhancing student learning.

Mwanda et al. (2017) examined the effectiveness of integrating ICT into the teaching and learning of biology, proposing a policy framework to facilitate effective computer integration into instruction. The study advocates for improved accessibility to computers, sufficient training in computer technology usage, and a development process.

Furthermore, Garraway-Lashley (2014) determined that the incorporation of computer technologies in Biology instruction enhances students' academic performance. The research revealed that students who received instruction with ICT integration achieved significantly higher mean scores in Biology than those who

underwent traditional instruction. The study also emphasized the beneficial effects of ICT on students' performance in the subject. It employed a quasi-experimental non-equivalent control group design for the post-test results. This finding indicates a notable difference in the academic performance of Biology students exposed to computer technology compared to those taught through traditional methods.

Additionally, Timotheou et al. (2023) investigated the effects of digital technologies on education and the factors affecting schools' digital capacity and transformation. The findings of the study illuminate how ICTs can positively influence the digital transformation of schools and identify the factors that should be considered for schools to achieve effective and efficient change.

2.5 Effects of MAI on academic performance

Research has demonstrated that the use of Multimedia Assisted Instruction (MAI) can positively influence academic performance across a range of subjects and educational levels (Ilhan & Oruc, 2016). Khan et al. (2020) examined the effects of Multimedia Instructions on the Academic Performance of Students. Their findings indicated that multimedia instruction has a directly positive correlation with the academic performance of both secondary and higher secondary students. By integrating multimedia components, educators can develop engaging learning experiences that enhance students' comprehension and retention of knowledge. Additionally, research by Akinbadewa (2020) has underscored the beneficial effects of Multimedia Assisted Instructions on students' academic performance in biology within secondary schools. These interactive resources not only inspire students but also provide practical and immersive learning experiences, resulting in improved academic results.

Taculod and Arcilla (2020) explored the effects of Multimedia-Assisted Instructions on students' academic performance in Biology within secondary schools, emphasizing the motivational and interactive learning advantages. The findings revealed that students who received instruction through interactive multimedia achieved superior results ($M=23.32$, $SD=3.17$) compared to those taught using the traditional lecture method ($M=20.37$, $SD=4.45$), which served as the control group. Allan et al. (2022) utilized Multimedia-Assisted Instructions (MAI) as a methodological approach in their research on students' academic performance in Biology within secondary schools. The objective of the study was to assess the impact of computer-assisted instruction on students' learning outcomes and engagement in biology education. The interactive and technology-enhanced nature of MAI was intended to motivate students and enrich their learning experience in the subject. Research regarding the effects of multimedia-assisted instruction on student performance has predominantly yielded favorable outcomes. For example, a study conducted by Calabuig-Moreno et al. (2020) revealed that students who were taught using multimedia tools achieved significantly higher scores on assessments compared to their peers who received traditional instruction. The researchers attributed this enhancement in performance to the increased engagement and comprehension facilitated by multimedia content.

In a similar vein, Bolanta (2024) carried out a study in Nigerian secondary schools, discovering that students exposed to multimedia-based learning in biology attained superior scores in both formative and summative assessments compared to those instructed through conventional lecture methods. The researchers observed that multimedia tools, including animations and simulations, effectively clarified

challenging concepts such as genetics and cell division, thereby contributing to the students' improved academic performance.

In a related study, Akinbadewa and Sofowora (2020) examined the impact of multimedia-assisted instruction on students' performance in science subjects, including biology, within Nigerian senior secondary schools. The findings revealed that MAI not only enhanced academic performance but also fostered greater interest and motivation among students to learn. The researchers contended that the interactive characteristics of multimedia tools rendered learning more engaging, which was especially advantageous for students who faced challenges with traditional lecture-based teaching.

Additional evidence supporting the effectiveness of MAI is provided by a study conducted by Kareem (2018), who analyzed the influence of multimedia instructional strategies on the academic performance of biology students in Lagos, Nigeria. Their results demonstrated that students who participated in multimedia-enhanced lessons achieved superior test scores on subjects such as human anatomy and photosynthesis when compared to their peers who received conventional instruction. The authors concluded that the incorporation of multimedia facilitated a connection between theoretical knowledge and practical application, leading to enhanced academic results.

2.6 Effect of Multimedia Assisted Instruction on Students' Attitude Towards The Study of Biology Concepts

The attitude that students hold towards a subject often plays a crucial role in determining their success in that field. In the case of biology, which necessitates a comprehension of intricate concepts like cellular functions, genetics, and ecology, students' attitudes can significantly affect their willingness to engage with the subject

matter (Carver et al., 2017). On the other hand, students who harbor a negative attitude may find themselves struggling with the subject, which can lead to diminished performance and a disinterest in pursuing careers related to science. Research has demonstrated that many students view biology as challenging due to the abstract nature of its concepts and the considerable amount of memorization required (Tyler-Wood et al., 2012). This viewpoint can lead to feelings of disinterest, anxiety, and a lack of motivation to study biology. Consequently, it is essential to investigate instructional strategies that can positively affect students' attitudes towards the subject. Multimedia-assisted instruction holds the promise of positively influencing students' attitudes towards biology by rendering the subject more interactive, engaging, and relevant (Akinbadewa & Sofowora, 2020). Studies suggest that when students are actively involved in the learning process through multimedia resources, they are more inclined to cultivate a favorable attitude towards the subject (Vijayalakshmi & Kumar, 2020).

For instance, Septiani and Rejekiningsih (2020) conducted research in Nigerian secondary schools and discovered that students who learned biology concepts through multimedia tools exhibited a more positive attitude towards the subject compared to their peers who received traditional instruction. The interactive characteristics of multimedia content, including animations and simulations, enhanced the learning experience, making it more enjoyable and enabling students to connect with the material in a more significant manner.

In a similar vein, Bizimana et al. (2022) investigated the effects of multimedia instruction on students' perceptions of biology within a Ugandan secondary school. Their results indicated that students who engaged with multimedia resources, including interactive videos and digital representations of biological processes,

exhibited a heightened interest in biology. The research proposed that by offering a more dynamic and visually stimulating learning experience, multimedia-assisted instruction alleviated students' anxiety regarding the subject and rendered it more accessible. Additionally, a study conducted by Kareem (2018) in the United Arab Emirates assessed the impact of multimedia instruction on students' attitudes towards biology. This research concentrated on the implementation of interactive software that enabled students to delve into biological concepts via virtual laboratories and simulations. The findings revealed that students utilizing the software experienced a notable transformation in their attitudes, shifting from perceiving biology as a challenging and unengaging subject to recognizing it as captivating and pertinent to real-world scenarios.

Moreover, Kapici et al. (2020) examined the influence of virtual laboratories on students' attitudes towards biology. Their research demonstrated that students who engaged in virtual lab activities were more inclined to exhibit a favorable attitude towards learning biology. The interactive characteristics of the virtual labs facilitated hands-on experimentation with biological concepts, thereby enhancing their interest and involvement in the subject. The researchers concluded that multimedia tools, by fostering opportunities for active learning, could reshape students' views of biology from a passive, memorization-driven discipline to an interactive and enjoyable endeavor.

While multimedia-assisted instruction has been demonstrated to have a beneficial effect on students' attitudes towards biology, certain studies warn that its efficacy may be affected by various factors. Ayittey (2015) discovered that students' pre-existing attitudes towards biology could influence their reactions to multimedia instruction. Those students who held a negative view of the subject were more likely

to resist the new instructional approaches, indicating that educators might need to integrate MAI with supplementary strategies to alter deeply rooted negative perceptions.

Furthermore, Buckley (2000) emphasized the difficulty of ensuring that multimedia content is culturally pertinent and corresponds with students' experiences. In some instances, multimedia resources created in different cultural settings may fail to connect with students, thereby restricting their effectiveness in fostering positive attitudes. Consequently, the effectiveness of MAI in transforming students' attitudes towards biology may hinge on the degree to which the content is customized to fit the local educational environment and the students' existing knowledge.

2.7 Factors affecting the use of MAI in Teaching and Learning Process

Research conducted by Almaiah et al. (2022) specifically investigates the technological obstacles associated with Multimedia Assisted Instruction (MAI). Their findings explore problems such as inconsistent internet connectivity, technical failures, software issues, and limited access to devices, emphasizing how these obstacles can impede the successful implementation of MAI within educational environments. This research offers significant insights into the technological challenges encountered by both educators and students when employing multimedia tools for teaching and learning.

Additionally, a study by Kim (2022) examined educators' perspectives on the barriers and challenges related to information and communication technologies (ICTs) and multimedia integration in the ESL classroom.

Furthermore, challenges exist in the integration of MAI and ICT tools in the teaching of biology, as noted by Ong'amo (2015). Smith (2023) concentrated on the difficulties arising from insufficient resources in the application of Multimedia

Assisted Instruction (MAI) in educational contexts. The research investigated issues such as limited funding, lack of technical assistance, and inadequate access to multimedia content and educational software, underscoring how these challenges can obstruct the effective use of MAI in teaching and learning processes. This study provides insights into the effects of resource limitations on the incorporation of multimedia tools in education and suggests potential strategies to overcome these challenges.

Furthermore, Namasiku (2020) identified the obstacles to the integration of Information and Communication Technology in the teaching and learning of Mathematics at Junior Secondary Schools in the Mahalapye region. The results will inform conclusions regarding the media utilized, which are influenced by technical expertise, technical challenges, and a shortage of technicians in the mathematics education sector, as well as provide recommendations for the effective integration of ICT in mathematics instruction.

In addition, Gbemu (2022) examined the self-efficacy beliefs of teachers in colleges of education and their actual utilization of ICTs as MAI tools for teaching within the Kumasi Metropolis. The findings indicate that the integration of MAI in teaching requires the presence of a technician; in the absence of such support, the lack of technical assistance can pose significant challenges. "Technical barriers hindered the effective delivery of lessons and disrupted the natural progression of classroom activities. Moreover, Aljuwayr (2018) explored the perceptions of high school science teachers in Saudi Arabia regarding the challenges and concerns associated with the integration of science content, technology, engineering, and mathematics.

Research conducted by Chen et al. (2021) investigates the issues related to the digital divide within the framework of Multimedia Assisted Instruction (MAI). This

study examines the inequalities in access to technology and digital resources among students, influenced by factors such as socioeconomic status, geographic location, and infrastructure limitations. The findings highlight how the digital divide can lead to disparities in the use of MAI for educational purposes and propose strategies to tackle these challenges, aiming to foster more equitable access to educational resources and technology-enhanced instruction.

Furthermore, a study by Lee et al. (2023) explored the challenges linked to pedagogical alignment in the realm of Multimedia Assisted Instruction (MAI). This research emphasizes the significance of aligning MAI with curriculum standards, learning objectives, and pedagogical strategies to boost student engagement and learning outcomes. The study investigates the difficulties encountered in ensuring that MAI effectively supports teaching practices and meets student learning needs. By addressing the challenges of pedagogical alignment, educators can enhance the integration of multimedia tools in instruction, thereby improving the overall teaching and learning experience.

Nevertheless, a study conducted by Wang et al. (2022) examined the obstacles associated with resistance to change within the framework of Multimedia Assisted Instruction (MAI). This research delves into the reasons why both educators and students might oppose the integration of technology, such as MAI, into the educational setting, citing a preference for conventional teaching methods, apprehension towards technology, or worries regarding the influence of MAI on teaching practices. The study offers valuable insights into the elements that contribute to resistance to change and proposes strategies to tackle this issue, thereby facilitating the effective incorporation of multimedia tools in education. Additionally, Ghavifekr et al. (2016) explored the challenges and issues arising from teachers' perceptions of

MAI in conjunction with the use of ICT tools during the teaching and learning process. Conversely, Abdulrahman et al. (2020) found that a significant challenge for teachers is the lack of time, which impacts their capacity to fulfill various responsibilities, with some participating teachers explicitly identifying which components of Multimedia Assisted Instruction (MAI) demand additional time.

Additionally, a study conducted by Garcia et al. (2021) examined the difficulties associated with teacher competence within the framework of Multimedia Assisted Instruction (MAI). This research investigates aspects such as educators' ability to effectively use technology, pedagogical methods for integrating technology, and the necessity for continuous professional development to improve the successful application of MAI in educational settings. The study emphasizes the significance of teacher competence in leveraging multimedia tools for instruction and discusses strategies to assist educators in enhancing their technological capabilities and teaching practices.

Furthermore, a study by Vignare et al. (2020) identified the challenges related to curricular alignment in the realm of Multimedia Assisted Instruction (MAI). The research underscores the necessity of aligning curricula across various institutions to enable the smooth transfer of credits, especially in sequential courses like introductory biology. By tackling the challenges of curricular alignment, educators can improve the effectiveness of MAI implementation and foster collaborative initiatives aimed at enhancing learning outcomes.

In addition, Chen et al. (2022) carried out a study on the utilization of Evidence-Based Practice Doctor of Physical Therapy Curricular Guidelines. This research highlights the critical need for aligning curricula with evidence-based practice guidelines to elevate the quality of physical therapy education. By exploring

the application of curricular guidelines, educators can confront challenges related to curriculum alignment and ensure that MAI effectively supports evidence-based practices in physical therapy education.

Accessibility and equity are vital factors in numerous fields, such as urban planning, public services, and education. Research has investigated the relationship between accessibility and equity to tackle disparities and foster inclusivity. Notably, a study by Mu et al. (2023) concentrated on the spatial optimization of park green spaces to enhance accessibility equity, underscoring the significance of equitable access to public land. Moreover, Chen et al. (2024) introduced a novel approach for the planning of urban park green spaces that takes into account both spatial accessibility and distributional equity, with the goal of rectifying inequities in access to green areas. In addition, Li (2024) presented a new framework for transportation planning aimed at older adults, shifting the emphasis from transportation equity to accessibility capability, thereby addressing the unique needs of older populations. By incorporating considerations of accessibility and equity into various planning initiatives, researchers strive to develop more inclusive and equitable environments for all individuals. Furthermore, studies have examined the correlation between students' participation in apprenticeships and their readiness for learning and academic performance in subjects such as mathematics (Omotayo et al., 2023).

Additionally, research into the effects of technology, including modified flipped classrooms, has demonstrated beneficial impacts on students' readiness, engagement, and comprehension across various courses, including basic science (Webb & Doman, 2020). Furthermore, investigations into the challenges faced by mathematics teachers in the teaching and learning process have emphasized the necessity of addressing students' readiness and engagement to improve instructional

effectiveness. By analyzing students' engagement and readiness, educators can customize teaching strategies to better facilitate student learning outcomes and academic success, while also shedding light on the difficulties encountered by educators in implementing Multimedia Assisted Instruction (MAI) and the essential role of institutional support in overcoming these challenges (Gumisirizah et al., 2024).

2.8 MAI as a teaching and Learning Resource

Insights derived from UNESCO's policy regarding digitalization, technology, and I.C.T indicate that Multimedia Assisted Instruction (MAI) can significantly enhance democratic and transparent educational planning and management (Mairesse, 2019). This policy is crucial in advancing initiatives that employ MAI to improve educational results and, in turn, support economic growth. By highlighting the significance of innovative educational methods, UNESCO advocates for the incorporation of technology, multimedia tools, and digital platforms within educational environments (Tammaro et al., 2017). By aligning their educational practices with UNESCO's policies that endorse the implementation of MAI, educational institutions can cultivate a skilled workforce, encourage entrepreneurship, and stimulate economic development through improved learning outcomes and technological progress (Okoye et al., 2023).

