UNIVERSITY OF EDUCATION, WINNEBA

EFFECT OF AUDIO-VISUAL INSTRUCTIONAL MATERIALS ON SENIOR HIGH SCHOOL STUDENTS' PERFORMANCE IN DISSECTION AND DIGESTION IN MAMMALS

PRISCA LOVIA ACQUAH

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PRISCA LOVIA ACQUAH

(220003227)

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DECLARATIONS

Student's declaration

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

SIGNATURE: …………………………….

DATE: …………………………………….

Supervisor's declaration

I, Dr. James Awuni Azure 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.

SIGNATURE: …………………………….

DATE: …………………………………….

DEDICATION

This work is dedicated to my lovely Husband Mr. Francis Domson Asare, my children Godlove Nhyira Asare, Godwin Nyametsease Asare, Nyamewotum Asare, Nyameba Asare and Nyameyie Asare.

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LIST OF ABBREVIATIONS

WSHS	Winneba Senior High School
WSH	Winneba Senior High
WAEC	West Africa Examination Council
WASSCE	West Africa Senior School Certificate Examination

ABSTRACT

This study investigates the impact of audio-visual aids on the academic performance of Senior High School students in the topics of dissection and digestion in mammals at Winneba Senior High School, located in the Effutu Municipality of the Central Region, Ghana. The specific objectives of the study were to assess students' understanding of dissection and digestion concepts and evaluate the effectiveness of audio-visual aids in enhancing academic performance. A quasi-experimental design was employed, involving 2 intact classes one as experimental and the other as control groups. A simple sampling procedure that employed balloting was used to select two intact classes from the accessible population. The sample demographics of the study encompassed a total of 98 respondents (50 students in the Experimental group and 48 in the control group). The Experimental group with a class size of 50 students were made up of 24 males and 26 females whiles the control group with the class size of 48 was made up of 19 males and 29 females. Data was collected using pre-and post-tests, as well as a questionnaire, and was analysed using percentages, means, standard deviations and T-test. The results indicated significant improvements in academic performance post-intervention, with positive shifts in students' conceptions of the subject matter. Additionally, gender-based analysis revealed similar performance outcomes between male and female students in the experimental group. The study also found that students developed more favourable attitudes toward the use of audio-visual aids as a teaching method. These findings suggest that integrating audio-visual aids into biology lessons can significantly enhance both academic performance and conceptual understanding. The study recommends that schools should prioritize the integration of audio-visual aids into the teaching of Dissection and Digestion. Educators are encouraged to utilize a variety of multimedia resources, such as videos, animations, and interactive simulations, to improve student understanding of complex topics to enhance their performance. In conclusion, the findings of this study support the hypothesis that the use of audio-visual aids positively influences students' performance in dissection and digestion in mammals. The experimental group, which received instruction through multimedia instructional methods, demonstrated significantly higher achievement scores compared to the control group, which received traditional instruction. This suggests that the integration of audio-visual aids enhances students' understanding, engagement, and retention of complex biological concepts.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter will deal with the background to the study, statement of the problem, the purpose of the study and the significance of the study. The chapter also presents the research questions that will guide the study and the research hypothesis that are formulated and tested in this study. It will further discuss the delimitations and limitations of the study as well as the organization of the study.

1.1 Background to the Study

Science serves as the cornerstone of contemporary technology, with nations globally, especially developing countries like Ghana, striving to enhance their technological and scientific capabilities. This pursuit is increasingly vital as society becomes more reliant on scientific advancements (Quarcoo-Nelson, Buabeng, & Osafo, 2012). Historically, science has been prioritized in educational curricula, recognized as essential for cultivating an educated populace (Stuckey *et al*., 2013). Among the sciences, biology is particularly valued for its educational significance, its intrinsic connection to human life, and its experimental nature, which integrates with various other scientific disciplines (Bibby, 1964, cited in Yeboah, 2014).

Biology, as a natural science, explores the living world, addressing aspects such as structure, function, development, and interactions among organisms and their environments (Umar, 2011). It is foundational for numerous fields that contribute to national technological progress, including medicine, pharmacy, nursing, agriculture, forestry, biotechnology, and nanotechnology (Ayittey, 2015, cited in Ahmed and Abimbola, 2011).

However, recent reports from the West Africa Examination Council (WAEC) indicate a significant decline in student performance in biology examinations. This decline may be linked to evolving teaching methodologies. Traditionally, the lecture method has dominated biology instruction in Ghanaian senior high schools, which often fails to foster critical thinking and creativity among students, as it primarily engages auditory learning and limits active participation. Many students, particularly those in their final year, struggle with practical identification of internal animal structures during laboratory sessions, highlighting the need for improved instructional strategies to enhance biology education (Cronin, 2009).

Research indicates that diverse learning styles exist within classrooms, and students thrive in environments that accommodate their unique preferences (Tekkaya, Ozkan, & Sungur, 2010). The challenges faced by students in grasping biology concepts are often attributed to the teaching methods employed, the high school curriculum, and the instructional strategies of educators. Consequently, it is crucial for biology instructors to diversify their teaching approaches to meet the varied learning needs of their students.

Recognizing that students possess different learning styles, educators must identify these preferences and adapt their instructional strategies accordingly to optimize the teaching and learning process (Olufunminiyi, 2015). The integration of technology into education has emerged as a promising strategy to enhance science instruction in the 21st century. While there is optimism about technology revolutionizing education, the reality often falls short, as many schools focus more on acquiring technological resources than on adequately preparing teachers to utilize these tools effectively (Huang, Spector, & Yang, 2019; Gleason & Von Gillern, 2018).

Effective science education can be bolstered through the use of simulations and audiovisual aids, which activate essential science process skills necessary for scientific inquiry (NRC, 2011). These skills are categorized into basic and integrated science process skills (Darmaji, Kurniawan, & Irdianti, 2019). Research by Dale Edgar Founding suggests that people remember 10% of what they read, 20% of what they hear, 30% of what they see, 50% of what they hear and see, 70% of what they say and write, and 90% of what they see as they do a thing, emphasizing the importance of multi-sensory learning experiences (Shabiralyani, Hassan, Hamad, & Iqbal, 2015).

Practical activities not only foster deeper understanding but also transform the learning experience from passive reception to active engagement. Audio-visual aids serve as valuable tools in this process, enhancing clarity and effectiveness in teaching by allowing students to engage with content through multiple senses (Padhi, 2012). The strategic integration of technology in lesson planning can create collaborative learning environments, supporting both curriculum goals and higher-order thinking skills (Ranasinghe & Leisher, 2009, cited in Shabiralyani *et al*., 2015).

1.2 Statement of the Problem

The challenges encountered by students in identifying the internal organs of mammals during practical biology sessions have been highlighted through discussions with Biology teachers at Winneba Senior High School in the Central Region. Despite providing diagrams and detailed instructions, students struggle to independently identify organs such as the liver, lungs, and heart during dissections (Abdellatif, 2020). This necessitates the teacher's constant assistance, indicating a significant gap in student comprehension and skill acquisition.

Furthermore, the topic of the digestive system presents additional difficulties. Teachers require effective media to visualize and accurately explain the digestive process to prevent student misconceptions (Gul *et al.,* 2024). Current literature indicates that traditional teaching methods employed by many biology instructors do not yield optimal results in student learning outcomes (Faria & Lobato Miranda, 2024). Research by Ramdiah *et al.* (2019) emphasizes that conventional teaching approaches often fail to engage students effectively, while Ogunkola and Samuel (2011) identify the use of innovative teaching methods as crucial for meaningful learning in biology.

Despite this understanding, many biology educators at the Senior High School level continue to rely on outdated instructional methods (Ekow *et al*., 2023). The need for more effective pedagogical strategies is clear, as studies show that audio-visual aids can enhance student engagement and understanding, leading to improved academic performance.

This study aims to explore the effectiveness of audio-visual aids as an instructional approach to enhance Senior High School students' performance in understanding dissection and digestion concepts. These topics are integral to the biology curriculum and encompass various biological systems, including digestive, reproductive, circulatory, respiratory, and excretory systems. Given their foundational importance in biology education, addressing this gap is essential for improving student outcomes in practical assessments such as Biology Practical Paper 3 of the West African Senior School Certificate Examination (WASSCE).

Students' inability to perform dissections and understand digestive processes represents a significant challenge in biology education that requires thorough investigation. Addressing this issue is crucial for several compelling reasons.

Firstly, the educational impact of inadequate performance in practical examinations can have far-reaching consequences. Students who struggle with these fundamental concepts may become discouraged and less inclined to pursue further studies in biology or related fields (Kaiser *et al.,* 2023). By enhancing their understanding through effective teaching methods, we can foster a more positive attitude toward science education, encouraging students to engage more deeply with the subject matter.

Secondly, dissection and digestion are core components of the biology curriculum that are frequently assessed in academic evaluations (Kaiser *et al.*, 2023). As such, it is crucial to improve instructional strategies to ensure that students are well-prepared for these assessments. A solid grasp of these concepts is essential not only for academic success but also for building a strong foundation in biological sciences.

Lastly, this research holds significant potential for teacher development. By identifying and promoting effective teaching methods, such as the use of audio-visual aids, we can provide valuable guidance for professional development among biology teachers. Equipping educators with innovative tools and strategies will enhance their ability to facilitate student learning and engagement.

Solving this problem is vital not only for improving student academic performance but also for nurturing a deeper understanding of biological concepts among learners. This study aims to contribute meaningful insights into effective instructional strategies that can transform biology education at the Senior High School level.

1.3 Purpose of the Study

The purpose of the study was to investigate the effect of audio-visual aids on Senior High School students' performance on dissection and digestion in mammals.

1.4 Objectives of the Study

The objectives of the study were to determine:

1. the effect of audio-visual instruction on students' academic performance in dissection and digestion in mammals.

2. the difference in performance between the male and female students in the experimental group on dissection and digestion in mammals.

3. investigate the perception of students in the experimental group about the application of audio-visual aid as an instructional method of teaching dissection and digestion of mammals.