Multimedia tools, including simulations, videos, graphs, and images, significantly contribute to broadening access to education by improving engagement, comprehension, and accessibility. The effectiveness of multimedia and mobile learning in English instruction highlights how technology aids in the delivery of educational content and fosters more engaging learning experiences. By integrating multimedia components into educational resources, educators can address various learning styles and preferences, thereby making intricate concepts more

understandable and accessible to students. Furthermore, Tuharea et al. (2023) examined the application of multimedia technology in the development of digital learning content, underscoring the beneficial effects of technology on the educational process. Multimedia tools facilitate the creation of interactive and visually appealing learning materials, offering students opportunities for self-directed and personalized learning experiences. Additionally, Prasetyo et al. (2022) created Android-based multimedia learning tools for recognizing human body anatomy, illustrating how technology can improve access to educational resources, particularly in the health sector. By utilizing multimedia resources, educators can provide interactive and immersive learning experiences that accommodate various learning preferences and capabilities.

Furthermore, digitalization and technological tools, such as multimedia-assisted instruction resources, are essential in reshaping the teaching and learning process. Additionally, Peng (2023) examined the role of mobile devices in language learning, emphasizing how multimedia tools, including English newspaper reading applications, improve language acquisition and student engagement. Moreover, Feng (2023) analyzed the advantages and disadvantages of multimedia-assisted instruction technology in college music education, illustrating how these tools enhance teaching content and learning outcomes. By incorporating digitalization and multimedia resources into the educational process, teachers can develop interactive, engaging, and personalized learning experiences that address various learning styles and preferences. These technological tools enable access to information, encourage active participation, and improve comprehension, ultimately revolutionizing the conventional teaching and learning model.

Integrating multimedia-assisted instruction (MAI) resources with social media applications such as Twitter, Facebook, YouTube, Telegram, Snapchat, WhatsApp, Instagram, and Wikipedia can significantly enhance the teaching and learning experience in multiple ways. This integration has led to increased engagement and interaction. By utilizing social media platforms alongside MAI resources, educators can foster interactive learning environments that promote student involvement and collaboration. Platforms like Twitter and Facebook support communication and discussions among students, nurturing a sense of community and facilitating peer-to-peer learning (Yu et al., 2023).

Moreover, it has resulted in access to a variety of educational content. Social media platforms such as YouTube and Wikipedia offer a wide range of multimedia resources, including videos, articles, and tutorials. Nevertheless, Neal (2023) conducted research on note-taking to investigate the impact of guided notes and interactive notebooks on student performance in algebra during mathematics examinations in colleges. By incorporating these platforms into MAI resources, students are able to explore a variety of content, thereby improving their comprehension of intricate concepts. Platforms like Instagram and Snapchat can be employed to link classroom learning with real-world situations and experiences. Educators can utilize these visual platforms to illustrate the practical applications of theoretical concepts, making the learning experience more relatable and engaging for students. Hennessy et al. (2022) determined that by utilizing social media applications within MAI resources, educators can create a dynamic and interactive learning environment that encourages collaboration, access to diverse content, and real-world relevance, ultimately enhancing the overall teaching and learning experience.

Multimedia-assisted instructional resources significantly contribute to the enhancement of the teaching and learning process by offering engaging, interactive, and varied learning experiences. By integrating multimedia components such as videos, simulations, graphs, and interactive presentations, educators can address different learning styles, reinforce concepts through visual aids, and encourage active participation among students (Luo et al., 2022).

Additionally, a study conducted by Feng (2023) underscored the significance of multimedia technology in college music education, illustrating how multimedia-assisted instruction enriches teaching content and enhances learning outcomes, thereby overcoming the constraints of traditional teaching methods. Furthermore, the research by Hou and Zhou (2022) concentrates on the integration and optimization of multimedia network-assisted English teaching resources. By utilizing association rule algorithms, educators can improve the quality of English teaching materials and offer personalized learning experiences for students.

In a similar vein, social media platforms like Twitter are increasingly being employed by both students and educators as Multimedia Assisted Instruction (MAI) tools to improve the teaching and learning experience. Research conducted by Kimani (2023) investigates the attitudes and perceptions of online instructors regarding the use of social media in educational contexts, illuminating the advantages and challenges linked to utilizing platforms such as Twitter in teaching environments. By incorporating Twitter into MAI resources, educators can promote real-time communication, collaboration, and information exchange between students and instructors. Tumwebaza (2023) suggested a machine-learning-based framework for managing misinformation in Uganda, utilizing word 2-vector and long short-term memory techniques; the platform's microblogging format facilitates brief and

interactive discussions, allowing for the swift distribution of information, resources, and feedback. Furthermore, social media platforms like Twitter create opportunities for increased engagement and interaction, nurturing a sense of community and connectivity among learners. In summary, the incorporation of Twitter and other social media platforms into MAI resources provides a vibrant and interactive learning atmosphere that enhances communication, collaboration, and engagement, ultimately benefiting the educational process. Mobile technologies, including smartphones, iPads, iTunes, and smartwatches, as well as handheld digital assistants and ubiquitous laptops, play a vital role in improving the teaching and learning process through Multimedia Assisted Instruction (MAI). Additionally, Ngao et al. (2023) highlighted the transformative influence of mobile technologies in initial teacher education programs, underscoring how these tools facilitate access to educational materials, encourage interactive learning experiences, and support teacher training.

However, educators' perspective have been raised on adapting these kinds of tools and creative media skills to enhance simulation-based learning in education. Technologies such as virtual reality (VR) headsets, augmented reality (AR) applications, simulation software, and interactive multimedia tools play a crucial role in creating immersive and engaging simulation experiences for learners Zheng (2023). Additionally, the integration of mobile devices, tablets, and laptops equipped with simulation software allows students to access simulations anytime, anywhere, promoting hands-on learning and skill development (Nyenga, 2021). By leveraging these resources, educators can provide realistic and interactive simulation experiences that enhance learning outcomes and prepare students for real-world applications.

In a similar vein, various resources can be employed in animation as Multimedia Assisted Instruction (MAI) media to improve the teaching and learning

experience. Technologies including animation software, graphic design applications, video editing tools, and online platforms for producing animated content provide educators and students with the ability to create captivating and interactive learning materials (Suselo et al., 2019). Afify (2018) confirmed that video creation software, utilizing tools such as Adobe Premiere Pro, Camtasia, or iMovie, is effective for producing and editing educational videos. These resources empower educators to craft engaging video content that visually elucidates complex concepts in Biology topics like genetics and heredity, thereby enhancing learning through demonstrations and examples.

Furthermore, the research conducted by Lafifa (2023) focused on the development and validation of animation-based science learning media within the stem-l model, aimed at enhancing students' critical thinking and digital literacy through creative tools utilized in animation software such as Adobe Animate. This approach enables educators to produce animated content that clarifies abstract biological concepts, making the learning experience more interactive and engaging, particularly for visual learners.

In addition, a study by Abdulrahman et al. (2020) examined tools employed in Simulation Platforms like PhET Interactive Simulations, Labster, or Sim Scale, which offer interactive simulations that empower students to investigate real-world scenarios, perform experiments, and visualize abstract concepts within a virtual setting.

Moreover, Kone (2022) explored the effective application of quiz tools such as Kahoot, Quizizz, or Google Forms, which allow educators to design interactive quizzes and assessments that engage students, deliver immediate feedback, and effectively evaluate learning outcomes. The incorporation of these resources into

interactive multimedia presentations as part of Multimedia Assisted Instruction (MAI) significantly enhances the teaching and learning process in various ways. These resources encourage active participation, accommodate diverse learning styles, support self-paced learning, provide prompt feedback, and cultivate critical thinking and problem-solving abilities among students.

Furthermore, resources are employed in graphics within Multimedia Assisted Instruction (MAI) to improve the teaching and learning experience. Common resources utilized in graphics for MAI include Graphic Design Software, which consists of tools such as Adobe Photoshop, Canva, and GIMP, allowing educators to produce visually attractive graphics, diagrams, and illustrations that clarify complex concepts and enhance educational materials. Infographic creation tools and platforms like Piktochart and Vengage enable educators to craft informative infographics that present data and information in a visually appealing and easily comprehensible manner. Moreover, Interactive whiteboards and Presentation Software, including SMART Boards and presentation software like Microsoft PowerPoint, empower educators to develop interactive graphics, annotations, and visual aids during Biology lessons, fostering student engagement and participation. By integrating these graphic resources into MAI, educators can enhance teaching and learning in various ways. Visual graphics assist in simplifying abstract concepts in Biology, improve comprehension, engage visual learners, and render learning materials more interactive and memorable for biology students.

Additionally, graphics resources can facilitate information retention, stimulate critical thinking, and promote creativity in the learning process, ultimately enhancing the overall educational experience for students (Zheng *et al.*, 2023). Similarly, Virtual and Augmented reality utilize virtual reality (VR) and augmented reality (AR)

technologies to create immersive learning experiences that allow students to explore concepts in a dynamic and interactive virtual environment. Additionally, Hisan and Mudzakir (2024) emphasized on the development of geography microlearning media content assisted by Instagram platform to learn inland waters for high school students' animation and visual aids incorporate animations, infographics, diagrams, and visual aids to make complex concepts more understandable and engaging for students, enhancing comprehension and retention of information.

Barbulet (2023) examined various alternative options, including multimedia tools such as images, the Internet, newspapers, radio, and television, that can be utilized in language instruction to enhance the educational experience. Furthermore, Shrivastava (2015) investigated the initiatives aimed at improving digital literacy among elementary students through the implementation of technology-based learning media.

Conversely, Wang et al. (2023) analyzed the application of multimedia technology in interactive translation learning for students. Their study explores how multimedia resources, such as images, can convert traditional educational materials into interactive digital formats, thereby enriching the learning experience through the integration of diverse multimedia technologies, including images, within educational environments. Moreover, the incorporation of multimedia resources in Multimedia Assisted Instruction (MAI), which includes images, videos, and simulations, has been demonstrated to enhance students' understanding and retention of information. Visual aids and interactive components assist in elucidating complex concepts, reinforcing learning, and improving knowledge retention among students (Luo et al., 2022).

Additionally, Latha (2023) noted a significant improvement in the digital divide among Malaysian tertiary students and its effects on online learning during the

COVID-19 pandemic. Multimedia Assisted Instruction has empowered educators to customize resources to accommodate individual student needs, preferences, and learning styles, offering the flexibility to tailor content, provide multimedia materials, and present interactive exercises.

A study conducted by Feng (2023) indicates that MAI tools foster personalized learning experiences that address diverse student needs. Tools associated with MAI, such as interactive presentations, simulations, and multimedia content, have rendered learning more engaging and interactive for students. By integrating visuals, animations, and interactive features, MAI has heightened student involvement and interest in the learning process.

Feng (2023) examined the advantages and disadvantages of multimedia-assisted instructional technology in the context of college music education. The research highlighted how the incorporation of multimedia technology in music instruction can transcend traditional teaching boundaries, enhance content delivery, and elevate teaching quality by providing students with direct access to abstract concepts.

In a study by Xenofontos et al. (2016), two conditions were analyzed: the experimental condition, which involved the use of the Experiment Design Tool (EDT), and the control condition, which did not utilize the EDT. Within each condition, an Inquiry Learning Space (ILS)—an online educational environment—and a virtual laboratory were chosen from the Go-Lab learning platform, recognized as EDT. The findings indicated that the integration of the EDT within a computer-supported inquiry learning environment promoted the enhancement of content knowledge, while the cultivation of inquiry skills necessitated a more extended engagement with such EDT tools or learning environments. Conversely, Shrivastava

(2015) investigated the influence of a multi-user virtual environment ecosystem on a middle-grade curriculum initiative, which encouraged students to take on the role of scientists, allowing them to explore research questions by navigating the project's virtual environment and gathering and analyzing data from diverse sources over time. The results of the project research revealed that although students were initially focused on the technology interface itself, they gradually became more involved in the student-led, collaborative inquiry experiences facilitated by the integrated scientific investigation. Furthermore, Fatayer (2016) has emphasized the advantages of employing multimedia resources in educational and training contexts, illustrating their efficacy in improving learning results and skill acquisition.

By integrating Multimedia-Aided Instruction (MAI) resources into professional and educational environments, organizations and institutions can establish vibrant and interactive learning spaces that encourage knowledge gain and skill development. The application of MAI resources has greatly improved both work and education by offering interactive and captivating learning experiences. MAI resources provide visual and auditory stimuli that accommodate various learning preferences, thereby enhancing information retention and comprehension.

Moreover, MAI resources support self-directed learning, enabling individuals to progress at their own pace and revisit material as necessary. This adaptability boosts work efficiency and educational achievements by fostering a more profound understanding of intricate concepts and nurturing critical thinking abilities. Additionally, MAI resources support self-directed learning, enabling individuals to progress at their own pace and revisit material as necessary. This adaptability boosts work efficiency and educational achievements by fostering a more profound understanding of intricate concepts and nurturing critical thinking abilities.

According to Haleem et al. (2022), research has been conducted to understand the role of digital technologies in education, which have heightened the significance and conceptualization of education. This has led to the establishment of new communication models and the creation of spaces for training, information exchange, debate, and reflection, among other activities, while also dismantling the barriers of traditionalism within the classroom. Furthermore, Kellner and Share (2019) explored the critical media literacy guide, which significantly impacts media engagement and transforms education by moving away from traditional media, such as boards and pens, and fostering a teaching approach that emphasizes the necessity for training and updating one's knowledge in accordance with current educational demands. This is due to the fact that multimedia-assisted instruction has been shown to enhance student engagement, resulting in an increased amount of time that students dedicate to studying outside of class when it is integrated into the teaching and learning process (Aprianto, 2020).

Multimedia Aided Instruction (MAI) resources provide numerous advantages in both professional and educational environments, notably resulting in increased engagement. MAI resources deliver interactive and visually appealing content that captures the attention of learners and boosts engagement. This heightened engagement can facilitate better retention of information and comprehension. Furthermore, a study by Rumiantseva et al. (2023) examined the significance of multimedia in enhancing educational quality. The findings indicate that the incorporation of innovative technologies into the educational framework can greatly improve students' grasp of the subject matter and elevate the overall quality of education. This tailored approach addresses various learning styles and fosters a more profound understanding of concepts. Additionally, the same research conducted by

Cabanilla (2023) demonstrates that MAI resources contribute to the development of critical thinking abilities, creativity, and digital literacy, all of which are vital in today's job market. This methodology not only enhances skill acquisition but also equips individuals to meet the challenges of the contemporary workplace.

Multimedia Aided Instruction (MAI) resources have greatly enhanced educational technology by facilitating the implementation of android-based interactive multimedia for student learning activities, thereby improving the overall learning experience and educational outcomes for students (Utami et al., 2023).

Furthermore, by integrating multimedia elements into instruction, MAI resources contribute to the development of critical thinking skills, creativity, and digital literacy, which are vital in today's digital age. This methodology not only enhances skill development but also equips students to face the challenges of future workplaces.

Dandan et al. (2024) conducted a study focusing on the teaching methods for digital skills and the development of computer literacy among students. This research highlights the significance of developing computer skills, critical thinking, communication abilities, and the capacity to incorporate the latest technologies into the teaching and learning processes.

Moreover, a similar study by Wu et al. (2024) emphasized a thorough exploration of personalized learning within smart education, ranging from student modeling to personalized recommendations that enhance various learning styles while considering fundamental user details, course materials, and student interactions, accurately capturing FSLSM learning styles. Their findings indicate that educational technology enhances the quality of education by emphasizing that MAI resources facilitate self-paced learning, allowing students to advance at their own pace and

revisit content as necessary. This personalized approach accommodates diverse learning styles and fosters a deeper comprehension of concepts, including instructional materials and the behaviors of all participants in the educational process. Additional research has also supported the notion that MAI can elevate educational quality and connect learning to real-life situations.

2.9 Availability of MAI Resources for Integration of MAI in Classroom

One of the most remarkable aspects of MAI integration in education is the accessibility of MAI resources. If these materials are not present in schools, effectively utilizing MAI in the classroom may prove challenging. A study by Srinivasan (2024) examining Nigerian secondary physics teachers' views on the obstacles to integrating information and communication technology indicates that limited access to technology devices and insufficient technological infrastructure in schools can obstruct the incorporation of multimedia resources. The unequal distribution of resources and unreliable internet connectivity may hinder teachers' capacity to effectively integrate multimedia tools into their teaching practices. Additionally, a study conducted by Tamrin et al. (2017) investigated the challenges faced by teachers in optimizing the use of learning media in Padang. This research employed a descriptive qualitative method to collect data, with the researcher serving as the primary instrument and the teachers as the key informants, while the principal acted as the secondary informant. The findings reveal that teachers expressed satisfaction with their current practices and felt no necessity for change or development in their teaching and learning patterns with the aid of media. The research concludes that teachers believe that teaching does not accommodate various types of media, resulting in a lack of proficiency in utilizing learning media. This study recommends that teachers alter their habits regarding media usage, while school

leaders should provide opportunities for them to incorporate media into their teaching processes. In Ghana, a study conducted by Atabek (2019) aimed to investigate the incorporation of technology within teacher education. The findings of the study indicated that one of the significant challenges faced by Ghana in implementing Multimedia Assisted Instruction (MAI) in classrooms pertains to issues surrounding access and technological infrastructure. The research underscored the necessity of tackling access and infrastructure challenges to successfully incorporate MAI resources into educational environments. Atabek (2019) highlighted the difficulties associated with the integration of technology in education. The results indicated that the hardware itself does not constitute the primary barriers to technology integration. A lack of both in-service and pre-service training, along with insufficient content support and incentive systems, emerged as major perceived hindrances to technology integration. Furthermore, the inadequacy of physical and technological infrastructure was identified as a crucial obstacle to effective integration. Interestingly, the novelty of the technologies in comparison to older ones was not found to impede technology integration.

Furthermore, Ameen (2023) conducted research on the progress of crowd-monitoring systems, providing a thorough analysis of systematic methodologies and automation algorithms. This research holds significant implications for the burgeoning field of smart cities. By offering a tool that aids in decision-making and the planning of public safety strategies, this study contributes to the creation of innovative, data-driven, and theory-informed solutions to tackle urban challenges. In addition, Axhami (2023) investigated the role of information and communication technologies as a vehicle for education in Albania. The research highlighted that the effective integration of ICT in teaching necessitates a substantial level of

digitalization of services and infrastructure, along with the enhancement of teachers' digital competencies.

Moreover, James and Olaniyan (2024) performed a study aimed at addressing the issue of out-of-school children in rural regions through a media integration strategy in Oyo State, Nigeria. This research evaluated how a media integration approach could be employed to combat the issue of out-of-school children, particularly in the rural areas of Oyo State. Their findings underscored the necessity of equipping educators with digital literacy skills to effectively leverage modern media tools for educational objectives. Additionally, Dewanto et al. (2024) focused on the impact of digital literacy, innovative mindsets, and interpersonal communication on teacher performance.

Although individual studies may not be linked to a specific researcher, the recognition of pedagogical integration as a vital element affecting the effective application of MAI resources in educational practices is a common topic in the literature on educational technology. Nevertheless, Long et al. (2024) reached a consensus on the influence of tradition and technology, as a review of multimedia integration in Guizhou's vocal music research highlights the necessity for educators to thoughtfully design and incorporate multimedia components in a pedagogically sound way, ensuring that technology enhances the learning experience rather than detracting from it. Likewise, tackling the issue of pedagogical integration necessitates professional development opportunities for teachers to improve their instructional design capabilities and digital literacy. By providing educators with the knowledge and strategies to successfully integrate MAI resources into their teaching methodologies, schools can address the challenges related to pedagogical alignment and foster engaging and effective learning experiences for students (Cheng & Wang,

2023). This research uncovered the leading digital transformation and the removal of obstacles for teachers to implement artificial intelligence in basic education in Hong Kong. However, a study conducted by Olanrewaju et al. (2021) examined the impact of digital disparities on e-learning in rural secondary schools and remote communities throughout Nigeria during the COVID-19 pandemic. The research utilized a concurrent embedded mixed-method design to gather data from rural secondary schools across six Nigerian states. The findings from this study revealed a deficiency in ICT strategies and policies in Nigeria, along with socioeconomic status, inadequate internet connectivity, electricity issues, and a high poverty rate as the main factors contributing to digital gaps in remote areas, which can impede the integration of MAI resources and limit students' access to multimedia learning tools.

A study by Onwukwe et al. (2020) highlighted the evaluation and application of information and communication technology in the instruction of vocational subjects within the Ika North East Local Government Area of Delta State. The findings indicated that while most schools possess ICT facilities, these resources are not being fully utilized by both teachers and students. This underutilization is attributed to overcrowding in many schools and the limited availability of ICT resources. In light of these findings, the study recommends that the government should provide a substantial number of functional ICT facilities that are accessible to both teachers and students, and that the costs associated with these ICT resources should be subsidized to facilitate their acquisition. Furthermore, the government should review the curriculum to include the integration of ICT facilities, among other recommendations. Additionally, the study identified several challenges that hindered the use of multimedia assisted instruction (MAI) in these schools, including inadequate MAI skills, rising MAI costs, and poor physical infrastructure. A separate

study conducted in Ethiopia indicated a lack of proper access to MAI in teaching and learning practices. The data analysis from that study revealed that the objective of incorporating multimedia assisted instruction into educational practices has not yet been achieved (Alemu, 2015). Moreover, an investigation into the availability and utilization of MAI resources in secondary schools located in Ardo-Kola and Jalingo, Taraba State, Nigeria, found that the availability, accessibility, and use of MAI resources for educational purposes were all significantly low. According to over 80% of respondents, MAI resources were not present in the schools surveyed; however, multimedia resources could be accessed and utilized by both teachers and students for educational purposes (Onwuagboke et al., 2014).

Ghana has achieved significant advancements in reforming its educational system. The government of Ghana is of the opinion that multimedia-assisted instruction can enhance both educational access and quality (Ofori, 2022). This research focused on the perceptions of Senior High School teachers regarding the incorporation of multimedia in the teaching of fundamental economic concepts. In 2003, Ghana introduced the multimedia for Accelerated Development (ICT4AD) education policy (Soma et al., 2021). Nevertheless, Fiakofi (2018) examined the relationship between multimedia usage and the academic performance of students in Physics at Adisadel College, located in Cape Coast, Ghana. Ultimately, a decade-long study indicated that Ghana experiences a low level of penetration of multimedia-assisted instruction (MAI) infrastructure, including the internet, mobile phones, and television; consequently, access to multimedia is limited to a small number of individuals in urban schools (Grimus, 2017).

2.10 Teachers' and Students' MAI Skills and knowledge

The MAI skills possessed by both teachers and students are crucial in shaping their attitudes and utilization of MAIs within the educational framework. These skills can significantly affect how teachers and students engage with MAIs during classroom activities. Additionally, the level of knowledge that teachers and students have regarding MAIs can further impact their selection and application of these tools in the teaching and learning environment. Furthermore, a study conducted by Rizqiyah et al. (2024) underscored the significance of teachers' digital literacy and Technological Pedagogical Content Knowledge (TPACK) in the creation of effective Multimedia Assisted Instruction (MAI) resources. Educators who possess a comprehensive understanding of MAI tools are better equipped to choose suitable multimedia resources that correspond with curriculum goals and teaching strategies. However, research by Nasution et al. (2022) highlighted the development of problem-based learning scenarios grounded in the fundamental concepts of integrated environmental courses within social education.

Another study conducted by Aboufotouh (2024) on the use of pro writing aid and the BASDELL model in Business English writing classes for management sciences students reveals that teachers' comprehension of Multimedia Assisted Instruction (MAI) can greatly impact student engagement and learning outcomes.

When educators are skilled in employing technology-enhanced resources, they can create interactive and engaging lessons that cater to diverse learning styles, potentially improving student understanding and retention. The awareness of both teachers and students regarding MAI can influence the integration of technology into the curriculum. Educators with a solid understanding of MAI can seamlessly

incorporate multimedia elements into their lesson plans, thus fostering a dynamic and interactive learning environment (Khamparia, 2018).

This research explores the impact of interactive multimedia in e-learning technologies and the function of multimedia in e-learning and digital multimedia. On the other hand, a different study by Rumiantseva et al. (2023) emphasized the importance of using multimedia tools to improve educational quality. However, findings from Zhang et al. (2022) suggested that although teachers have some knowledge about internet usage in teaching and learning, they face challenges in effectively integrating the internet into their instructional methods. The research also revealed that teachers' understanding of MAI and network technology is significantly limited. Furthermore, a study by Azmi (2018) indicated that trainee teachers in Malaysia show confidence in incorporating MAI into their teaching practices, with male teachers exhibiting greater confidence than their female counterparts in using MAI for instruction.

Furthermore, various research studies indicate that vocational educators may demonstrate increased confidence in employing Multimedia-Aided Instruction (MAI) in their teaching and learning processes, attributed to several factors inherent to their educational environment and professional experience. Pertaining to vocational subjects, a study conducted by Onwulji et al. (2018) examined the influence of multimedia-aided instruction on the interest of junior secondary one students in geometry. The findings revealed that students who were taught geometry through multimedia-aided instruction exhibited a higher level of interest in learning the subject compared to those who received instruction via traditional methods. Additionally, the study found that both male and female students in the experimental group displayed similar interest ratings. Consequently, the study recommended,

among other suggestions, that mathematics educators should be encouraged to incorporate multimedia-aided instruction within their mathematics classrooms. Similarly, research by Arriesgado et al. (2024) investigated the effects of technology-aided instruction and demonstration lesson methods in teaching cookery, aiming to identify the underlying reasons for the challenges and skill deficiencies, and to determine the effectiveness of technology-aided methods in teaching cooking to junior and senior high school students. The study underscored the importance of addressing issues related to the termination of educational foundations, boundary limitations, self-segregation, and social segregation.

Additionally, Wang *et al.* (2023) investigated on the learning assistants and the use of questioning in online courses about introductory physics which increased the teacher-student ratio and provide timely support to student exploration. MAI resources can complement this approach by providing multimedia tools that simulate real-world scenarios, offer virtual simulations, and enhance practical skill development, leading to increased confidence among vocational teachers in utilizing such resource. Vocational teachers often receive training and professional development in the use of technology for skill development and workplace readiness. This exposure to technology integration strategies and tools can enhance vocational teachers' confidence in incorporating MAI resources effectively in their teaching practices (Zhan, 2024).

Nonetheless, a study conducted by Wang (2022) indicates that a deficiency in diversity among educators, especially regarding minority representation, could restrict the variety of perspectives and experiences that are integrated into the use of MAI resources within the classroom. Educators from varied backgrounds can provide distinctive insights that enhance the selection and application of technology-enhanced

learning tools. The lack of diversity among teachers, particularly concerning minority representation, may limit the spectrum of perspectives and experiences involved in the incorporation of MAI resources in educational settings. Minority educators may contribute cultural relevance and sensitivity to the selection and application of MAI resources, ensuring that educational materials resonate with a diverse student body. This can improve the effectiveness of MAI in meeting the needs and preferences of students from various cultural backgrounds (Brown et al., 2022). However, Sloan (2013) performed a study on the use of multimedia to improve the accessibility of the learning environment for disabled students, reflecting on the skills for accessible project. Furthermore, Mendoza (2023) in Australia highlighted the importance of diversity and inclusion in education, revealing that the minority representation of teachers can impact the use of multimedia by encouraging culturally responsive teaching practices, facilitating the integration of Indigenous perspectives in multimedia resources, and addressing the digital skills gap within marginalized communities. Research such as that by Smith (2022) and Chen et al. (2023) has shown that a majority of teachers lack the preparedness and skills necessary to utilize technology-enhanced learning tools, including MAI. These studies have suggested that while some educators exhibit advanced capabilities in incorporating multimedia resources into their teaching, others may possess average or limited knowledge in this domain.

In a separate investigation conducted by Ghavifekr et al. (2016), the results indicated that educators were not proficient in utilizing technological software and hardware within the teaching and learning framework. They noted that 55.6% of teachers were unable to employ MAI as instructional tools. This suggested that a significant number of instructors at the College were not incorporating MAI into their

courses. Nevertheless, many identified that a primary obstacle to the implementation of technology was the lack of technical knowledge among teachers and the scarcity of resources. Furthermore, Mensah et al. (2022) highlighted the importance of technology integration in the teaching and learning of geography in senior high schools across Ghana. Consequently, this study aimed to evaluate the knowledge of Senior High School Geography teachers regarding the integration of technology into their classrooms, utilizing the Technological Pedagogical Content Knowledge (TPACK) model as an analytical framework. The research employed a descriptive survey design to deliver a thorough examination of the research issue. A total of 113 geography teachers participated in the study by completing a TPACK survey questionnaire. The data were analyzed through mean and standard deviation calculations. The study's findings revealed that teachers exhibited a high level of content and pedagogical knowledge in geography.

A study conducted by Wang (2024) examined in-service teachers' views on the integration of technology in English as a foreign language classroom in China, revealing that resource limitations, including inadequate access to suitable technology tools, insufficient technical support, and restricted funding for multimedia instructional resources, can hinder the effective implementation of technology-enhanced learning in educational contexts. Furthermore, research by Rumiantseva et al. (2023) highlighted the significance of multimedia in enhancing educational quality. Additionally, Bwalya et al. (2024) investigated the development of technological pedagogical content knowledge among pre-service biology teachers through a TPACK-based approach. The findings of the study suggest that teacher training institutions should consider the introduction of content-focused technology integration courses that actively involve pre-service teachers in microteaching lesson studies,

encouraging reflection on technology use and collaborative design of curriculum materials that incorporate technology to support their TPACK development, thereby promoting effective multimedia-assisted instruction in the teaching and learning process.

2.11: Conceptual Framework

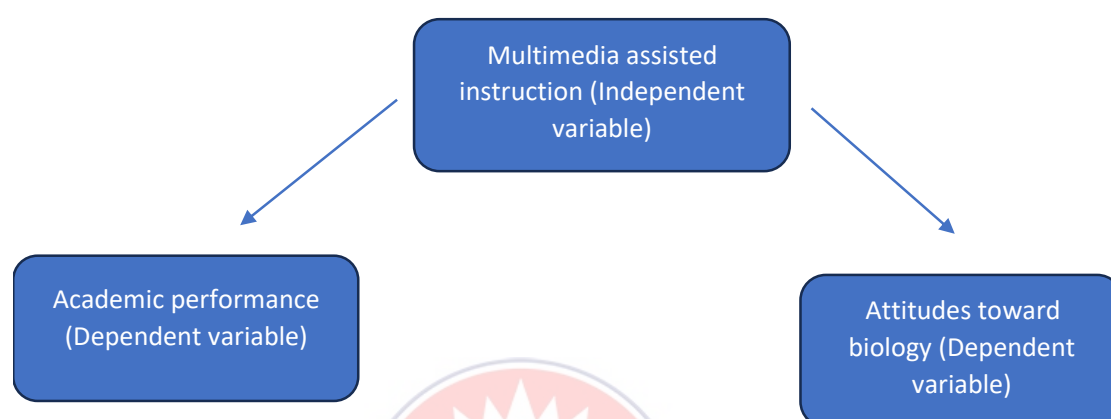


Figure 1: Conceptual Framework

The conceptual framework for this research is structured to demonstrate the connection between multimedia-assisted instruction (MAI), students' academic performance, and their attitudes towards biology concepts.