1.5 Research Questions

The following research questions were addressed in the study;

1. What is the effect of audio-visual aids on students' academic performance in dissection and digestion in mammal?

2. What is the difference in performance between the male and female students in the experimental group on dissection and digestion in mammals?

3. What is the perception of students in the experimental group about the application of audio-visual aid as an instructional method of teaching dissection and digestion of mammals?

1.6 Significance of the Study

The findings of this study are poised to make a substantial contribution to both academic literature and practical applications in biology education. By addressing the identified gaps in students' abilities to perform dissections and understand digestive processes, this research will provide valuable insights for biology teachers in the selected schools and beyond.

One significant benefit of this study is its potential to transform teaching methodologies in biology. Currently, many educators rely heavily on traditional instructional approaches such as lectures and demonstrations, which may not effectively engage students or facilitate deep understanding. This study advocates for the integration of audio-visual aids into the teaching and learning process, which can enhance student participation and engagement. By shifting to a more interactive and multisensory learning environment, students are likely to experience increased learning gains in biology.

Moreover, the study aims to foster the development of essential skills among students, including creativity, problem-solving abilities, informational reasoning, communication skills, and other higher-order thinking skills. These competencies are crucial not only for academic success but also for preparing students for future challenges in various fields.

The results of this study will serve as a reference for science teachers at Winneba Senior High School (WSHS) and may encourage other biology educators to adopt similar innovative approaches when teaching dissection and digestion concepts. By comparing the effectiveness of audio-visual aids with traditional instructional methods, teachers can make informed decisions about their pedagogical strategies. This could lead to a broader shift in teaching practices across the region, ultimately enhancing the quality of biology education.

Most importantly, this study aims to ensure that students develop a solid understanding of biological concepts by enabling them to identify the internal organs of small mammals confidently. By filling the existing gap in literature regarding effective instructional strategies in biology education, this research not only contributes to academic discourse but also provides practical value that can significantly impact student learning outcomes and teacher effectiveness in real-world educational settings.

1.7 Limitations of the Study

This study acknowledged several limitations that may have impacted its findings and overall generalizability. Firstly, the scheduling of dissections on Saturdays posed a challenge, particularly for day students who were unable to attend due to personal commitments or transportation issues. This resulted in a reduced sample population, potentially affecting the robustness of the data collected.

Secondly, the audio-visual aids used in this study delivered instructions exclusively in English, accompanied by an accent. This may have presented comprehension challenges for some students, requiring their full attention to effectively understand the material. Variations in language proficiency among students could have influenced their ability to engage with the content.

Lastly, not all students were selected to participate in the study, which may have limited the representativeness of the sample. This selection bias could have affected the generalizability of the findings to a broader population of biology students. It is important to consider these limitations when interpreting the results and drawing conclusions from the study.

1.8 Delimitations of the Study

This study is specifically confined to Winneba Senior High School (SHS) in the Effutu Municipality of the Central Region of Ghana. The research will focus exclusively on a selected group of second-year science students who are enrolled in biology as an elective subject.

The scope of the study is further narrowed to specific topics within the biology curriculum, concentrating solely on the dissection and digestion of mammals. These topics correspond to sections of the Senior High School elective biology syllabus, specifically section four, unit one (page 29) and section four, unit two (page 32).

Winneba SHS was chosen for this study due to its strong emphasis on science education, particularly biology, making it an ideal setting for examining the challenges and opportunities in teaching these subjects. The school has a diverse student population and has previously highlighted issues related to student engagement and understanding in biology. By focusing on this institution, the research aims to provide targeted insights that can lead to improvements in teaching practices.

By establishing these delimitations, the study aims to provide a focused and in-depth analysis of the effectiveness of audio-visual aids in enhancing student understanding and engagement in these critical areas of biology education. This targeted approach allows for a more manageable and detailed examination of the research questions while acknowledging that findings may not be generalizable beyond this specific context.

1.9 Organization of the Study

The study report is divided into five chapters: The first chapter deals with the introduction of the study. The second chapter covers the review of related literature. The third chapter outlines detailed information on the research methodology. The fourth chapter looks at the data that will be collected and how the data will be analysed. The fifth chapter covers a discussion of the results, a summary of the study, conclusion, recommendations and suggestions for further studies

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

The literature pertinent to the topic is covered in this chapter. The study's main goal is to investigate the impact of using audio-visual aids as a component of the instructional technique (teaching method) for teaching mammal dissection and digestion and how this will affect students' performance in biology.

The chapter reviews pertinent literature that supports the study as follows: the theoretical and conceptual underpinnings of the study, the definition of audio-visual aids, how they are used in the teaching and learning process, how they are used in biology instruction, how well teachers use audio-visual aids in the classroom, and studies conducted by others highlighting the value of audio-visual aid integration in education.

2.1 Theoretical Framework

2.1.1 The Behaviourist Theory

According to McLeod (2017), the behaviourist approach only considers observable stimulus-response behaviours and maintains that all behaviours are learned through contextual interaction. Behaviourism stresses the importance of environmental factors in shaping behaviour, almost to the exclusion of intrinsic or inherited factors. In essence, this is a learning concentration. According to the "learning hypothesis," it is possible to learn new things, and all behaviours no matter how complex it is, can be reduced to a simple stimulus-response link. Stimulus-response association emphasize the idea that learning occurs through associating a stimulus such as visual images or sounds with response such as behaviour or action. Audio visual aids provide strong stimuli that can be linked to specific learning objectives. The behaviourist theory provides a strong foundation for understanding how audio-visual aids can enhance learning. By providing clear stimuli, reinforcement, repetition, and immediate feedback, these aids can facilitate the acquisition of knowledge and skills. This idea is useful to the study, especially to biology learning, which necessitates an encouraging setting and engaging real-world materials to reduce the abstract level and simplify the complexity of the subject.

2.1.2 The Cognitive Theory of Multimedia Learning

It has been pointed out that audio-visual aids are beneficial to learning due to the audio-visual processing channels of the human mind which register pictures, words and sounds in the sensory memory. This is elicited via the cognitive model of multimedia learning proposed by Mayer (2001).

The cognitive theory of multimedia learning, proposed by Richard Mayer in 2001, explains how people process and learn from multimedia materials. It consists of three main principles: the multimedia principle, spatial contiguity principle, and temporal contiguity principle. These principles guide designers in designing effective multimedia learning environments.

The multimedia principle suggests that people learn better from multimedia presentations that include relevant words and pictures, allowing for dual-channel processing. The spatial contiguity principle suggests that learners benefit from spatial integration of corresponding words and pictures, reducing cognitive load and improving comprehension. The temporal contiguity principle emphasizes the importance of presenting corresponding words and pictures simultaneously, facilitating the integration of both modalities and reducing cognitive load.

Additionally, Mayer emphasizes the importance of coherence and modality principles. Coherence suggests minimizing extraneous or irrelevant material to avoid cognitive overload, while modality suggests presenting information in the most appropriate modality for the content. By considering these principles, instructional designers can optimize information presentation, enhance learner engagement, and promote meaningful learning experiences.

Based on the model, pictures and texts entering the eyes and ears are held in the visual and auditory modalities of short-term memory. Mental conversion between the verbal and pictorial models is possible. The cognitive model culminates at integration which brings the verbal and pictorial models together with prior knowledge in the long-term memory, as learning consolidates (Mayer, 2002). Given the right conditions, students in rural schools can realise greater potential in their learning.

Two Channels and How They Work

The first step to understanding why multimedia learning can be so powerful is understanding how the brain processes information. Mayer explains that the brain takes in information and processes it in multiple channels, based on how that information is presented. The first channel is for visually represented material and the second is for auditorily represented material. When a learner is presented visual information, including pictures, videos, charts, or printed words, all of that information goes into the visual channel and is processed there. Auditory information includes spoken words in a narration and other non-verbal sounds, and these are processed by the brain separately from the visual. As a learner is learning, the new material first gets logged in their sensory memory. For a moment, the image is captured in its entirety, or the spoken words are logged in their entirety. After that initial moment, the learner must begin to work with the information to process it and learn. This happens in the working memory.

With two separate channels, the learner can work with more information because the varying presentations of material are processed differently. In working memory, the learner can choose relevant images to remember and work with, and they can choose relevant words to remember and work with. Each of these sets of information are processed and organized into models that help the reader understand and remember the information. While in the working memory, the information remains separate and the learner generates two models. Finally, the learner integrates the visual model and the auditory model together with their prior knowledge and experiences. Once all the material has been combined in a functional way, the new knowledge can move into long-term memory. Multimedia instruction helps students learn more deeply because it takes advantage of these two separate channels and allows the student to go through the process of making multiple models to really understand the material that is presented to them.

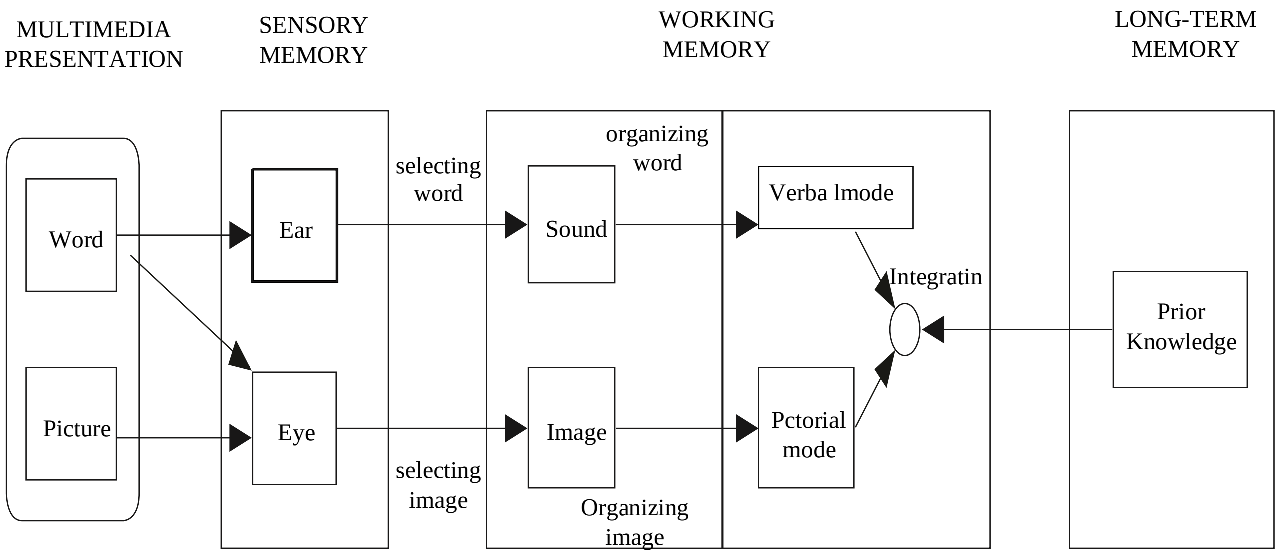

Figure 1: The cognitive theory of multimedia learning (Mayer, 2001)

2.2 General Overview of Visual Aids

Over time, there has been a significant evolution and development in teaching techniques. Students were only educated through lectures and texts up until the turn of the 20th century. School museums were the only other available means of practical education at the time (Cockerill, Comeau, Lee & Vinayak, 2015). For pupils to experience what they were learning in the classroom first hand, educational excursions were planned. The "Visual Education Movement" in America, which had its start in 1908, pushed teachers to use visual media in the classroom. The first collection of educational films was introduced into the classroom using a movie projector during this movement. The "audio visual instruction movement," which featured educational videos with sound, was a new method to academia that emerged with the advent of radio transmission and recording in the 1920s and 1930s (Reiser, 2001).

Instead of giving students direct encounters, audio-visual tools and materials can give them rich, real experiences. However, it became a discipline in the 1920s, a time of great advancement in cinema technology. A movement for visual instruction emerged that promoted the use of visual resources to help students better understand abstract concepts. The movement became known as audio-visual instruction as sound technology advanced.

There are numerous meanings of audio-visual aids. The majority of these criteria have been talked about in terms of tools and resources and how they are used in the teaching and learning process. According to Dike, (1993), the phrase also refers to texts whose meaning is conveyed through means other than reading. They may use a combination of senses to convey information, or they may use the senses of sight and hearing separately. The diversity of these resources is, in fact, a noteworthy quality.

According to Nwankwo, (2004), audio-visual materials relate to hardware and software tools that can support and further the learning process. Models and mockups, video-taped instructional materials, film strips for instructional television, slides and transparencies, pictorial illustrations, graphic materials, and maps are a few examples of these tools. Three-dimensional figures are also included. Computers and radio vision may possibly be among them.

The phrase "audio-visual resource" is frequently used to describe educational tools that can be utilized to convey meaning without entirely relying on vocal symbols or language, according to Anzaku (2011). Audio-visual aids are utilized to enhance learning by making it livelier and more realistic for the individual (Kinder, 2012). According to Mgbodile (2009), audio-visual tools produce higher learning outcomes in all learning domains, namely the cognitive, effective, and psychomotor domains, in the teaching and learning of the sciences.

Ofoegbu (2009) describes audio-visual aids as teaching tools that come in two varieties: verbal and material. The resources, which he referred to as the hardware and software used in teaching, comprise, among other things, objects, models, photographs, paintings, drawings, diagrams, and videos. Talabi (2004) provided a different definition of audio-visual materials, defining them as a combination of audio-visual elements utilized in instructional or learning processes to assist teaching and learning. Audio-visual aids are supplemental tools that teachers can use to clarify, establish, and correlate concepts, interpretations, and appreciation through the use of several sensory channels, claims Abolade (2004).

According to this perspective, visual aids are more effective in facilitating learning since they offer additional stimuli in addition to the speech information provided by teachers. This suggests that visual aids provide students a more solid understanding of things and processes. Visual aids are anything delivered to an audience in a way that listeners can see to support the information they hear, according to Hamilton (2014).

2.3 Historical Evolution of Audio-Visual Aids in Education: A Journey through Milestones, Technologies, and Visionaries

The use of audio-visual aids in education represents a rich history of innovation, adaptation, and pedagogical transformation. This section delves into the historical evolution of audio-visual aids, exploring key milestones, technological advancements, and influential figures who have shaped their development.

Early Beginnings: The Emergence of Visual Aids

The roots of audio-visual education can be traced back to the late 19th century when lantern slides and the magic lantern, an early projector, were used to display images and illustrations to enhance classroom teaching. These innovations laid the foundation for the integration of visuals into education. Notable figures like John Amos Comenius, who authored "Orbis Pictus" in 1658, created illustrated books that served as precursors to modern educational visuals (Spicer, 2019).

The Advent of Motion Pictures

The early 20th century witnessed a significant leap in audio-visual technology with the introduction of motion pictures and film projectors. Pioneers like Thomas Edison and the Lumière brothers made major contributions to this development. Films became a powerful tool for educators, enabling them to bring real-world experiences into the classroom. Documentaries, educational films, and newsreels became instrumental in visual learning.

The Rise of Overhead Projectors and Slides

The mid-20th century marked the rise of overhead projectors and transparency slides (Shareef & Nithyanantham, 2022). These tools allowed educators to project written content, diagrams, and illustrations onto screens, enhancing the visibility of material for a large audience. Overhead projectors became ubiquitous in classrooms, making it easier for teachers to interact with their students while presenting information.

Television and Educational Broadcasting

The advent of television in the mid-20th century revolutionized the use of audio-visual aids in education. Television programs, such as "Sesame Street" and educational channels like PBS, provided engaging and informative content for learners of all ages (Calvert, 2021). The influence of individuals like Fred Rogers, the host of "Mister Rogers' Neighborhood," demonstrated the potential for educational television to captivate and educate young minds (Vargas, 2020).

The Digital Revolution and Interactive Multimedia

The late 20th century and the early 21st century saw a transformative shift with the proliferation of digital technology. Personal computers, CD-ROMs, and later, the internet, gave rise to interactive multimedia (Kalolo, 2019). The work of educational software developers like Seymour Papert, who pioneered the Logo programming language, paved the way for computer-assisted learning. Educational software, online tutorials, and interactive simulations became essential tools for educators (Bottino, 2020).

Influential Figures in Educational Technology

Throughout this historical journey, several influential figures have left their mark on the evolution of audio-visual aids in education. Among them, Jerome Bruner's work in cognitive psychology and educational theory emphasized the significance of active learning and the role of visuals in cognition. His ideas contributed to the design of instructional materials that leverage audio-visual elements to enhance learning (Bruner, 1964).

Additionally, Marshall McLuhan's exploration of media and its effects on education highlighted the idea that "the medium is the message." This concept underscored the importance of considering the medium used for education and its impact on the learning experience (Roncallo-Dow & Scolari, 2016).

In conclusion, the historical evolution of audio-visual aids in education is a testament to the dynamic nature of pedagogy and technology. From humble beginnings with lantern slides to the immersive virtual worlds of today, audio-visual aids have continually adapted to meet the evolving needs of educators and learners. This historical context provides valuable insights into the trajectory of these aids and their enduring importance in shaping modern education. As we stand at the cusp of new technological frontiers, understanding this history is essential for appreciating the potential and challenges of audio-visual aids in contemporary education.

2.4 Categories of Visual Aids

Projected and non-projected visual aids are two subcategories that can be distinguished (Pike, 2003; Rather, 2004; Mangal & Mangal, 2009).

Projected Visual Aids

According to Hussain et al. (2009), projected visual aids are images that are displayed on a screen using a certain kind of device, like a filmstrip projector, slide projector, overhead projector, or TV/VCR. In the same vein, Okaw (1995) claims that instructional materials requiring projection to be viewed are referred to as projected visual materials. Accordingly, Dash and Dash (2007) define projected aids as visual aids in which an expanded image is displayed on a screen or a white wall after a bright light is focused through a transparent image using a lens.

Among the visual aids that can be projected are film strips and silent movies, computer graphics, magic lanterns, epidiascope, macro projections, and overhead and opaque projectors (Wilson & Brent, 2005). An illuminated screen has the advantage of drawing students' attention when it comes to projected visual aids, thus teachers should choose and project visuals only for the aim of keeping their students' attention according to Bozki *et al.,* (2021). He continues by saying that substitutes for the real things, particularly those that are either too far away, too dangerous, too big to bring into the classroom, too small to be seen by the human eye, or unavailable due to their cost or value, may be employed as projected visual aids.

Projected visual aids are expensive, complicated, and require a light source or power source, such as electricity, to function, according to Aboyade (1981). Due to their lack of adaptability, they also considerably lessen the teacher's influence on the learning process and do not allow for comprehensive adjustment to reflect the lesson delivered. Likewise, according to McArdle (2015), projected visual aids are beneficial for large audiences because everyone in the room can see them well.

According to Barnes (2013), one benefit of projected visual aids over non-visual aids in this regard is that they may be used to present any type of written, drawn, or printed material. Additionally, he points out that this kind of projection may be used in a space that is moderately well-lit, which makes it simpler to take notes and engage with students. In support of this, Boor (2013) argues that the use of projected media resources in the classroom enhances student-teacher interaction and gives instruction a more scientific foundation by offering a framework for organized lesson design.

Non-Projected Visual Aids

These are visual aids that can be used without the need for any kind of projection. These visual tools don't need a projector, a projector screen, or energy (Anyanwu, 2003). Print or non-print items may be used as non-projected visual aids (Sisiliya, 2013). In contrast to non-print resources including chalkboards, felt boards, bulletin boards, photographs, posters, images, maps, graphs, wall charts, flip charts, globes, realia, models, specimens, and textbook illustrations, print materials include journals, textbooks, newspapers, magazines, periodicals, and other publications.