This framework includes several essential elements: the independent variable (multimedia-assisted instruction), the dependent variables (academic performance and students' attitudes), and the mediating factors that affect the efficacy of multimedia instruction.

The framework illustrates the interplay between multimedia-assisted instruction and students' academic performance and attitudes. It suggests that when MAI is effectively executed, it can enhance academic performance by improving students' comprehension of intricate biology concepts through engaging and interactive content. At the same time, MAI can have a favorable impact on students' attitudes towards biology by rendering the subject more approachable and enjoyable.

The framework acknowledges that the influence of Multimedia-Assisted Instruction (MAI) is influenced by various factors, including teacher proficiency, access to technology, student engagement, cultural relevance, and gender. These elements can either improve or impede the effectiveness of multimedia-assisted instruction, depending on how they are managed within the educational setting.

Multimedia-assisted instruction encompasses the utilization of a range of digital and multimedia resources, such as videos, animations, simulations, interactive software, and virtual laboratories, in the educational process (Rumiantseva et al., 2023). These resources aim to enrich the learning experience by rendering abstract concepts more accessible, engaging, and comprehensible for students. MAI incorporates visual, auditory, and kinesthetic learning modalities to accommodate various learning styles, and it frequently includes interactive components that promote active participation from students (Budiarto & Rejekiningsih, 2021).

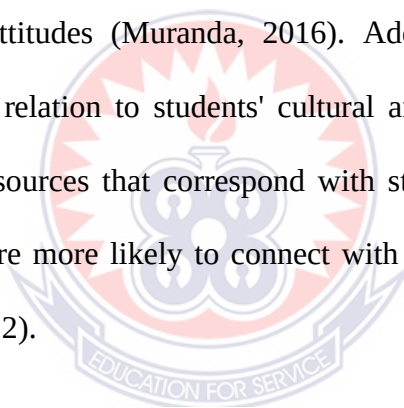
Academic performance pertains to the level of achievement attained by students in biology, as evaluated through their scores on assessments, tests, and examinations (Moon et al., 2021). An enhancement in academic performance signifies that students have successfully comprehended and retained the concepts presented, showcasing their capability to apply knowledge in both theoretical and practical scenarios.

Students' attitudes towards biology include their interest, motivation, and general perception of the subject (Cimer, 2012). A favorable attitude towards biology is marked by heightened enthusiasm for learning, a greater readiness to engage with the material, and a more positive perspective on the subject's significance for their future studies and careers. The proficiency of teachers in effectively incorporating multimedia tools into their lessons is essential. Educators must be adept at utilizing

technology, selecting suitable multimedia content, and crafting lessons that optimize the advantages of these tools.

The presence of technological resources, including computers, tablets, projectors, and dependable internet access, is vital in influencing the effectiveness of multimedia-assisted instruction (Jawaid & Tariq, 2018). In the absence of sufficient access to technology, the potential advantages of MAI may not be fully achieved.

The degree of student involvement with multimedia content can greatly influence the results of MAI (Fiakofi, 2018). Students who are engaged tend to participate actively in learning activities, delve into interactive components, and dedicate time to comprehending the material, which results in improved performance and more favorable attitudes (Muranda, 2016). Additionally, the significance of multimedia content in relation to students' cultural and educational backgrounds is crucial. Multimedia resources that correspond with students' experiences, language, and prior knowledge are more likely to connect with them and promote meaningful learning (Tasneem, 2022).



CHAPTER THREE

M ETHODOLOGY

3.0 Overview

This chapter outlines the research methodology used for the study. The chapter describes the research design and research instruments used in the study. It also justifies the selection of the samples and research instruments and also indicates how issues of validity and reliability were addressed.

3.1 Research Approach

The research utilized a mixed methods approach, incorporating both quantitative and qualitative strategies (Cohen et al., 2018). Mixed method research is defined as a study carried out by one or more researchers that integrates various elements of both quantitative and qualitative research methodologies, along with the types of conclusions derived from the research. As noted by Cohen et al. (2018), the aim of mixed methods is to provide a more comprehensive and dependable understanding of a phenomenon than what a single approach could achieve. Creswell (2014) states that mixed method research can elucidate the mechanisms underlying phenomena and offer various perspectives on them, thereby enhancing the relevance and credibility of the findings and facilitating the identification of unexpected results. In instances where data is collected through multiple approaches to analyze how the findings align, the application of mixed method research serves as a means of triangulation. Quantitative methods concentrate on testing hypotheses, gathering standardized data, and performing statistical analyses (Creswell, 2012). The strength of quantitative research is its reliability, ensuring that the same measurements consistently produce the same results over time (Sadık, 2019). In this study, quantitative data was collected through pre-test and post-test scores.

The method of naturalistic inquiry that aims to get a thorough knowledge of social phenomena in their natural settings is known as qualitative research. In qualitative research, non-numerical data is gathered and analyzed to better comprehend ideas, viewpoints, or experiences. It might be utilized to uncover intricate details about an issue or come up with fresh study concepts.

3.2 Research Design

Cohen et al. (2018) describe research design as the foundational structure of a study that outlines the theory and methodology to be employed, the necessary types of data, the instruments to be utilized, the sources of data (the population and sample), the methods for data analysis, interpretation, and reporting, the justifications to be presented to substantiate the conclusions reached, and the level of confidence that can be attributed to the results. This research adhered to an action research design.

3.2.1 Action research design

Action research represents a targeted intervention within the real world aimed at resolving the issues faced by practitioners, along with a thorough analysis of the outcomes resulting from such an intervention (Cohen et al., 2018).

Cohen et al. (2018) delineate an eight-step procedure to be adhered to when conducting action research. The eight steps include identifying the problem, exploring potential interventions to tackle the issue, selecting a specific intervention, planning the intervention with established success criteria, executing the intervention, monitoring and documenting the implementation and its effects, reviewing and assessing the intervention, and evaluating the effectiveness of the intervention in resolving the problem.

Figure 2 presents the cyclical procedure for action research

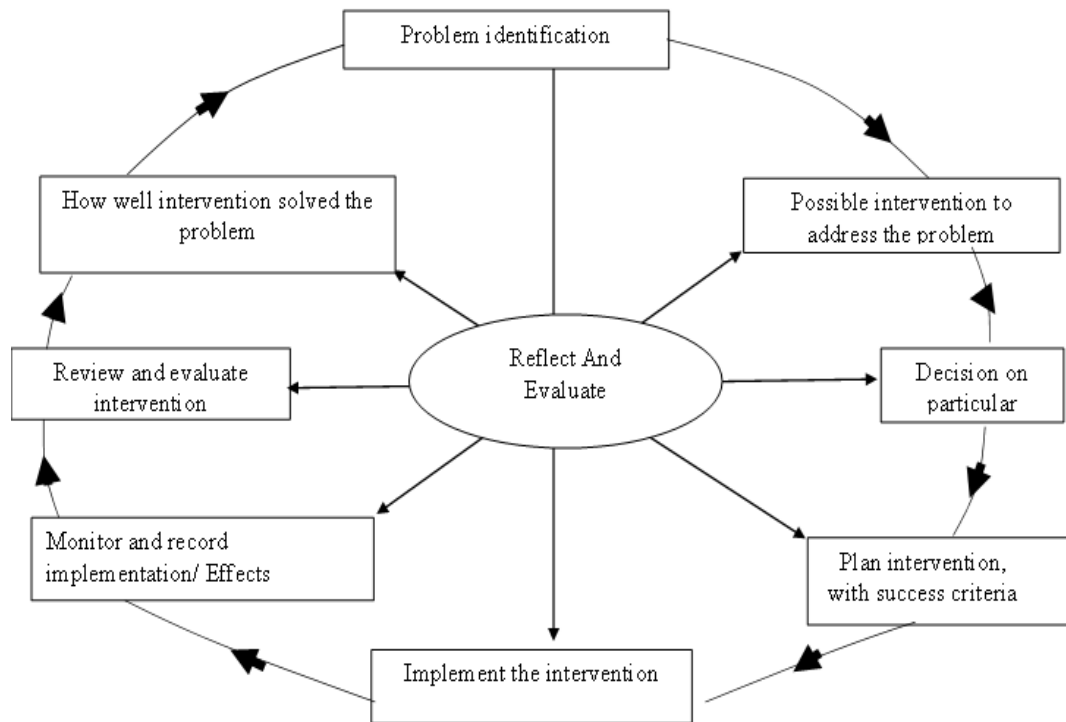


Figure 2: Cyclical Procedure for Action Research

3.3 Population

According to Feng (2023), the term population denotes the complete set of individuals or elements that fulfill particular criteria or characteristics that the researcher aims to investigate. The population within a study consists of individuals, groups, organizations, or other entities that are the focus of the research and to which the results of the study may be applicable or generalized (Denscombe, 2017). Robinson (2014) characterized population as the entire collection of individuals, objects, or events that exhibit specific criteria or characteristics relevant to the researcher. In this study, the population comprises students from Winneba Senior High School.

3.3.1 Target population

All students offering Biology in Winneba Senior High School in the Effutu Municipality.

3.3.2 Accessible population

A total of 60 students from 2 science 3 were selected for this study comprising of 28 males and 32 females.

3.4 Sample and Sampling Techniques

Zhang et al. (2023) characterized sampling as the procedure of selecting a subset of individuals, items, or elements from a broader population for the purpose of conducting research or a study. This process entails choosing a representative sample that mirrors the characteristics of the population of interest, enabling researchers to draw conclusions and make inferences about the larger group based on the data gathered from the sample. Sampling techniques are essential in research to guarantee the validity and generalizability of study results to the target population. Liu et al. (2017) articulated sampling as the systematic process of selecting a subset of individuals, items, or elements from a larger population to represent and examine specific characteristics of interest. By utilizing various sampling methods tailored to the research objectives, researchers can ensure the reliability and validity of their study results. Liu et al. (2017) elaborated on the different types of sampling methods employed in research, which include: Random sampling, stratified sampling, convenience sampling, purposive sampling, and snowball sampling.

In this research, a purposive sampling technique was employed to choose an intact class (Form 2 Sc 3) consisting of 60 students, which includes 28 males and 32 females.

Purposive sampling is a method where researchers select specific cases to be part of the sample based on their judgment regarding the typicality or the presence of the particular characteristic being investigated (Cohen et al., 2018).

The 2Sc3 class was intentionally chosen due to their comparatively lower performance in Biology relative to other science classes (Field survey, 2023).

3.5 Instrumentations

Research instruments are tools utilized for measurement, aimed at gathering data on a specific topic from research participants.

Among the various research instruments employed in studies are observation, interviews, questionnaires, tests, checklists, tally sheets, flow charts, attitude scales, and rating scales.

Instrumentation encompasses the tools, devices, equipment, or instruments utilized to measure, monitor, control, or analyze a range of physical quantities, properties, or phenomena within scientific research, engineering, industry, or other domains. These instruments are meticulously designed to accurately capture data, collect measurements, record information, or execute specific functions, thereby facilitating experimentation, observation, testing, or analysis. The role of instrumentation is vital in research, data collection, quality control, process monitoring, and experimental analysis across various disciplines, equipping researchers and professionals with the necessary means to gather dependable data and make informed decisions based on the findings, as noted by Smith (2023).

Data collection plays a crucial role in the generation of knowledge, guiding decision-making, enhancing practices, and fostering understanding across various domains such as research, academia, business, healthcare, and more. It is instrumental

in monitoring observations and determining the appropriate methods for data collection. (Sikes, 2006).

The research employed a test item created by the researcher. In the creation of these test items, the topic of "genetics" as outlined in the senior secondary school syllabus and textbooks was referenced. This approach assisted the researcher in formulating the test items. The test encompassed the following concepts: Mendelian genetics, genetic inheritance, DNA structure, genetic disorders, and the applications of genetics across different fields. The study utilized tests, interviews, and questionnaires.

3.5.1 Test

A test can be characterized as a tool or systematic method for observing and detailing one or more attributes of students through a numerical scale. The instruments utilized for this research included the treatment tool "Biology Performance Test (BPT)" which served as the pre-test instrument, "Biology Performance Test (BPT)". The treatment tool was a self-instructional examination that lasted for 2 hours for an average student. It comprised five lessons organized into modules. The subjects addressed in the test include the structural traits of DNA, Mendelian genetics, cell division, and the application of genetics in Biology. The pre-test (CPT) was employed to assess the students' performance in Biology prior to the treatment exposure (MAI). Both the pre-test and post-test Biology assessments featured multiple-choice questions and short-answer questions, each carrying the same score, culminating in a total score of 30 marks. Two post-tests were administered following the execution of the intervention.

3.5.2 Interviews

Interviews involve the collection of data through the process of asking questions. Data can be gathered by listening to individuals, recording their responses, filming them, or utilizing a combination of these methods. Interviews can be categorized as unstructured or semi-structured. Unstructured interviews typically feature open-ended questions, allowing participants the freedom to express as much or as little as they desire, without the researcher imposing their own views. During the interview, questions that encourage participants to elaborate may be asked (Patton, 2002). An interview schedule is essentially a list of structured questions that have been prepared to guide interviewers, researchers, and investigators in gathering information or data on a specific topic or issue (Schreiber & Stern, 2001). This schedule enables interviewers and researchers to obtain more detailed information, as they can pose follow-up questions or seek clarifications regarding the prepared questions. Consequently, the information collected is more pertinent and beneficial. The researcher believed that to gain deeper insights into students' attitudes following the integration of MAI, interviews would be the most effective tool. The researcher employed both structured and unstructured interviews to evaluate students' attitudes towards the use of MIA in biology studies.

3.5.3 Questionnaire

A questionnaire serves as a structured research tool utilized to collect data from a significant number of participants (Phellas et al., 2011). It comprises a sequence of questions or items intended to assess specific variables or constructs. Questionnaires may be categorized as open-ended or closed-ended. In this study, a structured questionnaire was utilized, which was of the closed-ended type. The questionnaire was divided into two sections. Section A included questions aimed at

collecting demographic information about the respondents. Section B contained ten statements formatted on a three-point Likert scale, where respondents were asked to express their level of agreement. The statements in Section B were designed to gather insights regarding the challenges encountered by students in the application of Multimedia Aided Instruction (MAI) in the study of Biology.

3.6 Validity and Reliability of the Research Instrument.

The objective of effective research concerning validity and reliability is to guarantee that the research results are precise, consistent, and dependable. Validity confirms that the study assesses what it aims to assess, whereas reliability guarantees that the outcomes are stable and can be reproduced. By attaining elevated levels of validity and reliability, researchers can enhance the credibility and strength of their research findings.

3.6.1 Validity

Lee et al. (2023) characterized validity as "the extent to which an empirical measure adequately reflects the real meaning of the concept under consideration." Trochim and Donnelly (2008) articulated validity as "the best available approximation to the truth or falsity of a given inference, proposition, or conclusion." Cook and Campbell (1979) defined validity as "the best available approximation to the truth of a given research inference." Shadish et al. (2002) described validity as "the degree to which evidence and theory support the interpretations of test scores entailed by proposed uses of tests." Trochim (2006) explained validity as the degree to which a study accurately reflects or assesses the specific concept that the researcher is attempting to measure.

The researcher engaged in discussions with his supervisor, other lecturers, and colleagues regarding whether the instruments accurately represent the concept of the study. Their insights were thoroughly considered and effectively integrated. The achievement test underwent proper validation by experts holding doctorate degrees in the relevant field, focusing on criterion validity, content validity, and construct validity.