According to Jurich (2001), using non-projected visual aids in the classroom, such as pictures, gives each student a tool to link unfamiliar words to their meanings. Understanding and memorization are aided by this. Additionally, Iwu et al. (2011) contends that non-projected visual aids, such as specimens, are especially helpful in facilitating effective science idea teaching since they make the job of science teachers easier. Models convey abstract and difficult concepts in a reduced form for learners to understand, according to Akram and Sufiana (2012)

It's interesting to note that Dash and Dash (2007) point out that non-projected visual aids are easy to utilize because any child can see them, hang them on the wall, touch them, and handle them. They may typically be found readily and made by teachers in the staff room or by obtaining them from the neighborhood. Hilmi and Sim (1997) further claim that these aids might come in a wide range of sizes, shapes, and colors, as well as have local appeal or interest. They can also be modified to meet the requirements of other topic areas.

2.5 The Essence and Development of Visual Aids in Teaching and Learning

The world's oldest form of instruction is still, for many purposes, the most effective: visual methods of instruction (Curzon & Tummons, 2003). Before they could speak or write, early men learned through direct experience. Primitive societies frequently used visual signs before written languages were developed. There is a case to be made that the usage of visual aids dates back to the time when humans felt the need to express their ideas through graphics or images. In his essay, Barbour (2001) cites Plato as one of the first thinkers to illustrate his most abstract ideas using concrete objects like "the cave".

Prior to puberty, Recto (2005) claims that prehistoric children might learn by doing and by seeing normal social interactions. While girls learnt to conduct household chores by watching their moms, boys were taught how to hunt, fish, and dig. Real objects were frequently preferred for instructing kids. The lads were taught how to utilize basic tools like arrows, bows, and spears, for instance. Children learned visually by taking part in and copying adult activities because education's goal was to give children practical skills (Kerubo, 2016). In a similar vein, adults preferred to teach young students by using tangible materials and visual examples.

Boys and girls experienced a long period of education during initiation, especially in indigenous African societies. This was made possible by the significant usage of sculptures and artwork, the majority of which were constructed of wood and metal. Numerous ideas were shown, and the kids learned by doing and by watching their teachers. Even though how concepts were represented visually differed from society to society, they were all used as a medium to aid in understanding (Kerubo, 2016). Additionally, early man communicated visually by placing stones in specific configurations and drawing patterns in the sand along the shore. Surface-drawn maps were another visual aid for giving instructions. The use of fire and smoke signals, on the other hand, as a means of long-distance visual communication between humans is mentioned by Borowski et al. (1998). Visual communication has generally been a widespread habit among generations of people for a very long time.

The 21st century's advancements in science and technology, in particular, have substantially increased the amount of visual content that is available (Sisiliya, 2013). For instance, the development of computers has made visual media production and design simpler (Costley, 2014). Every year, new materials and projection tools are developed, which has completely changed how visual content is displayed. With the use of digital video technology, teachers can create their own movies or find ones that best suit the requirements and interests of their pupils (Shrosbree, 2008). Teachers from all around the world are now able to share visual content with their students because to the increasing use of mobile devices to access the internet.

The use of multimedia to improve learning is advantageous because it makes it easier and more possible to obtain information using a variety of teaching methods; it encourages interactive learning and, as a result, increases both students' and teachers' enthusiasm for learning (Cockerill et al, 2015). Video technology is very helpful in laboratory science because it makes it possible to see processes and promotes a deeper level of understanding than is possible with merely text-based explanations.

Teachers, researchers, and students are finally realizing the importance of audio/visual resources, not as a stand-alone teaching tool or resource, but rather as an efficient, essential instructional medium that enables the presentation of knowledge through visual experience and learning. According to Nwike and Anene, (2013) research, there is a considerable impact of treatment with (audio visual aids) on students' achievement in the sciences. According to Jonah (2013), who backed this point of view, there is a statistically significant difference between pupils who receive instruction using audio visual aids and those who do not. The idea that each instructional tool offers a unique learning experience and that some tools may offer more learning opportunities than others was also supported by Dale in Carton, (2015). For instance, real audio-visuals offer more learning opportunities because students can see and touch them. As the use of audio-visual media appeals to stimulates and employs each student's five senses, including sight, hearing, and touch, conceptualizing is made clearer and more tangible. Shah and Khan, (2015) noted that animation and information given on screen offered a distinct learning experience than printed text, which was advantageous for the growth of critical thinking. Gilakjani, (2012) also agreed that the use of effective teaching tools, such as audio-visual aids, can improve both teaching and learning. Visual presentations can assist students distinguish between main and secondary sources of information when they are addressing topics that call for more complex reasoning.

According to Saima, Qadir and Shazia, (2011), audio-visual aids are crucial to the teaching-learning process because they make it more efficient, provide in-depth knowledge about the subject matter, make the classroom environment appealing, and inspire both students and teachers. According to Slavin, (2018), instructional or audio-visual resources including textbooks, photographs, diagrams, flashcards, posters, television, etc. are items or gadgets that aid in the teaching and learning processes because they have an impact on the senses of sight and hearing.

In many subjects, including English (Sharma, 2013), Biology (Satyaprakasha & Sudhanshu, 2014; Udayakumar, 2013), Science (Krishnakumar, 2013; Owolabi & Oginni, 2014), and Physics, research findings from numerous recent studies have shown that the use of multimedia, such as audio-visual aids in class room teaching, improved learning, retention of material presented, and students performed better than those taught through conventional method (Erdemir 2011). According to Duttley (2012), teachers may not have a choice but to use audio visual resources for successful teaching and learning if positive results in the teaching and learning of science are to be realized.

2.6 Empirical Literature Review

Many different academics have investigated the relationship between visual aids and student performance. This demonstrates the importance of visual aids in learning generally and the teaching process. A few of the findings about visual aids and their influence on students' performance and achievement will be reviewed in this section of the dissertation.

2.6.1 Visual Aids and Learners Performance

A study was conducted in 1997 by Harwood and McMahon to determine how integrated video media affected students' performance in Chemistry. One of the conclusions was that students in the treatment group who took chemistry courses supplemented by structured chemistry video series performed significantly better than their counterparts in the control group. Additionally, it was discovered that students liked watching instructional films and suggested using them more frequently in the future. Similarly, Vaughn and Wang, (2009) investigated how user-controlled visual aids could help students comprehend basic statistics. University of Texas at Austin students were exposed to animated visual aids during the study. The results demonstrated that the specific animated visual aid had a considerable positive impact on students' academic performance and confidence in their ability to apply level information.

Perry (2013) conducted study on rural high schools in Southeast Ohio about the same issue of visual assistance. She intended to investigate how visual media affected students' performance and attitudes in biology classes. Through the study, it was discovered that teachers in the classroom frequently and to varied degrees employ visual aids, which was associated with an improvement in students' engagement, focus, and attitudes toward the subject. However, the study did not discover any evidence of a link between student performance and the consumption of videos. However, she asserted that videos might be an effective and practical teaching approach if students can concentrate and pay attention in class more effectively. This is true because increased student attention has a favourable impact on how lessons are delivered and how well students learn.

Slavin (2018) argued that instructional or audio-visual materials such as textbooks, picture diagrams, flashcards, posters television etc. are materials or devices that help in the teaching-learning process because they influence the senses of seeing and hearing, but their utilisation must depend on proper planning. This seems to confirm the view expressed by Onasanya and Adegbiya (2007) that a planned utilization of instructional materials helps the students comprehend, retain and recall concepts, principles or theories and acquire professional skills. Idris (2015) revealed that the use of Audio-visual materials in the teaching and learning of speaking skills was significantly better than the use of conventional methods in which no audio-visual materials were used. Karemera, Reuben and Sillah, (2003) found that student performance is significantly correlated with students' satisfaction with the academic environment and the facilities there such as a library, computer labs etc. Concerning background variables, she found a positive effect on high school performance and school environment. She also found significant statistical evidence between family income level as a measure of background home environment towards learners' access to audio-visual gadgets and the academic performance of students.

To investigate the impact of visual representations in primary mathematics in schools in the Northeast of England, Barmby *et al.* (2013). The purpose of the study was to investigate the learning effects of using visual representations in primary classrooms to teach multiplication and fractions. Findings demonstrated that when these concepts were taught through visual representations, knowledge and performance in multiplication and fractions improved.

Nooriafshar, (2005) of Australia conducted study on the efficiency of hands-on activities and visual aids in teaching mathematical concepts, concentrating on a group of twenty first-year undergraduate students who were chosen for the experiment and came from various mathematical backgrounds. In a study, the researcher used visual ways to teach mathematical concepts and used questionnaires to get feedback from the students on what they thought was the most useful. According to his research, 65% of the students who took part in the study preferred having correlations and patterns visually explained to them.

Ikeuchi, (2003) subsequent study on general education students at Takamatsu First High School in Kagawa Prefecture discovered that visual aids had a significant impact on students' learning. The researcher found that audio-visual aids were prevalent in schools and had a favourable impact on students' academic performance in a study that sought to connect visual aids to student learning.

An investigation into how visual aids can improve learning in Pakistan's District Dera Ghazi Khan by Shabiralyani *et al*., (2015) found a positive relationship between visual aids and student learning. The research showed that using visual aids in the classroom improved the learning environment and increased students' thinking. Researchers found that engaging visual aids effectively replaced boring learning settings. Additionally, it was shown that when kids have successful and enjoyable learning experiences in school, especially when visual aids are used, their personal grasp of the subject matter grows.

Gul et al. (2014) looked at the impact of audio-visual assistance on secondary school pupils' cognitive abilities. The experimental group of pupils who were taught using audio-visual aids outperformed the control group in an experiment involving government female secondary schools in Pakistan. The results revealed that the employment of audio-visual aids benefited pupils' cognitive abilities. Additionally, it was shown that using audio-visual aids in the curriculum to supplement conventional instruction can result in improved learning outcomes.

Additionally, a study on the effects of audio-visual resources on instruction and learning in private secondary schools in the Makurdi metropolis was conducted by Ode (2014). It was discovered that all of the chosen private schools in Makurdi used a variety of audiovisual resources for teaching and learning, including filmstrips, microforms, slides, transparencies, tape recordings, flashcards, opaque materials projected on a screen, photographs, discs, art and study prints, charts, atlases, maps, posters and billboards, and realia. According to the study's findings, the usage of audio-visual materials had a major impact on teaching and learning since they helped students understand concepts better and had a wider range of learning opportunities.

Higher learning outcomes in terms of achievement scores are likely to occur when appropriate audio-visuals are integrated into the curriculum to supplement the traditional method, according to research done by Quarcoo-Nelson et al. (2012) to examine the impact of visual aided instruction on students' achievement in Physics. According to the study, senior high school pupils who received audio-visual aids to their training performed better than those who received traditional instruction. Quarcoo-Nelson et al. (2011) proposed that teachers investigate several types of audiovisual aids to employ in their instruction in order to improve instruction in Ghanaian schools. On the other hand, a study conducted in Uganda by Lakot, (2014) found that visual aids have a significant impact on boosting students' performance in the history subject. The study suggested that in order for the fundamental principles of history to be transmitted from generation to generation, the sufficiency and accessibility of visual aids should be highly appreciated.

Fentiman *et al.*, (2013) research indicated that the use of visual aids had an impact on students' academic performance and interest in the subject matter. Further research revealed that the inclusion of photos, murals, and other visual aids with descriptions on the walls of classrooms enhances the learning environment while also entertaining students. Visual aids were found to be crucial in increasing pupils' learning in a two-year study that involved watching and filming instruction at a few schools in the

Manzese ward of the Kinondoni municipality. The impact of employing improvised instructional materials on the academic achievement of secondary school physics students in Oyo state was examined by Oladejo et al. (2011). Students exposed to educational materials with some audio-visual aids performed better than those taught using conventional instructional materials, according to an experimental study that entailed giving some students improvised instructional materials. The use of improvised teaching tools, such as visual aids, was found to help teachers more economically and to encourage student participation, which helps learners perform better in class.

Students were verbally introduced to different teaching principles in a study by Moreno and Oregano-Layne (2008), and the principles were then reinforced using one of four different techniques: the principle was accompanied by a text example, the principle was accompanied by a video example, the principle was accompanied by a visual example from the teacher, or the principle was not accompanied by any examples. After that, each student received a conceptual test, an application test, and an opinion poll. Students' attention and retention of the subject matter increased when they had access to videos or in-person visualizations. Contrarily, students who received text-based explanation and those who did not received further explanation did not differ from the control group in their excitement for or understanding of the subject.

2.7 Teachers' Effectiveness in the Use of Audio-Visual Aids for Teaching and Learning in Senior High Schools

Educational inputs called instructional materials are essential for teaching any subject in the school curriculum. They are resources that the instructor employs to amplify his lessons (Adeniyi, 2001). In every teaching-learning process, teachers are regarded as the key implementers of effective resource usage. Utilization describes the extent to which a particular substance is used in the performance of a particular task (Uzuegbu, Mbadiwe & Anulobi, 2013). It entails putting worth into things (Asogwa, Onu & Egbo, 2013). Utilization mostly determines the worth of educational materials by how well they individually or jointly meet the derived educational needs.

In the same way that it is revolutionizing all facets of human life, the effective use of audiovisual aids in the classroom changes the learning environment from one that is teacher-centred to one that is learner-centred (Guan et al., 2018). Coleman et al. (2016) stressed that the transition from teaching to learning creates a student-centred learning environment in which teachers serve as facilitators rather than sages on stages, changing the teacher's role from that of a knowledge transmitter to that of a facilitator, knowledge navigator, and co-learner. According to Keengwe *et al*. (2008a), the use of multi-media technologies guarantees that classroom instruction is delivered in a way that is highly effective, fascinating, motivating, interactive, and of high quality while considering the needs of various learners.

Nwankwo (2004) researched the subject, looking at how audio-visual aids were used to teach English in Anambra State's secondary schools. It was discovered that teachers needed audio-visual resources to ease the teaching of English and enhance overall job effectiveness. It was discovered that there was a correlation between the English teachers' usage of audio-visual aids in the classroom and both their prior training and experience as teachers. According to study results, many teachers had no prior experience with audio-visual materials, which made it impossible to attain the desired academic outcomes. The secondary schools chosen were discovered to be sufficiently furnished with books and chalkboards that were used very well. However, the schools lacked software resources like charts, tapes, slides, and transparencies, and the few visual aids that were present were not successfully utilised. One of the issues preventing the availability of audio-visual aids in Anambra schools was a lack of sufficient funding. Other issues included a lack of energy and expensive technology that increased the cost of supplies for teaching materials. All these issues have an impact on pupils' academic performance and learning in general. However, the following research on visual aids and student performance was also carried out in Ghana.

2.7.1 Enhanced Learning Experience

Audio-visual aids provide a multisensory learning experience that fosters better understanding and retention of complex concepts. Mayer (2009) emphasizes that multimedia learning environments can enhance retention and understanding by reducing cognitive load and facilitating deeper comprehension of intricate subjects. This is particularly relevant in biology education, where visual representations can clarify complex processes such as dissection and digestion.

Freeman *et al.*, (2014) further support this assertion by demonstrating that active learning strategies, including the use of multimedia resources, significantly improve student performance in science and mathematics. Their findings align with Hattie (2009), who underscores the importance of instructional strategies tailored to enhance student engagement and understanding.

2.7.2 Improved Teaching Quality

The use of audio-visual technology enhances the quality of teaching by facilitating clearer explanations and demonstrations. Research indicates that teachers who employ visual aids create a more dynamic and interactive classroom environment (Agun et al., 1977). This not only improves educators' performance but also contributes to a more effective teaching-learning process.

Additionally, advanced audio-visual technology has been linked to increased student concentration and participation (Savchenko, 2021). The interactive nature of these tools encourages active involvement from students, fostering a conducive learning environment.

2.7.3 Increased Student Motivation

Research indicates that audio-visual aids significantly boost student motivation. For instance, students have reported feeling more engaged and motivated when multimedia resources are incorporated into lessons (Agun *et al*., 1977). This finding is consistent with other studies that demonstrate how multimedia resources enhance students' attitudes towards learning by making lessons more engaging (Çelik & Aytin, 2014).

Moreover, the motivational aspect highlighted by students underscores the role of engagement in academic success. Deci and Ryan (2000) found that motivated learners are more likely to succeed academically, reinforcing the importance of incorporating audio-visual aids into instructional strategies.

2.7.4 Facilitation of Understanding Complex Concepts

Audio-visual aids have proven particularly effective in facilitating the understanding of complex subjects. Research by Mayer and Moreno (2003) emphasizes that multimedia presentations help reduce cognitive load and enhance comprehension of intricate topics. In biology education, for example, visual representations can clarify processes such as dissection and digestion, making them less abstract for students.

Additionally, studies have shown that combining audio with visual elements leads to better retention of information compared to using either modality alone (Mayer & Moreno, 2003; Mayer, 2009). This multimodal approach not only promotes understanding but also supports long-term memory retention.

2.7.5 Challenges and Considerations

While audio-visual aids offer numerous benefits, some challenges remain. Canning-Wilson and Wallace (2000) noted that excessive or irrelevant audio-visual information could interfere with comprehension. Educators must therefore be mindful of selecting appropriate materials that align with learning objectives to avoid cognitive overload. Furthermore, some students may experience distractions from visual content if it is not effectively integrated into lessons. As highlighted by Cohen (2014), balancing visual input with auditory information is crucial for maximizing learning outcomes.

2.8 Psychological Aspects of Visual and Auditory Learning

Visual and auditory learning are two distinct but interconnected modes of acquiring information. Visual learning relies on the processing of visual stimuli, such as images, diagrams, and written text, while auditory learning involves the reception and interpretation of auditory cues, including spoken words and sounds. Both these modes are integral to the learning process, and understanding the psychological underpinnings is key to optimising educational strategies.

2.8.1 Psychological Principles of Auditory Learning

Auditory learning is a learning style in which a person learns through listening and speaking as the main way of acquiring and retaining information (Ariastuti & Wahyudin, 2022). Here are some psychological principles of auditory learning:

Verbal Instruction: Auditory learners benefit from verbal instruction, as they can better understand and retain information that they hear. They may struggle with written comprehension and find it helpful to have sound in the background while studying (Trinidad, Ngo, Nevada, & Morales, 2020).

Repetition and Recitation: Since speaking is a key component of auditory learning, repeating and reciting information out loud can greatly enhance the learning experience for auditory learners. This helps them to reinforce and retain the information they are learning (Trinidad *et al*, 2020).

Questions – and - Answer Sessions and Verbal Games: Engaging in question-and-answer sessions and playing verbal games can help auditory learners stay engaged and absorb important information about specific topics. These activities allow them to process information through listening and speaking (Trinidad *et al*, 2020).

Group Discussions and Study Buddies: Auditory learners benefit from group discussions and having a study buddy with whom they can ask and answer questions. These interactions provide opportunities for them to engage in verbal communication and reinforce their understanding of the material (Ariastuti & Wahyudin, 2022).

Context and Association: The amygdala and the hippocampus are two important areas of the brain involved in auditory learning. The amygdala is responsible for processing sound information, while the hippocampus is involved in the modification, linking, and retrieval of memories. Learning in the auditory domain is about context and association, which helps in understanding the order of events and the perception of objects or auditory information that identifies with objects (Trinidad *et al*, 2020).

2.8.2 Integration of Visual and Auditory Learning

Integrating visual and auditory learning can be a powerful approach to education, as it combines the strengths of both learning styles. While auditory learners prefer to learn through listening and speaking, visual learners benefit from seeing and observing information. Here are some key points from the literature on the integration of visual and auditory learning:

Multimedia Presentations: Research shows that students learn more deeply from words and visuals than from words alone. Multimedia presentations encourage active cognitive processing, promoting meaningful learning (Vu *et al.*, 2022). Incorporating visual elements, such as images, diagrams, and flowcharts, into auditory instruction can enhance understanding and retention of information.