3.6.2 Reliability

The degree to which the findings of a study can be reproduced under comparable conditions is referred to as reliability (Trochim, 2006). Devellis (2016) characterized reliability as the degree to which a measurement yields consistent outcomes when repeated assessments are conducted under the same circumstances. Carmines and Zeller (1979) viewed reliability as the consistency or stability of a measurement over time, across various items, or among different evaluators. These perspectives underscore the significance of reliability in research, ensuring that the results of studies are consistent, trustworthy, and reproducible. Cohen et al. (2007) articulated reliability in research as "the degree to which the results obtained from a measurement or a collection of measurements are consistent and stable." Their definition highlights the necessity of consistency and stability in research outcomes to guarantee that the data gathered is credible and can be depended upon for making inferences. To establish reliability, pre-test and post-test assessments were conducted at form two science in a different school of the same grade, given that their learning outcomes appeared to be nearly identical. Additionally, an expert review of the instrument was performed to ensure that the tools met high standards and would produce consistent results after multiple trials. Reliability was verified using the test-retest reliability method. Furthermore, the equivalent test was administered to the

same students after a two-week interval. Pearson's product moment correlation was utilized to analyze the results of the tests. The reliability coefficient was determined to be 0.702, indicating that the test was reliable.

3.7 Data Collection Procedure

Data was collected through the administration of tests followed by interview and questionnaire. The test aimed at assessing the effect of MAI in improving students' academic performance. The interview also aimed at assessing the attitude of students towards the study of biology. Moreover, the questionnaire contained statements about challenges students face in implementing MAI in learning biology concepts. The data collection procedure was in three phases, namely, pre-intervention phase, intervention phase and post intervention phase.

3.7.1 Pre-intervention phase

Before the intervention, the issue was recognized through the observation of students' reactions during class. Transitioning to a new subject necessitates that a teacher evaluates students' existing knowledge. The feedback from students was not promising. To eliminate any uncertainty, a brief Biology Performance Test (BPT, a pre-test) was administered while the researcher prepared simple multiple-choice questions derived from the topics covered in their previous class. The pre-intervention assessment consisted of 30 multiple-choice questions. Each correct answer was awarded one mark. The researcher documented the students' scores in the pretest for subsequent analysis.

3.7.2 Intervention

Before the intervention, the issue was recognized through the observation of students' reactions during class. Transitioning to a new subject necessitates that a

teacher evaluates the students' existing knowledge. The feedback from students was not promising. To eliminate any uncertainty, a brief Biology Performance Test (BPT, a pre-test) was administered, while the researcher prepared simple multiple-choice questions derived from the topics covered in their previous class. The pre-intervention assessment consisted of 30 multiple-choice questions. Each correct response was awarded one mark. The researcher documented the students' scores from the pretest for subsequent analysis.

The teacher illustrated the concepts by integrating Virtual Reality (VR) experiences, including 360-degree videos, animations, graphs, clips, simulations, and images, to enhance student engagement and comprehension of various topics such as Mendelian genetics, genetic inheritance, DNA structure, cell division, genetic disorders, and the applications of genetics in Biology. This approach made the lessons more tangible and memorable for students as they observed. Additionally, the researcher observed the students' methods of solving biological problems in a more expert manner, utilizing diagrammatic representation, particularly in a scenario where four students were selected to present their responses to a question that required a 'description of the structure of DNA and its shapes,' intervening when necessary. Frequent class exercises (Appendix E) were employed to provide students with prompt feedback on their daily performance. Furthermore, questions were consistently discussed with students post-marking to ensure they received accurate information and could correct any misconceptions regarding specific content. Students were informed to prepare for an upcoming test during the meeting, which aimed to assess their understanding and retention rates.

3.7.2.1 Lesson one

Topic: Structure of the DNA

Instructional objectives:

By the end of the lesson, the student should be able to:

1. Identify the components of DNA, including nucleotides, sugar-phosphate backbone, and nitrogenous bases.
2. Explain the double helix structure of DNA and the role of hydrogen bonds in stabilizing the molecule.
3. Describe the complementary base pairing in DNA (A-T and G-C) and its significance in DNA replication and protein synthesis.
4. Explain the role of DNA as the genetic material in cells and its importance in encoding genetic information.
5. Describe how mutations in DNA can lead to genetic disorders and impact protein synthesis.
6. Understand the relationship between DNA structure and the inheritance of genetic traits.

Materials: Videos or animations, computer, 3D models, Simulation, DNA model kits, microscope, online quizzes or assessment.

RPK: Students Know the principles of inheritance, and the transmission of genetic traits from parents to their children.

Presentation: The researcher commenced the lesson by inquiring if all living organisms possess DNA. Why or why not? How do students believe DNA influences characteristics such as eye color, height, or abilities? The teacher queries the students about their awareness that DNA serves as a minuscule instruction manual located within each cell, directing the development, operation, and characteristics of all living

entities. Similar to how architects create blueprints for structures, DNA encompasses the genetic blueprint that defines every facet of an organism. The notion of DNA was presented to the students

The researcher elaborated on the function of DNA as the genetic material within cells and emphasized its significance in encoding genetic information. Furthermore, the discussion included how mutations in DNA can result in genetic disorders and affect protein synthesis. The researcher also examined the connection between DNA structure and the inheritance of genetic traits to the students.

The researcher employed interactive videos or animations to visually illustrate the structure of DNA, highlighting the double helix configuration and base pairing.

The researcher subsequently clarified why DNA, or deoxyribonucleic acid, is referred to as the molecule that contains the genetic instructions necessary for the development, functioning, growth, and reproduction of all living organisms, consisting of nucleotides, a sugar-phosphate backbone, and nitrogenous bases.

REMARKS: Evaluation was made on the objectives of the lesson at the end of the lesson. The students were able to answer questions based on the objectives of the lesson.;

3.7.2.2 Lesson Two

Topic: Mendelian Genetics

Instructional objectives: By the end of the lesson, the student should be able to:

1. Explain the principles of Mendelian genetics, including dominant and recessive traits, Punnett squares, genetic crosses, and inheritance patterns
2. Apply Mendelian genetics principles to predict the outcomes of genetic crosses, analyze pedigrees, and solve genetic problems.

3. Explain how genetic variation arises through Mendelian inheritance, mutations, and genetic recombination
4. Describe how Mendelian genetics concepts are applied in fields such as agriculture, engineering, medicine, and biotechnology to address real-world challenges and opportunities.

Activities

Materials: Animations, Simulation, computer with projector, A4 sheet, pencil.

Classroom Organization: Formal sitting classroom that is each student sits in his or own place in the class.

Presentation: I commenced the lesson by revisiting the concepts of DNA and its structure. The researcher elucidated to the students that Mendelian Genetics serves as the cornerstone for comprehending heredity and the fundamental principles that dictate the transfer of genetic traits across generations. To enhance understanding, the researcher employed interactive animations to visually illustrate concepts such as Punnett squares, genetic crosses, and inheritance patterns in a captivating and dynamic manner. Additionally, the researcher incorporated virtual lab simulations that enable students to perform genetic experiments, analyze outcomes, and grasp Mendelian inheritance through practical activities. He also provided video tutorials that clarify essential principles of Mendelian genetics, genetic disorders, and the applications of genetics in agriculture and medicine to enrich classroom learning.

A video sourced from Vidmate covered Mendelian principles including dominant and recessive traits, Punnett squares, genetic crosses, and inheritance patterns. Students were tasked with articulating the principles of Mendelian Genetics in their own words. The researcher elaborated on the definition of Mendelian Genetics to the students, along with the various principles associated with it. Following the

video presentation, the researcher prompted the students to discuss how genetic variation occurs through Mendelian inheritance, mutations, and genetic recombination.

The video was continued again after another 5 minutes.

The researcher discussed the following with the students.

What are Mendelian Genetics?

Demonstrate how the principles of Mendelian Genetics such as Punnett squares and genetic cross are being done.

The video was again played for another 5 minutes and was paused for discussion. The researcher asked students the following questions:

Explain how the Mendelian genetics principles is applied to predict the outcomes of genetic crosses, analyze pedigrees, and genetics recombination.

The researcher provided a comprehensive overview of the principles of Mendelian Genetics, including dominant and recessive traits, Punnett squares, genetic crosses, and inheritance patterns.

The researcher presented an example of a genetic cross and guided the students through the drawing process.

The researcher subsequently handed out colored pencils and A4 sheets to the students.

They were instructed to create three drawings of genetic crosses.

At the conclusion of the lesson, the researcher reviewed the key points once more to summarize the lesson and enhance the students' understanding.

REMARKS: The performances of the students were encouraging. The students demonstrated clear understanding of Mendelian Genetics.

3.7.2.3 Lesson Three

Topic: Cell Division

Instructional objectives: By the end of the lesson the student should be able to

1.0 Explain the term cell division:

1.1 Students will be able to differentiate and describe the phases of cell division

1.2 State the differences between mitosis and meiosis, including the processes of chromosome duplication, segregation, and cell division

1.3 Students will analyze how cell division contributes to genetic variation through processes such as crossing over, independent assortment, and random segregation of chromosomes

1.4. Students will apply cell division concepts to explain growth, repair, and reproduction in multicellular organisms, as well as the significance of cell division in maintaining genetic stability

Activities

Materials: Simulation, pictures, model kits, work sheet, pencil, sheets, projectors, computers, animations, videos, charts.

Classroom Organization: Formal sitting plan in the class. All students sit at their usual sitting place.

RPK: Students have knowledge of DNA structure, replication, and the role of chromosomes in carrying genetic information is crucial for understanding how genetic material is distributed during cell division.

Presentation: The lesson was introduced by brainstorming to bring out the meaning of cell division. The teacher discusses the procedures involved in cell division of living organisms.

The researcher discussed the phases of cell division. Sketches of these phases are used,

- a. Interphase
- b. prophase
- c. metaphase
- d. anaphase
- e. telophase.

The researcher explained the differences between mitosis and meiosis, including the processes of chromosome duplication, segregation, and cell division using charts.

REMARKS: The lesson was successfully delivered and the students actively participated in the lesson.

3.7.2.4 Lesson Four

Topic: Genetic disorder

Instructional objectives: By the conclusion of the lesson, the student should be capable of;

1. identifying prevalent genetic disorders, comprehending their origins, and distinguishing between inherited and acquired genetic conditions.
2. elucidating the molecular foundations of genetic disorders, encompassing gene mutations, chromosomal irregularities, and genetic variations that contribute to specific disorders.
3. evaluating case studies of individuals affected by genetic disorders, interpreting their symptoms, inheritance patterns, and the influence of genetic counseling and testing on diagnosis and management.

4. articulating the significance of genetic counseling in evaluating genetic risk, supplying information to families, and facilitating informed decisions regarding family planning and healthcare management.

Activities

Materials: interactive case study, Simulation, animation video, online resources and data base,

Classroom Organization: Formal sitting classroom that is each student sits in his or own place in the class.

RPK:

Students know Mendelian genetics is including concepts of dominant and recessive traits.

Presentation: The lesson commenced with a brief exercise where students were asked to elucidate the concepts of Mendelian Genetics and its underlying principles. The researcher engaged in a brainstorming session to clarify the meaning of genetic disorders. Furthermore, the researcher addressed common genetic disorders among students, exploring their causes and distinguishing between inherited and acquired genetic conditions through interactive case studies that illustrated real-life situations of individuals affected by genetic disorders. This approach established a foundational understanding of heredity and the fundamental rules governing the transmission of genetic disorders across generations. To enhance comprehension, the researcher employed an interactive animation video to visually convey concepts related to genetic disorders, interpret their symptoms, and explain inheritance patterns, as well as the significance of genetic counseling and testing in diagnosis and management, all in an engaging and dynamic manner. Additionally, the researcher integrated virtual lab simulations that enabled students to perform genetic

experiments, analyze outcomes, and grasp the inheritance of genetic disorders through practical activities. He also provided online resources and databases that elucidate the role of genetic counseling in evaluating genetic risk, offering information to families, and facilitating informed decisions regarding family planning and healthcare management.

The students were asked to differentiate between inherited and acquired genetic conditions.

REMARKS: Lesson was taught successfully. The students were able to answer questions based on the stated objectives.

3.7.2.5 Lesson Five

Topic: Application of Genetics in Biology

Instructional objectives: Upon completion of the lesson, the student should be capable of;

1. elucidating the application of genetic principles and techniques, including DNA sequencing, genetic engineering, and gene editing, across diverse biological contexts.
2. articulating the uses of genetics within the realm of biotechnology.
3. clarifying the role of genetics in the medical field, encompassing personalized medicine, pharmacogenomics, genetic counseling, as well as the diagnosis and treatment of genetic disorders.
4. enumerating the applications of genetics in biological research, such as the investigation of genetic diseases, population genetics, and evolutionary biology.

Activities

Materials: animations, videos, charts.

Classroom Organization: Formal sitting plan in the class. All students sit at their usual sitting place.

RPK: Students have knowledge of cell division.

Presentation: The lesson was introduced by brainstorming to bring out the principles of genetics and techniques, such as DNA sequencing, genetic engineering, and gene editing through the use of multimedia presentations, including videos, animations, and interactive graphics, to illustrate key genetic concepts and their applications in biology.

The educator elaborates on the significance of genetics in biological research, highlighting areas such as the investigation of genetic disorders, population genetics, and evolutionary biology through a video presentation.

Additionally, the researcher incorporated virtual laboratory simulations that enable students to perform genetic experiments, evaluate outcomes, and comprehend the ethical considerations relevant to medical applications, including personalized medicine, pharmacogenomics, genetic counseling, and the diagnosis and management of genetic conditions. He also supplied online materials and databases that elucidate the role of genetics in biology. The researcher took a moment to engage students by posing questions regarding the application of genetics within the biological sciences. A video from Vidmate was shown to the students, illustrating the diverse fields where genetics can be applied and demonstrating its practical applications in real-world scenarios.

The researcher engaged in a discussion with students about the application of genetics in biology. The students were guided through videos showcasing the application of genetics in the field of biology.

REMARKS: The lesson was delivered successfully. Evaluation was made on the lesson and response from the students were encouraging.

3.7.3 *Post Intervention*

A post-test (BAT) was administered to the students immediately following the intervention to assess their academic performance. This assessment aimed to evaluate the effectiveness of the intervention strategy in relation to the students' comprehension of the sub-topic. The post-test was designed to match the difficulty level of the pre-intervention test that was previously conducted. The number of questions and the distribution of marks were consistent with those in the pre-test (BPT). The results were compiled, and students' scores were classified into categories of unsatisfactory, good, and very good. The researcher also monitored the students' attitudes towards the subject following the intervention and conducted semi-structured interviews to gather insights directly from the students regarding their perspectives after the intervention was implemented. Upon completion of both tests (BPT and BAT), the raw data was systematically organized, tabulated, and analyzed using statistical methods, including mean, frequency count, and paired-sample t-test. An interview was conducted to collect information on students' attitudes towards the use of multimedia-assisted instruction.

3.8 Data Analysis Procedure

Analysis involves the computation of specific indices or metrics, as well as the identification of relational patterns present within a data set (Kothari, 2004). The

process of data analysis entails the acquisition of raw data and its transformation into information that is beneficial for user decision-making. Data was gathered and examined to address inquiries; the methodology of data analysis varies according to the research design selected by the researcher. In this investigation, the data was scrutinized based on the advancements achieved by students following each of the five lessons, and the discussions surrounding the findings were aligned with the research questions. The raw data was processed using SPSS, Version 27.