Visual Support for Auditory Learning: Providing visual support, such as images or diagrams, during auditory instruction can help auditory learners better understand and retain information. This can be particularly useful for complex or abstract concepts that may be difficult to grasp through auditory input alone (Elimelech & Aram, 2020).

By integrating visual and auditory learning strategies, educators can create a more inclusive and effective learning environment that caters to the needs of a diverse range of learners.

2.9 Dissections in Biology Education

The biology curriculum in Ghana requires sessions that include dissections of animals. It is a requirement that a learner must conduct during the second cycle of his or her education (Isaac, 2002). "It is thought that dissections enhance the knowledge and understanding of internal organs, their structures, their relationships and their functioning, and that maximum learning is most likely to be achieved by maximising the personal experience of the reality being taught" (Wheeler, 1993, p. 39).

The use of dissections in biology education began in the early twentieth century and it has been used to teach the morphology of animals since then. The traditional way dissections are usually taught in schools, where learners just cut, draw and label the dissected animal or organ, is weak in concept learning and problem-solving. This was supported by two-year research carried out on first- and second-year UK and Ireland medical students from selected universities using traditional and problem-based curricula. The traditional way of teaching dissections is too focused on the acquisition of facts without teaching learners to conceptualise and synthesise. These are very important attributes for a biology learner (Jacobs & Moore, 1998). Dissections can play many roles in the educational process: it can provide learners with the opportunity to verify their learning, trust their observations and appreciate the concept of variability as it presents itself and not as it is presented to them. “If directed creatively, dissections provide the platform for the independent learning and independent thinking that underpins the development of diagnostic aptitude” (Pawlina & Lachman, 2004, p. 2). Dissections take many of the thing’s learners have heard and read about and give them first-hand experience.

Historically, an important tool of investigation in human and animal anatomy has been dissections. However, a complete anatomy learning experience that includes dissections of animals or animal organs goes beyond identification of the parts of the dissected animal or organ. It should improve the learner’s conclusions and insights about the nature and relatedness of living organisms. For learners to succeed in their future careers related to biology, they must become thoroughly familiar with anatomical structures, their design features and their relationships to one another. According to the Human Anatomy and Physiology Society (HAPS) (2012), dissections are based on observational and kinaesthetic learning that instils a recognition and appreciation for the three-dimensional structure of the animal body, the interconnections between organs and organ systems, and the uniqueness of biological material. This means that a learner can generate knowledge through dissections of animals or organs and integrate the information and the interrelatedness of concepts. Balcombe (2000) acknowledges that dissections convey the inherent variability of living organisms which include the real texture of the tissues, the colour of the different parts of the animal or organ that one cannot observe on simulations and models even though they are imitations of the real organism. He also emphasises that the key question, with which the researcher agrees, is not whether one method is equal to the other but, rather, how well a given method promotes learning. There are some Physiology experiments that involve humans and live animals which provide an excellent opportunity to learn the basic elements specific to scientific investigation and experimentation. As learners work on these experiments, they can pose questions, propose hypotheses, develop technical skills, collect data, analyse results, and develop, and improve critical thinking and problem-solving skills (HAPS, 2012). The experiments or practicals may include exploring of animal organs through dissections and using the knowledge generated to answer problem-solving questions which will have been provided by the teacher.

Many authors including Lieb (1985), Marszalek and Lockard (1999), McCain (2005), Oakley (2011b), Offner (1993) and Preszler et al. (2007) have advocated the importance of animal dissections. They concur that dissection, as practical work, can be used by biology teachers to break the monotony of classwork. Learners also get to bond and establish teamwork skills as the activity is usually carried out in groups. This can, with time, be extrapolated into various other social and academic settings as the learners grow up. Learners who have dissected organs with close interest will certainly 'dissect' the theory with accuracy. A close participation in organ and animal dissections will also arouse some interests and opportunities that a learner may not have considered exploring. Dissections of animals or their organs may also be considered important because it:

- Helps learners to learn about the internal structures of animals.
- Helps learners to learn how the tissues and organs are interrelated.
- Gives learners an appreciation of the complexity of organisms in a hands-on learning environment.
- Provides one of the most memorable and instructive units in a Life Sciences course.
- Furthermore, it is said that to a wise man, a picture is worth a thousand words. This means that by observing the dissected organs, learners can acquire more knowledge than if they just receive theoretical knowledge from their teachers.

Dissections in education can be meaningful if correctly carried out with proper supervision and guidance from the teacher with clearly defined objectives which will engage both the learners' hands and brains. Michael (1993) observes that hands-on activities like the dissections of animals are only effective for learning if the learners' heads are being kept as busy as their hands. Dissections should not be done as a way of satisfying haphazard curiosity. In as much as curiosity is a basic aspect of science, it is not enough justification for dissections of animals or their organs. Justified animal dissections must be performed in the context of an intelligently planned and educationally valid curriculum. If dissections are used to develop other skills, learners will realise that there is more to dissection than just mutilating the dissected animal or organ.

Active learning is not something that is done for the learners; it is something they do for themselves (Michael, 1993). Active learning effects better retention, better retrieval, and better application of knowledge to other contexts (Heiman, 1987). "Facts can be efficiently transmitted by passive learning, but problem-solving skills are learned most effectively by active, hands-on experience" (Balcombe, 2000, p. 8). Using animal organ dissections, there is a shift from the passive learning experience to an active learning experience in which a learner can acquire the problem-solving skills which one needs in real life.

2.10 Culture, religion and animal dissection

The influence of culture and religion on animal dissection is a complex and multifaceted topic that has been explored in various studies. Cultural and religious beliefs often shape individuals' attitudes and behaviours towards animals and their treatment. These beliefs can significantly impact the acceptance or rejection of animal dissection in educational settings.

In some cultures, and religions, animals hold significant religious or spiritual value, and harming or dissecting them may be seen as sacrilegious or ethically problematic. For example, certain Eastern religions, such as Hinduism and Buddhism, emphasize the sanctity of all living beings and advocate for non-violence towards animals. In these contexts, there may be strong objections to animal dissection due to religious beliefs.

Conversely, in other cultural and religious contexts, the use of animals in educational practices may be more readily accepted. For instance, in Western cultures where Judeo-Christian traditions are prevalent, animals are often seen as resources provided for human use, and their dissection may be considered a necessary part of scientific education.

Several studies have investigated the influence of culture and religion on attitudes towards animal dissection. For instance, a study by Evans and Gray (2008) explored the views of Muslim students in the United Kingdom regarding animal dissection in educational settings. The findings indicated that religious beliefs played a significant role in shaping their attitudes towards dissection, with some expressing reservations or objections based on Islamic teachings.

Another study by Randler and Wilhelm (2002) examined the attitudes of German students from different cultural backgrounds towards animal dissection. The results revealed that students with a religious background, particularly those from a Muslim background, were more likely to have reservations or objections to animal dissection compared to their non-religious peers.

It is essential to recognize that cultural and religious attitudes towards animal dissection can vary greatly, even within the same religion or cultural group. Individual interpretations, personal beliefs, and varying levels of religious adherence can lead to a range of perspectives on this issue.

Educational institutions and teachers need to be sensitive to the cultural and religious diversity of their student populations when incorporating animal dissection into the curriculum. Alternative teaching methods, such as computer simulations or models, can be considered to accommodate students with objections based on cultural or religious beliefs.

Therefore, cultural and religious beliefs can significantly shape individuals' attitudes towards animal dissection in educational settings. While some cultures or religions may have objections based on ethical or religious grounds, others may view dissection as a necessary part of scientific education. It is crucial for educators to be aware of these cultural and religious considerations and provide alternative options to accommodate students with objections. Further research is needed to explore these influences in greater depth and across different cultural and religious contexts.

2.11 Gender Differences in Academic Performance

The exploration of gender differences in academic performance has garnered significant attention in educational research. This section reviews existing literature on the topic, focusing on patterns of performance among male and female students, factors influencing these differences, and implications for educational practices.

2.11.1 Academic Performance Trends

Recent studies indicate that gender differences in academic performance vary across educational levels and subjects. A study by Workman and Heyder (2020) highlights that while males generally outperform females at the senior high school level, females tend to excel at the tertiary level, particularly in STEM subjects. This shift suggests that various factors, including teaching methodologies and societal influences, may contribute to changing performance dynamics as students progress through their education.

In contrast, findings from Ghana indicate that males consistently outperform females in mathematics and science subjects (Kyei & Benjamin, 2011; Oppong, 2011). These results challenge the notion that females are inherently less capable in traditionally male-dominated fields and underscore the need for targeted interventions to support female students' engagement and success in STEM areas.

2.11.2 Influencing Factors

Several factors contribute to observed gender differences in academic performance. Research has shown that gender stereotypes significantly impact students' self-perception and motivation (You & Sharkey, 2012). For instance, societal expectations may lead to lower confidence among females in pursuing STEM subjects, despite their competencies. Conversely, males often engage more in extracurricular activities that may detract from their academic focus.

Additionally, Pryer *et al.*, (2009) found that female students tend to exhibit higher levels of conscientiousness compared to their male counterparts. This trait translates into greater effort in their studies, as females are more likely to study longer hours and seek feedback from teachers. Such behaviours contribute to improved academic outcomes for females, especially in language and arts subjects where they traditionally excel.

2.11.3 Minimal Gender Differences

Despite some studies indicating significant differences between genders, other research suggests that these disparities are minimal or non-existent in certain contexts. For example, a meta-analysis by Voyer and Voyer (2014) found negligible gender differences in standardized mathematics tests. Similarly, Ajai and Imoko (2015) reported no significant differences between male and female students' achievement and retention scores in mathematics.

These findings suggest that while there may be observable trends favoring one gender over another in specific subjects or contexts, the overall impact of gender on academic performance is often small. This aligns with Hyde's (2005) meta-analysis, which concluded that most effect sizes related to gender differences in academic performance are minor.

2.11.4 Implications for Educational Practices

The existing literature underscores the importance of addressing gender differences through informed educational practices. Educators should be aware of the potential influences of gender stereotypes on student performance and strive to create inclusive environments that encourage all students to excel regardless of gender.

Furthermore, targeted support for female students in STEM fields is essential to bridge the performance gap observed at various educational levels. Advocacy campaigns focused on women's empowerment and mentorship programs can help foster confidence and interest among female students pursuing traditionally male-dominated subjects (Ullah & Ullah, 2019).

2.11.5 Gender Attitude Towards Biological Specimen Collection and Dissection

Understanding gender attitudes towards biological specimen collection and dissection is essential for promoting equitable and inclusive learning experiences in biology education. The study of gender attitudes provides insights into how students, based on their gender identity, perceive and engage in activities involving the handling of biological specimens.

A study on high school biology teachers in Switzerland found that women expressed concern about what dissection might be teaching the value of animal life more frequently than men and were more willing to use animal-free alternatives instead of animals in their teaching (Zemanova, 2022).

A survey conducted with college students found that when the packaging and healthiness of the food are gender congruent, both male and female participants rate the product as more attractive, report that they would be more likely to purchase it, and even rate it as tasting better (Zhu, Brescoll, Newman & Uhlmann, 2015)

A study on Ontario science and biology teachers' practices and attitudes towards animal dissection and dissection alternatives found no statistically significant influence of gender on the attitude towards animal dissection and alternatives. However, more women expressed concern about what dissection might be teaching the value of animal life and were more willing to use animal-free alternatives instead of animals in their teaching (Oakley, 2012).

A study on educator and student use of and attitudes toward dissection and dissection alternatives found that more than a third of biology students preferred the use of alternatives over animal specimens, yet most did not request dissection alternatives. Educators cited student performance as the main factor driving their decision to use dissection or alternatives and reported conducting dissection exercises because of student interest (Osenkowski, Green, Tjaden & Cunniff, 2015).

A study on sex and gender equity in research found that despite recognition of the importance of sex and gender in most areas of research, important knowledge gaps persist owing to the general orientation of scientific attention to one sex or gender category and because of a misconception that disaggregation of sex does not apply to other living organisms that can be classified by sex (Heidari, Babor, De Castro, Tort & Curno, 2016).

Overall, gender attitudes towards biological specimen collection and dissection are complex and influenced by various factors such as concern for animal life, willingness to use alternatives, and student interest. While some studies found that women expressed more concern about the value of animal life and were more willing to use animal-free alternatives, other studies found no statistically significant influence of gender on attitudes towards dissection and alternatives. It is important for educators to consider these factors when designing educational activities involving biological specimens and to provide a safe and respectful learning environment for all students.

2.12 Virtual or Online Dissections

Literature has shown that some learners are totally against dissections to the extent of choosing to forfeit the marks rather than touching fresh animal organs (Balcombe, 2000). Learners like that would rather dissect artificial animals or organs and practice virtual or online dissections. A few authors have argued for and some against the use of artificial organs or virtual dissections (Kinzie et al., 1993; McNeely, 2000; Moore 2001; Orlans, 1988). The researcher believes that both ways of dissections have their own advantages and would rather let those learners who are uncomfortable with fresh organ dissections dissect the artificial ones than have them not do it at all. The only stumbling block in the case of most Ghanaian schools might be affordability because fresh animal organs are much cheaper than artificial specimens. In Ghana natural specimens can be obtained free from the environment whiles artificial models are expensive and difficult to come by in the Ghanaian setting. These costs are beyond the reach of many schools in Ghana, to invest on one practical for one subject.

Hart, Wood and Weng (2005) argue that new computer technology can transform the possibilities for providing effective and efficient learning of human-animal morphology in the absence of old-fashioned dissections. This new software allows learners to dissect online; it could minimise problems faced by learners due to the smell of the organs, squeamishness or blood phobia during real organ dissections. According to King, Ross, Stephens and Rowan (2004), the use of dissection alternatives is not very popular with teachers. The teachers are mainly using alternatives as supplements, rather than substitutes, to fresh animals or organ dissections. Their study demonstrated that teachers reported using charts, videos, 3D models, CD-ROMS, and other computer-based resources, but only 31.4% of these teachers agreed that alternatives were as good as dissections of fresh animals or organs for teaching anatomy and/or physiology. This shows that the teachers are not yet convinced that the alternatives to fresh animals or organs are just as good for dissections. Almy, Goldsmith, and Patronek, (2001) have come to similar conclusions as King et al. that teachers were not certain about considering computer simulation as a pedagogical tool, even though 78.1% of the teachers in the study acknowledged using alternatives but mostly as supplements to real dissections.

Many variables can influence the teachers' decision to use alternatives as a substitution for, or in conjunction with traditional dissections. Cockerham (2001) and Hart et al. (2008) highlighted some of the factors that increase teachers' likelihood of using virtual dissections alternatives: a teacher's positive attitude towards virtual dissections, their previous experience using virtual dissections, their access to them, perceptions of effectiveness, willingness to explore new modes of learning, negative attitudes towards the use of animals in dissections, availability of resources, budgets, time and support. Taking into consideration the factors highlighted by Hart et al. (2008), the researcher is of the opinion that in as much as some teachers might acknowledge that the use of online dissections is good enough, if they are not confident in their use or if the school cannot afford the alternatives, they would rather use the traditional way of dissections and force their learners to carry out the fresh organ dissections as well.

According to Oakley's (2011a) study, most of the teacher participants "found unparalleled value in traditional dissections" (p. 256). The majority of the teacher participants (87.5%) acknowledged that real animal dissections is important to the teaching of Life Sciences, and more than half (56.3%) strongly argued that there are no substitutes for real animal dissections. It is evident from the findings of these authors that the teachers are still far from being convinced that the use of alternatives for dissections is just as good as traditional animal or organ dissections.

In as much as teachers acknowledge that there are some negative impacts of traditional dissections in schools, they believe that the benefits of traditional dissections outweigh the concerns. The benefits of traditional dissections include their pedagogical value. Many teachers consider that the best possible way learners can learn is to work with an actual organ and observe real-life interconnections between the organ parts.

These surprises, mentioned by Oakley, (2011a), along with the hands-on nature of dissections, are considered as benefits only physical dissections can provide. Another benefit which was considered important is the development of motor skills as they manipulate dissection instruments. A high degree of safety precautions is needed as they use sharp scalpels, and a delicacy of hand-eye coordination is also required. Learner engagement or enjoyment during dissections of animal organs is an exciting, one-of-a-kind experience that interests them and promotes desire for further studies as biology. Animal organ dissections give learners an opportunity to appreciate, develop respect and admiration for animals from which the organs were acquired. Opponents of dissection might argue that animal dissection desensitizes students to animal cruelty and encourages them to regard animals as mere things, but according to the survey carried out by Donaldson and Downie (2007), most of both staff and students disagreed with that line of thinking but considered that dissection attributed to a better understanding of the animal value. Measures like introducing ethics teaching in bioscience education (Downie, 1993) may improve the ethical sensitivity of the students to animal use according to the findings of Clarkeburn, Downie and Mathew, (2002). Alessi and Trollip (2001) argue that the use of alternatives can be used instead of the actual experience when the latter is unsafe, costly, very complex or logistically difficult but in the case of animal organ dissections, it is much cheaper to use the traditional dissections.

Oakley (2011b) highlights that some advocate for artificial organs or online dissections and draw attention to the concerns of some teachers. These include health and safety if they are exposed to formalin solution for too long during the dissections which can be a health hazard to the learners as well. This concern does not apply to the Ghanaian context because the animal organs dissected are usually bought a day before the practical and are stored in the fridges; hence there is no need to put them in formalin solution. Pedagogical concerns include misbehaviour of learners who deliberately mutilate, abuse, or otherwise disrespect the animals' bodies or organs. This situation can be avoided if the teacher moves around. Pedagogical concerns were also expressed about the retention of learners in the subject; some of them will have been turned off biology because they think it is gross. Some difficulties can arise when a learner refuses to dissect. Some are not willing to participate even as a helper or observer, despite having the requirement in the curriculum. Further difficulties are encountered in giving any learner who has an objection to dissections a meaningful alternate project which can count for the year mark. Others worried about the impact dissections could have on learners who were opposed to it for animal rights or other reasons. All these concerns may be addressed using alternatives to fresh organs like plastinated specimens or virtual dissections if the school has such resources.

Cross and Cross (2004) compared advanced adolescent biology students' performance when completing a physical dissection protocol. Before completing the protocol, they completed either computerised frog dissections using the multimedia application Biolab Frog Dissections or physical dissections. They found that students completing the physical dissections performed better on the protocol. Similarly, Marszalek and Lockard (1999) found that adolescent science students completing physical dissections produced superior learning gains from pre-test to post-test when compared to Digital Frog, a multimedia dissections application. When they measured retention over time, however, they found that these differences dissipated. It is interesting to note that these results conflict with those of Montgomery (2008) and Kinzie, Strauss, and Foss (1993), who found no learning differences between physical and virtual dissections. Downie and Meadows (1995) reported a scheme in which first year university Biology students were given a choice between dissecting a rat or opting out and doing an equivalent laboratory exercise using models, charts and demonstrators as alternatives. More than 10 examinations were recorded, opt-out and non-opt-out learners recorded the same mean mark. The opt-out students acknowledged that they generally found the model rat satisfactory as an alternative to the real rat. All these authors acknowledge that animal or organ dissections are important, the only difference is that some advocate for real animal dissections against those that say the performance is the same whether using real organs or artificial or virtual dissections. The researcher, having taken into consideration the arguments and evidence from the above-mentioned authors, thinks that teachers should be flexible and use both real and artificial organs. In that way, they can accommodate all learners for maximum participation in the dissections which will result in the acquisition of important skills like problem-solving skills.