3.9 Ethical Consideration

Research ethics pertains to the appropriate conduct guidelines essential for conducting research. It emphasizes the necessity for participants to comprehend the aims, objectives, and potential risks associated with their involvement (Seidman, 2006). Furthermore, it clarifies that participants retain the right to withdraw even after providing consent. This aligns with Mertens' (2010) assertion that informed consent stems from the participant's entitlement to autonomy. Researchers bear the obligation to safeguard participants from harm. The primary accountability for maintaining ethical research practices rests with the researcher. Researchers must strive to ensure that the physical, social, and psychological welfare of participants is not adversely impacted by the research. Research relationships should ideally be founded on mutual respect and trust. In this investigation, the study's purpose was thoroughly discussed with each participant prior to their engagement in the research. Punch (2008) argued that researchers must remain vigilant regarding ethical considerations, particularly in social research, as it involves data pertaining to individuals.

The examination of ethical considerations and the respect for participants is essential in social research. Thus, the respect for participants is a foundational aspect of social research. As a result, this study considered various ethical factors, such as

informed consent, anonymity, and confidentiality. A letter was sent to the headmaster of the school and the Head of the Science Department to secure their informed consent for the research. The anonymity of the study participants was also given considerable emphasis in this research. Olivers (2010) highlighted that anonymity is a vital component of research ethics, as it enables participants to maintain the confidentiality of their identities, ensuring that no one familiar to them can access the information shared, and none of the participants' names were recorded in the research. This study completely avoided plagiarism, and all referenced works were appropriately cited.



CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

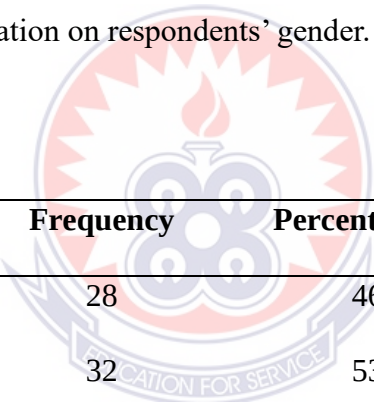
This section presents the data on students' academic performance before and after the intervention and students' perceptions of the use of MAI in teaching biology concepts. It also presents data on the challenges of using MAI in teaching biology concepts. The data is also discussed in this section.

4.1 Demographic characteristics

4.1.1 Gender of respondents

Table 1 presents information on respondents' gender.

Table 1
Gender of respondents



Gender	Frequency	Percentage (%)
Male	28	46.7
Female	32	53.3

The data in Table 1 shows that out of the total respondents, 53.3% were female, while 46.7% were male. This indicates a slightly higher representation of female students compared to male students in the study. The nearly balanced gender distribution suggests that the findings from the study reflect the experiences and challenges faced by both male and female students in employing Multimedia assisted Instruction (MAI) in learning Biology.

4.1.2 Age of respondents

Table 2 gives information on the age distribution of respondents

Table 2

Age of respondents

Age	Frequency	Percentage (%)
Under 15	11	18.3
15-16	18	30.0
17-18	20	33.3
Over 18	11	18.3

The demographic data on the age distribution of respondents, all of whom are Senior High School (SHS) students, provides insights into the typical ages of students participating in the study.

The data in Table 2 shows that 33.3% of the respondents are aged 17-18 years, which is the most common age group among students. The next largest group, representing 30.0% of the respondents, is aged 15-16 years. Both the younger students, under 15 years (18.3%), and the older students, over 18 years (18.3%), make up smaller portions of the respondent pool.

4.2 Research Question 1: What are students' attitudes towards the use of MAI in teaching biology?

This section presents the data on students' attitudes on the use of MAI in the biology classroom. The result is presented in Table 3.

Table 3*Attitudes of Students on the Use of MAI in the teaching and learning of Biology*

Item	Interview Guide	Number Of Response			
		YES	Percentage (%)	NO	Percentage (%)
1	The use of MAI was an interesting experience	60	100	0	0
2	The use of MAI is better in understanding the traditional concepts of selected topics, than the traditional motivation classroom presentation.	55	91.7	5	8.3
3	The use of MAI allows one to discuss Biology with others much more than the traditional method.	57	96	3	4
4	My level of motivation on Biology has increased with the use of MAI.	58	96.7	2	3.3
5	The information on all lessons on MAI was clear.	58	96.7	2	3.3
6	The MAI allowed me to understand complicated concepts in Biology better.	60	100	0	0
7	The use of MAI offered me an ideal environment for learning and sequencing various ideas on each lesson than traditional methods.	60	100	0	0
8	The use MAI in selected topics made me more creative	60	100	0	0
9	I have learnt more things through the use of MAI than I learned using Traditional method	58	96.7	2	3.3
10	I would like that Biology be taught with the use MAI than using traditional methods only.	60	100	0	0
11	I recommend the use of the MAI in the learning of the topic in Biology	60	100	0	0

According to the data illustrated in Table 3, the findings indicated that all students (100%) found the use of MAI to be an engaging experience and concurred that it heightened their interest in the chosen subjects. It is indisputable that students' enthusiasm for learning any discipline is essential, as it fosters self-confidence in their

academic pursuits and may lead to advancements in research innovation. Furthermore, a significant majority of learners (96.7%) acknowledged that the incorporation of MAI in the instruction and comprehension of selected topics has elevated their motivation levels. An increase in motivation plays a vital role in enhancing self-esteem and fostering optimism. This characteristic is essential for sustaining learners' involvement in various aspects of the educational process.

The results demonstrate that students view the use of MAI positively throughout their educational experiences. MAI is an essential resource for educators to enhance the effectiveness of both teaching and learning regarding the selected topics in Biology, enabling students to engage more actively and participate in discussions compared to conventional learning settings. This claim is supported by 91.7% of the students. It implies that as students become more familiar with MAI, their learning experience improves, leading to increased involvement in lessons. Furthermore, the findings indicated that students felt MAI helped them understand more intricate concepts within the chosen topics, with information being clearer when MAI was incorporated into the educational process, as confirmed by 96.7% of students. MAI provides innovative approaches for delivering similar information in diverse formats to strengthen comprehension in the teaching and learning of Biology, thus allowing students to investigate and comprehend concepts in Biology through various modalities. Additionally, all students (100%) supported the implementation of MAI in the teaching and learning of selected topics, as well as in other areas of Biology, claiming that their understanding of the concepts related to the chosen topics was improved through MAI in comparison to traditional methods. Based on insights collected from students through the interview guide, the researcher observed that

students were enthusiastic about integrating MAI into the teaching and learning of Biology.

4.2.1 Qualitative Data Analysis of Students' Attitude on the Use of MAI in the teaching and Learning of Biology

Thematic analysis was employed to examine qualitative data.

Themes were derived from the common factors that emerged from the follow-up questions (probing questions) posed after students' responses during the interview.

This section utilized both direct and reported speech.

Students' knowledge of MAI

Students demonstrated a significant depth of understanding regarding MAI and its applications in the educational process. Some participants noted that videos, animations, and simulations can facilitate discussions, online quizzes, tutorials, homework submissions, and lesson delivery throughout the week or school days. These instant messages can also serve as a channel for communicating information (issues) to teachers that may be challenging to comprehend, particularly after classroom hours. Through the use of clips, images, graphs, and animated videos, complex, abstract subjects become much more accessible, interactive, concrete, engaging, and concise. Online quizzes can improve the ease and effectiveness of assessment, providing timely and constructive feedback to both educators and students for remediation.

They additionally remarked, *"Our skills stem from being born in the technological era, during which we have engaged with video games, online games, and computer games, dedicating a significant portion of our time to the internet."*

Therefore, we believe that adapting to MAI in educational environments will not pose a challenge for us."

Enhanced confidence

This theme emerged when learners were asked "why they should recommend the use of MAI in the teaching and learning of Biology."

Learners believed that MAI usage is important aspect in the teaching and learning of Biology.

One interviewee stated: *"It is difficult to forget a concept learnt from MAI because lessons like the structure of DNA were taught in different learning modalities"* (videos, simulations, animations, pictures). The interviewee, further, cited that problems or topic in Biology that involved abstract bulky texts can be tackled using MAI using videos, animations, clips, graphs, simulations, pictures and online quizzes for assessment. Use of MAI helps to maintain high retention power, easy comprehension of Biology concepts, and provides a concise and concrete representative of a bulky abstract texts.

Another interviewee stated: *I strongly believe that the lessons that are MAI based are more interactive, creative, concrete, brief, engaging and motivates us learners to learn new things every day"* meaning, MAI can positively improve the learners' self-confidence of the selected topics and enhance the development of a positive attitudes towards Biology."

MAI could aid and broadens learning resources

This theme emerged as further question was asked "why they would like that Biology be taught with the use of MAI than using Traditional methods only". The integration of MAI in the teaching and learning of rate of genetics broadens the array

of resources used in the teaching and learning processes. Most learners indicated that MAI has the potential to provide different types of resources for preparation and delivery of content to the learners within and outside the lessons. One interviewee stated that; “they are a lot of things online that we as students have not even explored when we are learning the selected topics or any subject. The internet for example has all the facilities we can need for effective study and understanding the concepts in ranging from genetic simulation laboratories, e-test books, online consultation blogs and past papers.” Learners felt that MAI used in teaching the selected topics could foster their comprehension of subtopics of other complicated topics better if it could be used as a resource tool in the teaching and learning process.

Another interviewee stated that: *“Biology has a lot of subtopics, each with a different view point of focus, and in order to understand these abstract subtopics better, I believe that MAI can provide one of the best resources to explaining these concepts.”*

MAI usage can bring realism into learning

The above theme emerged when the probing question was asked as “why the use of MAI offered me an ideal environment for learning and sequencing various ideas on each lesson than traditional methods.” Learners believed that it can bring realism in the teaching and learning of selected topics in Biology, because of the different resources that MAI is able to offer. One interviewee stated that: *“it is not enough to just rely on our super imagination every time we are learning Biology concepts. Some things can be imagined and visualized well, but not all the contents of Biology”*. Another interviewee added that; *“the use of MAIs can link the imaginary pictures to the reality, unlike just conceptualizing the processes of genetics with the mind.”*

Another interviewee attested that: *“the use of MAIs bring content to life, and it is really hard to forget the experience of reality outside the book. It helps us to put abstract topics into context and experiencing it as a reality topic.”* In addition, MAIs can help to create a less intimidating environment for learning Biology concepts for weaker learners. One interviewee stated that: *“I know I am not good with imaginations, visualization and contextualizing text information. For me, as a learner, I learn and understand better concepts or things that I am able to see”*.

Learners exhibited a favorable disposition towards the implementation of Multimedia Aided Instruction (MAIs) in the instruction and comprehension of the chosen topics in Biology. They asserted that MAIs can simplify complex subjects, making them easier to learn through the resources they offer. Students perceived the integration of MAIs in the educational process as an engaging experience and concurred that MAIs heightened their interest in the selected topics. These findings align with the research conducted by Akinbadewa et al. (2020), which demonstrated the efficacy of multimedia instructional learning packages in improving secondary school students' attitudes towards Biology. Research has shown that multimedia learning packages represent an engaging and innovative approach to teaching and learning, fostering a positive attitude among educators. Abdulrahman et al. (2020) further explored the application of multimedia tools in educational processes. This paper presents a systematic review of various multimedia tools utilized in teaching and learning, aiming to investigate how multimedia technologies have emerged as an effective strategy for providing unrestricted access to quality education, enhancing learners' performance, and consequently improving learners' positive attitudes.

According to Waite (2004), teaching approaches rich in Multimedia and Interactive Technologies (MAIs) foster more positive attitudes among students, who enjoy engaging with multimedia or technological resources, feel more secure in experimenting and making mistakes, and value the prompt feedback provided by MAIs. Korkman (2021) highlighted the impact of inquiry-based collaborative learning and inquiry-based online collaborative learning on students' success and enduring learning. This study seeks to clarify the influence of these inquiry-based collaborative learning methods on students' success and long-term learning outcomes. The research conducted by Savelsbergh et al. (2016) demonstrated the effects of innovative teaching methods in science and mathematics on student attitudes and achievements. This study offers a meta-analytic review encompassing 56 publications from 1988 to 2014, detailing 65 independent experiments that explored the impact of various teaching approaches on student attitudes in primary and secondary science or mathematics education. Furthermore, Zhang et al. (2023) contended that MAIs enhance students' creativity and imagination as their knowledge frameworks expand; additionally, MAIs equip students with essential learning skills by enabling them to acquire necessary information and knowledge. Students also advocated for the integration of MAIs in the teaching and learning of specific topics, as well as other subjects in Biology. Based on insights gathered from student interviews, the researcher noted that students expressed a willingness to adopt MAIs in the teaching and learning of Biology.

Furthermore, a qualitative analysis of the responses gathered from the follow-up questions revealed that students possess knowledge in utilizing certain MAIs and express a desire for educators to permit their use for educational purposes, particularly during weekends and holidays. They appeared to be "children of technology,"

indicating that they would not struggle to learn with MAIs. Additionally, students advocated for the incorporation of MAIs in teaching and learning, as they assist in retaining concepts taught, enhance creativity, and motivate further learning. This observation aligns with the findings of Korkman (2021), who examined the impact of inquiry-based collaborative learning and inquiry-based online collaborative learning on students' success and long-term retention of knowledge. The objective of this study is to delineate the influence of inquiry-based collaborative learning and inquiry-based online collaborative learning techniques on students' achievement and enduring learning. The utilization of MAIs has expanded their educational resources, enabling them to conduct more extensive online research to gather essential information that enhances their learning experience. Ultimately, students contended that MAIs could introduce realism into the educational process, as they can provide clear imagery and visualized concepts.

4.3 Research Question 2: What is the effect of MAI on students' academic performance in selected topics in biology?

This section presents the raw scores of students' pre-intervention tests as well as post-intervention tests. The results of pre-intervention test and post-intervention test scores of students are presented in Tables 4

Table 4
Pretest and Post Test Scores

Student ID	Pretest	Posttest 1	Posttest 2	Total	Mean
1	5	27	29	61	20.33
2	9	28	29	37	22.00
3	6	24	27	30	19.00
4	4	26	26	30	18.67
5	8	30	30	38	22.67
6	10	20	25	30	18.33
7	3	26	28	29	19.00
8	5	21	29	26	18.33
9	2	24	26	26	17.33
10	1	23	28	24	17.33
11	7	26	22	33	18.33
12	5	25	28	30	19.33
13	2	22	30	24	18.00
14	3	27	30	30	20.00
15	1	28	28	29	19.00
16	4	21	30	25	18.33
17	7	23	29	30	19.67
18	6	22	30	28	19.33
19	9	30	30	39	23.00
20	10	23	30	33	21.00
21	6	22	30	28	19.33
22	5	30	30	35	21.67
23	8	23	26	31	19.00
24	7	22	27	29	18.67
25	1	26	29	27	18.67
26	3	27	30	30	20.00
27	2	28	30	30	20.00
28	10	30	32	40	24.00
29	9	28	29	37	22.00
30	10	30	30	40	23.33
31	5	30	30	35	21.67
32	2	25	27	27	18.00
33	3	28	24	31	18.33
34	8	22	28	30	19.33
35	4	30	30	34	21.33
36	7	29	30	36	22.00
37	6	28	30	34	21.33
38	5	22	27	27	18.00
39	12	25	28	37	21.67
40	11	26	28	37	21.67
41	13	26	27	39	22.00
42	12	29	29	41	23.33
43	14	27	29	41	23.33
44	16	27	30	43	24.33
45	15	30	30	45	25.00
46	18	27	29	45	24.67
47	19	25	27	44	23.67
48	17	26	28	43	23.67
49	20	26	27	46	24.33
50	11	30	30	41	23.67
51	22	30	30	52	27.33
52	24	29	30	53	27.67
53	21	28	29	49	26.00
54	23	28	28	51	26.33
55	22	22	22	44	22.00
56	25	21	25	46	23.67
57	21	26	29	47	25.33
58	22	28	28	50	26.00
59	21	29	30	50	26.67
60	21	30	30	51	27.00
Total	608	1571	1706	2208	1295
Mean	10.13	26.18	28.43	36.80	21.58

Table 4 presents the scores from the pretest, posttest1, and posttest2 for 60 students, including their total scores and means. The analysis indicates a notable enhancement in students' academic performance following the implementation of multimedia-assisted instruction.

The pretest scores varied between 1 and 10, culminating in a total score of 608 for all students, which translates to an average score of 10.13. These relatively low scores imply that prior to the intervention, students possessed a limited grasp of the chosen biology topics.

Following the introduction of multimedia instruction, there was a significant improvement in student performance. In posttest1, scores rose markedly, ranging from 20 to 30, with a total of 1571 and an average score of 26.18. The subsequent posttest revealed further advancements, with scores spanning from 22 to 32, totaling 1706 and averaging 28.43.

The total scores for each student exhibit a pronounced increase from the pretest to posttest2, underscoring the beneficial effects of multimedia-assisted instruction. The mean scores for the entire cohort improved from 10.13 in the pretest to 28.43 in posttest2. The overall mean score across all assessments was 21.58, signifying a considerable enhancement in students' comprehension and retention of the biology topics addressed.

The consistent rise in scores from the pretest to posttest2 illustrates the efficacy of multimedia instructional strategies in bolstering students' academic performance. The findings imply that multimedia-assisted instruction plays a significant role in fostering better understanding and retention of information, thereby leading to improved academic results in biology for the students at Winneba Senior High School.

The data unequivocally demonstrates that multimedia-assisted instruction has a positive influence on students' academic performance in biology, as evidenced by the substantial rise in posttest scores in comparison to the pretest scores.

This improvement in performance aligns with the findings of several researchers who have explored the impact of multimedia-assisted instruction on student learning outcomes. Matias and Agapito (2022) in their research posit that students learn more effectively when both visual and auditory information is integrated, as multimedia can cater to different learning styles and facilitate deeper cognitive processing. Similarly, a study by Alemdag and Cagiltay (2018) found that students taught using multimedia-enhanced lessons performed significantly better on assessments compared to those taught through traditional methods.

Moreover, Akinbadewa and Sofowora (2020) showed that the use of multimedia tools like videos, animations, and interactive simulations in teaching biology improved students' understanding of complex topics like genetics and cell biology.

In addition, Jenkinson (2018) have highlighted that multimedia learning environments can provide students with multiple representations of content, thereby making abstract and complex topics more accessible and easier to understand. In biology, where students often struggle with visualizing processes at the cellular or molecular level, multimedia tools like animations and 3D models can make these concepts more tangible, resulting in better learning outcomes.

Table 5 presents paired sample T test which provide insight into the effectiveness of multimedia-assisted instruction on students' academic performance in biology at Winneba senior high school.

Table 5*Paired sample t-test*

		Paired Samples Test							
		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	pretest - posttest1	-16.05000	7.17204	.92591	-17.90273	-14.19727	-17.334	59	.000
Pair 2	pretest - posttest2	-18.30000	7.47946	.96559	-20.23215	-16.36785	-18.952	59	.000

The mean difference between pretest and posttest1 scores is -16.05, indicating a substantial improvement in scores after the first exposure to multimedia instruction. The mean difference is negative because the posttest mean was subtracted from the pretest mean. The standard deviation of 7.17 suggests variability in the improvement across students, while the standard error of the mean (0.93) indicates the precision of the mean difference estimate. The 95% confidence interval of the difference ranges from -17.90 to -14.20, meaning we are 95% confident that the true mean difference lies within this range. The t-value of -17.33 and the significance level (p-value) of .000 demonstrate that the improvement in scores is statistically significant, meaning it is highly unlikely that this result occurred by chance.

The analysis comparing pretest and posttest2 scores indicates a more pronounced mean difference of -18.30. This additional enhancement underscores the enduring beneficial effects of multimedia-assisted instruction over an extended period. The standard deviation of 7.48 once again illustrates some variability in the extent of improvement, while the standard error of the mean (0.97) signifies the accuracy of this estimate. The 95% confidence interval for the difference, which spans from -20.23 to -16.37, suggests that the actual mean difference lies within this range.

with 95% confidence. The t-value of -18.95 and the p-value of .000 further validate that this improvement is statistically significant.

The findings from the paired samples t-test analysis reveal that multimedia-assisted instruction exerts a substantial positive influence on students' academic performance in biology. Both sets of comparisons, namely between pretest and posttest1, as well as pretest and posttest2, exhibit highly significant enhancements ($p = .000$). The ongoing rise in scores from posttest1 to posttest2 indicates that multimedia instructional strategies not only facilitate immediate gains in comprehension but also contribute to the sustainability and enrichment of students' learning over time.

These results provide robust evidence in favor of the hypothesis that multimedia-assisted instruction serves as an effective pedagogical strategy for enhancing students' academic performance in biology at Winneba Senior High School.

The p-values derived from the paired samples t-test analysis revealed a substantial level of statistical significance, with $p = .000$ for both comparisons (pretest vs. posttest1 and pretest vs. posttest2). This notable significance implies that the enhancements in students' academic performance following the implementation of multimedia-assisted instruction are highly improbable to have occurred by chance. This aligns with the research conducted by Almasseri and AlHojailan (2019), who examined the effects of multimedia presentations on student performance in Saudi Arabian educational institutions, reporting a highly significant p-value ($p < .001$) when contrasting the performance of students instructed through multimedia with those taught via traditional methods. The significant p-value illustrated that the

multimedia approach resulted in improved student outcomes, paralleling the findings of your study.

Furthermore, Peterson (2016) investigated the efficacy of multimedia-based learning within medical education and discovered that students who interacted with multimedia-enhanced learning resources performed significantly better on assessments than their counterparts who received traditional instruction. The study reported a p-value of .000, signifying that the enhancement in performance attributable to multimedia was statistically significant, mirroring the results of your study.

Moreover, Kurucova et al. (2018) in their study on the impact of multimedia environments on K-12 education found that students who used multimedia tools for learning achieved statistically significant gains in their test scores, with p-values less than .001. This strong significance parallels your findings and supports the argument that multimedia instruction leads to measurable improvements in academic performance.

4.4 Research question 3: What are the challenges faced by students' in employing Multimedia assisted Instruction (MAI) in learning Biology in Winneba Senior High?

Table 6 presents challenges faced by students' in employing multimedia.

Table 6
Challenges Faced by Students' in Employing Multimedia

Statement	Response	Frequency	Percentage
I find it difficult to access multimedia tools due to a lack of technical devices.	Agree	33	55.0%
	Neutral	14	23.3%
	Disagree	13	21.7%
I struggle with slow internet connections when using multimedia tools for learning.	Agree	34	56.7%
	Neutral	14	23.3%
	Disagree	12	20.0%
I often experience software or application crashes when using multimedia resources.	Agree	38	63.3%
	Neutral	9	15.0%
	Disagree	13	21.7%
I find it challenging to operate multimedia tools because of insufficient technical knowledge.	Agree	34	56.7%
	Neutral	11	18.3%
	Disagree	15	25.0%
The classroom environment is not conducive for using multimedia resources effectively.	Agree	39	65.0%
	Neutral	11	18.3%
	Disagree	10	16.7%
Distractions from multimedia content make it hard for me to concentrate on Biology lessons.	Agree	46	76.7%
	Neutral	8	13.3%
	Disagree	6	10.0%
There is insufficient time in class to fully utilize multimedia resources for learning Biology.	Agree	38	63.3%
	Neutral	11	18.3%
	Disagree	11	18.3%
Teachers do not always integrate multimedia effectively into the biology curriculum.	Agree	33	55.0%
	Neutral	16	26.7%
	Disagree	11	18.3%
The multimedia content provided does not always align with the topics we are studying in Biology.	Agree	38	63.3%
	Neutral	16	26.7%
	Disagree	6	10.0%
I find it difficult to follow along when multimedia resources are used in Biology lessons.	Agree	36	60.0%
	Neutral	15	25.0%
	Disagree	9	15.0%

An examination of the data related to the third research question—"What challenges do students encounter when utilizing Multimedia Assisted Instruction (MAI) for learning Biology at Winneba Senior High School?"—uncovers several significant barriers to the effective incorporation of multimedia technologies in science education.

Primarily, limited access to necessary technological devices stands out as a major challenge. A significant portion of respondents (55.0%) reported experiencing difficulties in obtaining multimedia tools due to the lack of personal or institutional devices. This observation highlights a critical infrastructural shortcoming that presents a considerable obstacle to the smooth implementation of MAI. Interestingly, while 23.3% of students remained neutral on this matter, indicating either sporadic access or indifference, 21.7% stated that they did not face this issue, suggesting some degree of device availability among a segment of the student body.

In addition to hardware constraints, inadequate internet connectivity surfaced as another notable challenge. A total of 56.7% of students recognized slow internet speeds as a barrier to their effective engagement with multimedia content. Considering that numerous MAI resources rely on internet access, this limitation significantly diminishes the potential advantages of such instructional tools. These results highlight systemic challenges related to infrastructure and digital equity that must be addressed to improve the adoption and effectiveness of multimedia-assisted learning within the biology curriculum. In the absence of sufficient technological support and dependable internet access, the educational benefits of MAI cannot be fully achieved, potentially worsening existing educational inequalities.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Overview

In this chapter, the researcher provides a summary of the research findings, draws conclusions based on the primary findings that addressed the research questions, and ultimately offers recommendations.

5.1 Summary of the Findings

The research study aimed to explore the efficacy of Multimedia Assisted Instructions in the teaching and learning of specific biology topics at Winneba Senior High School located in the Effutu District of Ghana. The summary provided here is derived from the study's findings and was prepared in accordance with the research questions that directed the investigation.

1. The outcomes from the t-test revealed statistically significant differences between the pretest mean and each of the two post-test means, indicating a consistent improvement over time.
2. Multimedia assisted instructional tools proved to be valuable resources that encouraged students to cultivate a positive attitude towards the study of biology.
3. Students encountered considerable challenges when utilizing Multimedia Assisted Instruction (MAI) in Biology, stemming from technical issues such as limited access to devices, slow internet connectivity, and software malfunctions, in addition to environmental factors like distractions, unsuitable classroom conditions, and inadequate time for the effective utilization of multimedia resources.

5.2 Conclusions

The performance of students showed improvement in the chosen subjects when MAI tools were utilized as a supplement to conventional teaching and learning methods. These MAI tools proved to be valuable resources that encouraged students to cultivate a positive mindset, fostering greater creativity and motivation, while also enhancing the teaching and learning experience in biology through their attitudes towards the specific topics covered. However, there were challenges that required attention to ensure the effective implementation of MAI. In conclusion, it can be stated that MAI contributes positively to students' academic performance in biology.

5.3 Recommendations

The subsequent recommendations were derived from the study's findings;

1. The School Management, Parent Teacher Association (PTA), and alumni should equip the computer laboratory with essential tools. This would facilitate the integration of Multimedia Aided Instruction (MAI) into the educational processes, potentially improving students' academic performance.
2. Educators ought to integrate MAI with various teaching and learning strategies to maintain students' engagement.
3. School authorities must ensure that students have improved access to technological devices and dependable internet, coupled with training to enhance their technical skills, thereby increasing the effectiveness of Multimedia Aided Instruction (MAI) in Biology.

5.4 Suggestion for Further Researches

1. This research was confined to a single school; consequently, it is advisable to carry out a comparable study on the effectiveness of MAI in teaching and learning across various schools in Ghana, enabling a basis for comparison.

2. It is essential to undertake a study aimed at investigating the effectiveness of MAI in classroom settings and other scientific disciplines, as this research was limited to examining the effectiveness of MAI specifically in the teaching and learning of Biology.
3. It is recommended that the study be replicated in diverse regions and districts of Ghana to enhance the generalizability of the results.



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APPENDICES

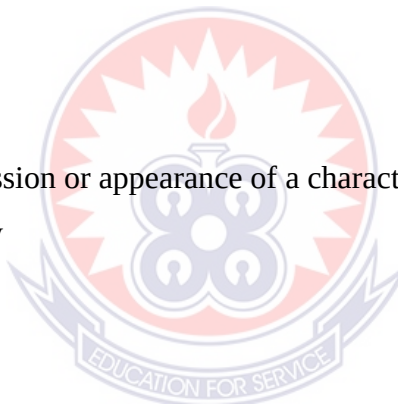
APPENDIX A: BIOLOGY PERFORMANCE TEST (BPT)

1. The term DNA stands for:
 - a) ribonucleic acid
 - b) deoxyribonucleic
 - c) cytosine
 - d) nucleic acid
2. Which of the following is not a component of DNA?
 - a) nucleotides
 - b) sugar-phosphate backbone
 - c) nitrogenous bases
 - d) Guanine
3. Who proposed the double -helix model of DNA?
 - a) Watson and Crick in 1953
 - b) John Dalton in 1953
 - c) JJ Thompson in 1953
 - d) Isaac Newton in 1953
4. In DNA, adenine always pairs with:
 - a) thymine
 - b) uracil
 - c) cytosine
 - d) guanine
5. In the complementary base pairing in RNA, adenine always pairs with
 - a) Cytosine
 - b) Uracil
 - c) Guanine
 - d) Thymine
6. Two major roles of the DNA are:
 - a) for genetic coding and as genetic material passed from parent to offspring
 - b) connect sugar to base
 - c) for protein synthesis
 - d) for complementing base pairing

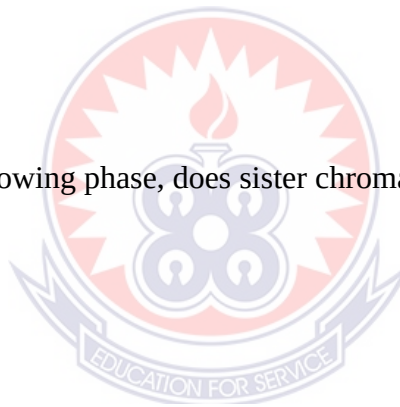


7. How many nucleic acids are present in the nucleus of eukaryotic cells?
 - a) 5
 - b) 3
 - c) 1
 - d) 2
8. When a variant alters a protein that plays a critical role in the body, it can
 - a) cause a health condition or disrupt the normal growth
 - b) enhances effective growth
 - c) normalizes growth
 - d) promotes a healthy condition
9. All the following are the principles of Mendelian genetics except
 - a) dominant and recessive traits
 - b) Punnett squares
 - c) genetic crosses and inheritance patterns
 - d) genetic mutation
10. The characteristics which are indicated by the blackened figures is probably:
 - a. Dominant
 - b. Recessive
 - c. Non-dominant
 - d. Sex-linked recessive
11. What are the genotypes of the parents?
 - a) Both are homozygous dominant
 - b) Both are heterozygous dominant
 - c) Both are homozygous recessive
 - d) The male is homozygous dominant; the female is homozygous recessive
12. The cytoplasm of an animal cell is divided by means of:
 - a) A cleavage furrows
 - b) A cell plates
 - c) A cell membrane formed within the cytoplasm
 - d) Mitosis
13. An example of alleles is
 - a) AB and Tt
 - b) TT and Tt
 - c) T and t
 - d) X and Y

14. Long radishes crossed with round radishes result in all oval radishes. This type of inheritance is:
- a) Multiple alleles
 - b) Complete dominance
 - c) Co – dominance
 - d) Incomplete dominance
15. The innate tendency of offspring to resemble their parents is called
- a) Variation
 - b) Heredity
 - c) Inheritance
 - d) Resemblance
16. A strand of DNA with the sequence A A C T T G
- a) CCAGGT
 - b) AACTTG
 - c) TTCAAG
 - d) TTGAAC
17. The physical expression or appearance of a character is called
- a) Morphology
 - b) Genotype
 - c) Phenotype
 - d) Ecotype
18. The number of types of gametes produced by a heterozygous individual is
- a) 1
 - b) 2
 - c) 3
 - d) Many
19. Mendelian genetics is applied in agriculture to enhance the following except:
- a) Improve crop yield
 - b) Resistance to diseases
 - c) Desirable traits
 - d) Poor crop yield



20. The type of cell division in which daughter cells receive an extra copy of chromosomes from parent cell?
- a) Mitosis
 - b) Cleavage
 - c) Interphase
 - d) Meiosis
21. Who coined the term Mitosis?
- a) Robert Hooke
 - b) Walther Flemming
 - c) Farmer and Moore
 - d) F. Twort
22. Which of the following is a microtubule organizing center?
- a. Centrosome
 - b. Kinetochore
 - c. G2 phase
 - d. Centrioles
23. In which of the following phase, does sister chromatids move towards opposite poles?
- a) Telophase
 - b) Anaphase
 - c) Prophase
 - d) Metaphase
24. Which of the following is a type of autosomal recessive genetic disorder?
- a) Haemophilia
 - b) Skeletal dysplasia
 - c) Sickel cell anemia
 - d) None of the above
25. If the father in a family has a disease while the mother is normal, the daughters only are inherited by this disease by this disease and not the sons. Name this type of disease?
- a) Autosomal recessive
 - b) Autosomal dominant
 - c) Sex-linked recessive
 - d) Sex-linked dominant

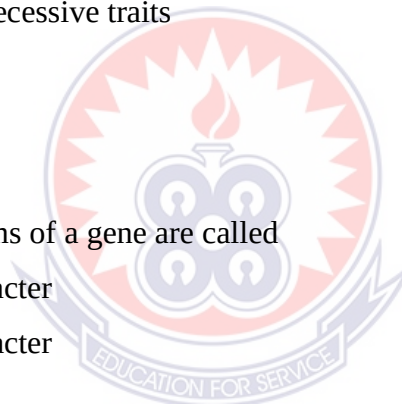


26. Cystic fibrosis is an autosomal recessive genetic disorder. What are the chances that the child would have disease if any one of the parents (either mother or father) is a carrier of the faulty cystic fibrosis gene?
- 100 per cent
 - 50 per cent
 - 25 percent
 - 0 percent
27. The mode of inheritance for the trait- Fragile X syndrome is
- X linked dominant
 - X linked recessive
 - Autosomal dominant
 - Autosomal recessive
28. Which of the following genotypes and phenotypes in a man may be correct result of aneuploidy in sex chromosomes?
- 22 pairs + Y females
 - 22 pairs + XY females
 - 22 pairs + XXY females
 - 22 pairs + XXXY
29. Which of the of the following is not a field of biology where genetics can be applied?
- Molecular biology
 - Cell biology
 - Anatomy and physiology
 - Psychology
30. Genetics is the study of genes, genetic variation and heredity in organisms.
- True
 - False
 - Both true and false
 - None of the above

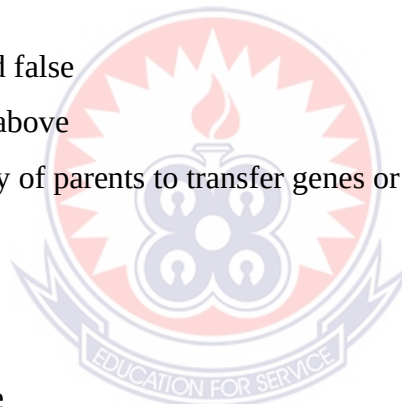
APPENDIX B: BIOLOGY ACHIEVEMENT TEST (BAT)

1. The thread-like structure found in DNA is called
 - a) Chromatin
 - b) Chromosome
 - c) Kinetochore
 - d) Cells.
2. Thymine as a canonical nucleobase occurs only in
 - a) RNA
 - b) DNA
 - c) Both RNA and DNA
 - d) None of the above
3. Uracil as a canonical nucleobase occurs in
 - a) Both RNA and DNA
 - b) RNA
 - c) DNA
 - d) All of the above
4. What is the function of glycosidic bonds in DNA and RNA?
 - a) The glycosidic bonds connect the sugar to the base
 - b) The glycosidic bonds connect the base to the sugar
 - c) The glycosidic bonds connect the base to all the 5 canonical nucleobases
 - d) The glycosidic bonds connect the sugar to all the 5 canonical nucleobases
5. Carriers of the colour – blindness trait include:
 - a) Men who are heterozygous for the trait
 - b) Men who are homozygous for the trait
 - c) Women who are heterozygous for the trait
 - d) Women who are homozygous for the trait
6. One specific role of the DNA is
 - a) for genetic coding
 - b) for cell duplication
 - c) for gene mutation
 - d) for gene multiplication

7. The two nucleic acids present in the nucleus of eukaryotic cells are
 - a. DNA and RNA
 - b. Thymine and Uracil
 - c. Chromosome and chromatin
 - d. RNA and protein
8. One main cause of genetic disorder is
 - a) Doubling the chromosomes of the daughter cells
 - b) When the number of chromosomes in parent and daughter cells remain the same
 - c) When a variant alters a protein that plays a critical role in the body, it can cause a health condition or disrupt the normal growth
 - d) By not altering a gene's instruction
9. One principle of Mendelian genetics is
 - a) dominant and recessive traits
 - b) cell plate
 - c) alleles
 - d) kinetochore
10. The alternate forms of a gene are called
 - a) Recessive character
 - b) Dominant character
 - c) Alleles
 - d) Alternative Gene
11. Genotype is the
 - a) Genetic Constitution
 - b) Genetic Constitution of the Phenotype
 - c) Trait Expressed Genes
 - d) Expressed Genes
12. Which of the following is a microtubule organizing center?
 - a) Centrosome
 - b) Kinetochore
 - c) G2 phase
 - d) Centrioles



13. Name the medication which hinders the shortening of the microtubule?
- a) Taxol
 - b) Vinblastine
 - c) Colchicine
 - d) Cytochalasin
14. An example of alleles is
- a) CD and Rr
 - b) RR and Rr
 - c) R and r
 - d) U and V
15. Long radishes crossed with round radishes result in all oval radishes. This type of inheritance is recessive trait.
- a) True
 - b) False
 - c) Both true and false
 - d) None of the above
16. The innate tendency of parents to transfer genes or traits to their offspring is
- a) inheritance
 - b) heredity
 - c) Variation
 - d) Resemblance
17. One positive application of Mendelian genetics in agriculture is:
- a) Improved crop yield
 - b) non-resistance to diseases
 - c) Undesirable traits
 - d) Poor crop yield
18. A strand of DNA with the sequence AAACC T TT G
- a) CCAAGGTT
 - b) AAACCTTGG
 - c) TTTCCAAAG
 - d) TTTGAAACC



19. According to Mendel, each sexually reproducing organism possesses
- a) One gene
 - b) Three gene
 - c) Two genes
 - d) Five genes
- 20) According to Mendel one gene is inherited from male parent and the other factor is inherited from
- a) The offspring
 - b) Ancestors
 - c) Cells
 - d) Female parent
- 21) Basically, eukaryotes have two types of cell division. These are:
- a) Mitosis and meiosis
 - b) Interphase and cleavage
 - c) Segregation and replication
 - d) Mitosis and reduction
- 22) The term mitosis was coined by Walter Flemming in the year
- a) 1982
 - b) 1882
 - c) 1990
 - d) 1856
- 23) The final phase of cell of cell division, between anaphase and interphase, in which the chromatids to opposite chromosomes move to opposite ends of the cell and two nuclei are formed.
- a) Metaphase
 - b) Interphase
 - c) Prophase
 - d) Telophase
- 24) Which of the following is not an example of Autosomal recessive disorders?
- a) Familial amaurotic cretinism
 - b) Galactosaemia
 - c) Cystic fibrosis
 - d) Diabetes

- 25) What will be the condition of the progeny if the father is normal, while the mother has one gene for haemophilia and colour blindness on one of the X.
- a) Only daughters are haemophilic and colour blind
 - b) Both sons and daughters will be haemophilic and colour blind
 - c) 50 percent haemophilic and colour blind sons
 - d) 50 percent haemophilic and colour blind sons and 50% normal sons.
- 26) Cystic fibrosis is an autosomal recessive genetic disorder. What are the chances that the child would have disease if any one of the parents (either mother or father) is a carrier of the faulty cystic fibrosis gene?
- a) 0 per cent
 - b) 50 per cent
 - c) 25 percent
 - d) 100 percent
- 27) Which of the following is not part of five canonical nucleobases?
- a) thymine
 - b) cytosine
 - c) guanine
 - d) sugar
28. The correct result of aneuploidy in sex chromosomes genotypes and phenotypes in a man may be 22 pairs + Y females?
- a) True
 - b) False
 - c) Both A and B
 - d) All of the above
29. Which of the of the following is a field of biology where genetics can be applied?
- a) Applied science
 - b) Cell biology
 - c) Horticulture
 - d) Psychology
30. Genetics is the study of genes, genetic variation and
- a) heredity in organisms
 - b) RNA
 - c) Ribosomes
 - d) Eukaryotes

APPENDIX C: INTERVIEW GUIDE FOR STUDENTS' ATTITUDES**AFTER MAI INTEGRATION**

Item	Interview Guide
1	The use of MAI was interesting experience
2	The use of MAI is better in understanding the traditional concepts of selected topics, than the traditional motivation classroom presentation.
3	USE OF MAI allows one to discuss Biology with others much more than the traditional method.
4	My level of motivation on Biology has increased with the use of MAI.
5	The information on all lessons on MAI was clear.
6	The MAI allowed me to understand complicated concepts in Biology better.
7	The use of MAI offered me an ideal environment for learning and sequencing various ideas on each lesson than traditional methods.
8	The use MAI in selected topics made me more creative
9	I have learnt more things about Biology through the use of MAI than I learned using Traditional method
10	I would like that Biology be taught with the use MAI than using traditional methods only.
11	I recommend the use of the MAI in the learning of the topic in Biology

APPENDIX D: EVALUATION TEST

TEST 1

1. Nucleic acid consists RNA and
2. The term DNA stands for
3. In DNA, adenine always pairs with
4. One specific role of the DNA
5. The glycosidic bonds connect the to all the 5 canonical nucleobases

TEST 2

1. When a variant alters that plays a critical role in the body, it can cause a health condition or disrupt the normal growth.
2. Dominant and recessive traits, Punnett squares, genetic crosses and inheritance patterns are principles of
3. The alternate forms of a gene are called
4. The cytoplasm of an animal cell is divided by means of
5. The innate tendency of parents to transfer genes or traits to their offspring is

TEST 3

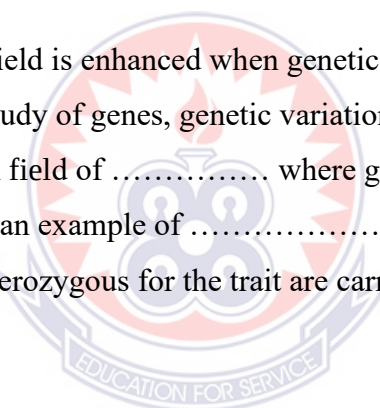
1. The type of cell division in which daughter cells receive an extra copy of chromosomes from parent is
2. The term mitosis was coined by
3. The phase, where sister chromatids move towards opposite poles is
4. Basically, in Eukaryotes the two types of cell division are and He
5. The term mitosis was coined by Walter Flemming in the year

TEST 4

1. Long radishes crossed with round radishes result in all oval radishes. This type of inheritance is
2. Cystic fibrosis is an autosomal recessive genetic disorder. The chances that the child would have disease if any one of the parents (either mother or father) is a carrier of the faulty cystic fibrosis gene
3. The progeny if the father is normal, while the mother has one gene for haemophilia and colour blindness on one of the X is,
..... And
4. The mode of inheritance for the trait- Fragile X syndrome is
5. The medication which hinders the shortening of the microtubule
.....

TEST 5

1. Improved crop yield is enhanced when genetics is applied in
2. Genetics is the study of genes, genetic variation and
3. Cell biology is a field of where genetics can be applied.
4. Sickle anemia is an example of
5. Men who are heterozygous for the trait are carriers of the colour



APPENDIIX E: MARKING SCHEMES

ANSWERS TO (BIOLOGY ACHIEVEMENT TEST) BPT

1. B	11.B	21. B
2. D	12. A	22. B
3. A	13. C	23. B
4. A	14. A	24. C
5. B	15. B	25. C
6. A	16. C	26. D
7. D	17. C	27. A
8. A	18. B	28. C
9. D	19. D	29. D
10. A	20. D	30. A

ANSWERS TO (BIOLOGY ACHIEVEMENT TEST) BAT

1. B	11. B	21. A
2. B	12. B	22. B
3. B	13. A	23. D
4. D	14. A	24. D
5. A	15. B	25. D
6. A	16. B	26. C
7. A	17. A	27. D
8. C	18. D	28. A
9. A	19. C	29. B
10. C	20. D	30. A

ANSWERS TO EVALUATION TESTS

TEST 1

1. DNA
2. Deoxyribonucleic acid
3. Thymine
4. Genetic coding
5. Sugar

3. 50 percent haemophilia and colour blind sons and 50% normal sons.

4. X linked dominant

5. Taxol

TEST 5

1. Agriculture

2. Heredity

3. Biology

4. Autosomal recessive disorders

5. Blindness trait

TEST 2

1. Protein
2. Mendelian
3. Alleles
4. Furrow cleavages
5. Heredity



TEST 3

1. Mitosis
2. Walter Flemming
3. Anaphase
4. Mitosis and meiosis
5. 1882

TEST 4

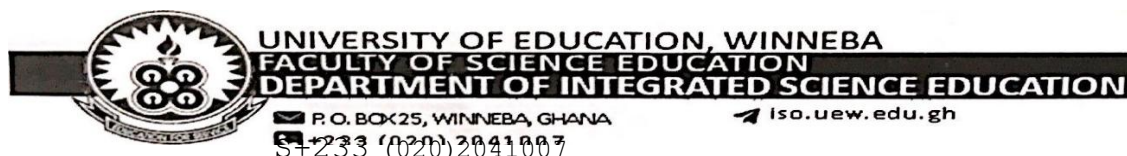
1. Multiple alleles
2. 50 percent

APPENDIX F: INTERVIEW QUESTIONS (QUALITATIVE)

1. How does MAI allow you to discuss biology concepts with others much more than traditional approach method
2. Why would you recommend the use of MAI in the teaching and learning of biology
3. Why do you want biology to be taught using MAI other than traditional method
4. Why does MAI offer you with an ideal environment for learning and sequencing various ideas on each lesson than traditional method



APPENDIX G: INTRODUCTORY LETTER



Our Ref: ISED/PG/VOL.I/111

16th April, 2024

The Head
Winneba Senior High

P. O Box 39

Winneba-Ghana

Dear Sir,

LETTER OF INTRODUCTION

I write to introduce the bearer of this letter, Miss. Priscila Ackah Appiah, with index number 8231610027, is an MPhil Science Education student at the University of Education, Winneba.

As part of the program requirement, Miss. Priscila Ackah Appiah is researching "Investigating the Effect of Multimedia Assisted Instructions on The Academic Performance of Students in the Teaching and Learning of Selected Topics in Biology at Winneba Senior High". She needs to gather information to analyze the said research topic.

I would be glad if you could give her the necessary assistance she may require.

Thank you.

Yours faithfully,

A handwritten signature in blue ink, appearing to read 'Charles K. Koomson', is written over a faint circular watermark of the University of Education, Winneba logo.

DR. CHARLES K. KOOMSON

Ag. Head of Department