The researcher's opinion is supported by Duncan (2008) who argues that this issue extends beyond instructional choice: the need to offer choice has been mandated in many educational settings. In such circumstances, virtual dissections may provide learning opportunities to students who would not engage in, and learn from, physical dissections for either moral or ethical concerns, and/or health concerns related to chemicals and hazardous laboratory instruments.

Numerous dissection alternatives are now available, including computerised virtual dissections, anatomical models, films, websites, and plasticated specimens. Learners now have a choice on the type of dissections they would like to carry out (Jukes & Chiuia, 2003; Smith & Smith, 2004). These developments should be welcomed by teachers because they minimise the controversies around real organ dissections for those learners who are uncomfortable in dissecting them.

2.13 The Impact of Audio-Visual Resources on Teaching the Digestive System in Elementary Education

The utilization of audio-visual resources for instructing digestion has demonstrated effectiveness in enhancing students' comprehension, stimulating their interest, and promoting self-efficacy and critical thinking skills. The incorporation of visual and auditory stimuli in educational materials aids in conveying complex concepts, facilitating a deeper understanding of the subject matter. By presenting dynamic animations, interactive simulations, and compelling narratives, audio-visuals capture students' attention and foster engagement, thus creating an immersive learning experience. Moreover, the interactive nature of these resources encourages active participation, enabling students to develop their critical thinking abilities (Sudaryanti, Yulianti, & Pramudiyanti, 2023).

A need analysis study aimed to obtain an overview of the current situation of the use of instructional media in science teaching processes in elementary schools. The study found that there is a need to develop audio-visual media to teach the digestive system to elementary school students (Stevi, & Haryanto, 2020).

Another study investigated the effect of audio-visual learning systems on self-efficacy and critical thinking ability in science lessons on the human digestive system. The study found that the proper use of audio-visual media in learning activities can improve interaction and communication between teachers and students, foster interest, and improve self-efficacy and critical thinking ability (Yasin, Syamsudin, Arifin & Warta, 2021).

2.14 Student Perceptions of Audio-Visual Aids

The use of audio-visual aids in educational settings has been extensively studied, with a particular focus on how these resources influence student perceptions and learning outcomes. This section synthesizes the findings from various studies that explore students' views on audio-visual aids, their effectiveness in enhancing engagement and understanding, and the implications for teaching practices.

2.14.1 Positive Perceptions of Audio-Visual Aids

Numerous studies indicate that students generally have positive perceptions of audio-visual aids as effective educational tools. Jain and Sharma (2023) found that incorporating audio-visual materials stimulates cognitive engagement and enhances the learning environment. Their research highlights that students appreciate the ability of visual aids to make abstract concepts more tangible and understandable, thereby improving comprehension.

Similarly, research conducted by Rahma Fitria et al. (2022) supports the notion that audio-visual materials make learning activities more enjoyable, reducing boredom during lessons. Students reported increased focus and motivation when engaging with multimedia resources, which aligns with findings from Hardiah (2018), who noted that audio-visual aids enhance comprehension and retention in listening classes.

2.14.2 Engagement and Interaction

Audio-visual aids are particularly effective in capturing students' attention and maintaining their interest throughout lessons. The dynamic nature of these resources encourages active participation, leading to higher levels of engagement in the learning process (Jain & Sharma, 2023). This is further supported by the findings of Bilican et al. (2012), who noted that students found multimedia tools more interesting than traditional audio formats like CDs or MP3s.

The interactive characteristics of audio-visual materials facilitate a more engaging classroom environment where students can participate actively in their learning. This engagement is crucial for fostering a positive attitude towards learning, as motivated learners are more likely to succeed academically (Deci & Ryan, 2000).

2.14.3 Catering to Diverse Learning Styles

One of the significant advantages of audio-visual aids is their ability to cater to diverse learning styles among students. Jain and Sharma (2023) emphasize that different students process information in various ways; while some may grasp concepts better through visual cues, others benefit from auditory inputs provided by audio-visual materials. This versatility allows educators to address the unique needs of each learner effectively.

Research by Rahma Fitria *et al.*, (2022) also highlights that students feel more enthusiastic and motivated when using audio-visual materials, as these resources facilitate a richer learning experience by combining visual and auditory elements.

2.14.4 Memory Retention

The literature indicates that audio-visual aids significantly enhance memory retention among students. Jain and Sharma (2023) assert that visual representations paired with auditory reinforcement help students recall information more effectively during assessments. This aligns with findings from Mayer (2009), who notes that multimedia presentations can improve retention by providing multiple channels for information processing.

Moreover, studies have shown that students who engage with both visual and auditory content are better equipped to remember what they have learned compared to those exposed to only one type of input (Mayer & Moreno, 2003).

Challenges and Considerations

Despite the numerous benefits associated with audio-visual aids, some challenges remain regarding their implementation in educational settings. For instance, while many students appreciate these tools, some may find them boring or confusing at times (Jain & Sharma, 2023). Educators must be mindful of selecting appropriate materials that align with learning objectives to avoid cognitive overload or disengagement.

Furthermore, teachers need to balance traditional teaching methods with multimedia approaches to ensure clarity and maintain student engagement throughout lessons.

2.14.5 How audio-visuals be used to engage students in learning about Digestion

Audio-visuals can be effectively used to engage students in learning about digestion by employing various strategies that tap into their visual and auditory senses. Here are some approaches for utilizing audio-visuals to enhance student engagement in digestion education:

1. Visualize the digestive process: Audio-visuals can help students visualize the digestive process, which can be difficult to understand through text alone. A need analysis study found that teachers need audio-visual media that can help to visualize the digestive process, and students perceive audio-visual media as an acceptable solution (Kamran, 2019).
2. Foster interest: The proper use of audio-visual media in learning activities can foster interest in the topic. A study found that audio-visual learning systems can improve interaction and communication between teachers and students, foster interest, and improve self-efficacy and critical thinking ability (Winarto, Syahid, & Saguni, 2020).
3. Enable active participation: Learning videos are one type of audio-visual media that can enable students' active participation in learning about the human digestive system. Learning videos display material in animation and are added with audio to explain the material. This can help students to better understand the digestive process and engage with the material (Winarto, Syahid, & Saguni, 2020).

In conclusion, audio-visuals can be used to engage students in learning about digestion by visualizing the digestive process, fostering interest, and enabling active participation.

2.15 Some specific audio-visual tools or resources that can be used to teach Digestion

Several audio-visual tools and resources can be used to teach digestion, (Weaver, 2011) including:

1. Videos: Videos can be used to visualize the digestive process and help students better understand the topic. Enchanted Learning offers a full glossary of digestion-related vocabulary and videos.
2. 3-D posters: 3-D posters can be made using simple props to visualize the digestive system. A life-size craft activity or a scrap-item craft activity can be used to make 3-D posters of the human digestive system.
3. Outdoor activities: The Science World Museum suggests a fun outdoor activity using an obstacle course to simulate the digestive system.
4. Audio-visual media: A need analysis study found that there is a need to develop audio-visual media to teach the digestive system to elementary school students (Stevi & Haryanto, 2020). Audio-visual media can help to visualize the digestive process and foster interest in the topic.

In conclusion, videos, hands-on activities, 3-D posters, outdoor activities, and audio-visual media are some of the specific audio-visual tools and resources that can be used to teach digestion.

2.16 Emerging Technologies in Audio-Visual Learning

Recent advancements in technology have the potential to revolutionize audio-visual aids in biology education. Emerging technologies like virtual reality (VR), augmented reality (AR), and interactive simulations are changing the landscape of biology education. Here are some key points from the search results:

Virtual and Mixed Reality: Virtual and mixed reality technologies have the potential to create immersive, participatory learning experiences for students. These technologies can be used to teach complex concepts in biology, such as evolutionary biology and astrobiology. For example, the BioVR learning tool is a virtual reality platform that allows students to explore and interact with evolutionary biology concepts in a 3D environment (Chang, Debra Chena, & Chang, 2019). Younger students also seem to benefit from the use of VR education in biology, given that a cohort of ninth-graders that experienced traditional learning materials supplemented by VR displayed improved analysis skills and learning attitudes towards biology (Chang *et al.*, 2019).

Augmented Reality: Augmented reality technologies can be used to enhance the learning experience by overlaying digital information onto the real world. In biology education, AR can be used to create interactive, engaging learning experiences. For example, a study examined prospective teachers' views on AR in biology teaching and found that AR activities can improve student engagement and understanding of the material (Xiong, Hsiang, He, Zhan, & Wu, 2021). Another study found that AR applications in biology lessons can improve academic achievement and motivation among students (Erbas & Demirer, 2019).

Interactive Simulations: Interactive simulations are computer-based tools that allow students to explore and manipulate complex systems. These simulations can be used to teach biology concepts that are difficult to visualize, such as cellular processes and molecular interactions. For example, an immersive virtual reality platform was used in an online biology course to teach students about cellular processes. The platform allowed students to explore and interact with cellular structures in a 3D environment, which improved their understanding of the material (Thompson, et al., 2019).

In conclusion, emerging technologies like virtual reality, augmented reality, and interactive simulations have the potential to revolutionize audio-visual aids in biology education. These technologies can create immersive, participatory learning experiences that improve student engagement, understanding, and motivation. By incorporating these technologies into biology education, educators can create dynamic, engaging learning environments that prepare students for the challenges of the 21st century.

2.17 Conceptual Framework of the Study

This study seeks to understand how the use of audio-visual aids in teaching biology impacts student learning outcomes, focusing specifically on dissection and digestion. The use of various tools such as videos, interactive 3D simulations, posters, and outdoor activities aims to foster student engagement, improve comprehension, and change attitudes toward these biology concepts.

However, the effectiveness of these aids depends on several moderating factors, such as the teacher's ability to integrate these tools into the learning process and the students' psychological learning preferences (visual vs. auditory). The framework also recognizes that students' attitudes towards dissections, influenced by cultural, religious, and gender-based perspectives, may shape their engagement with biology.

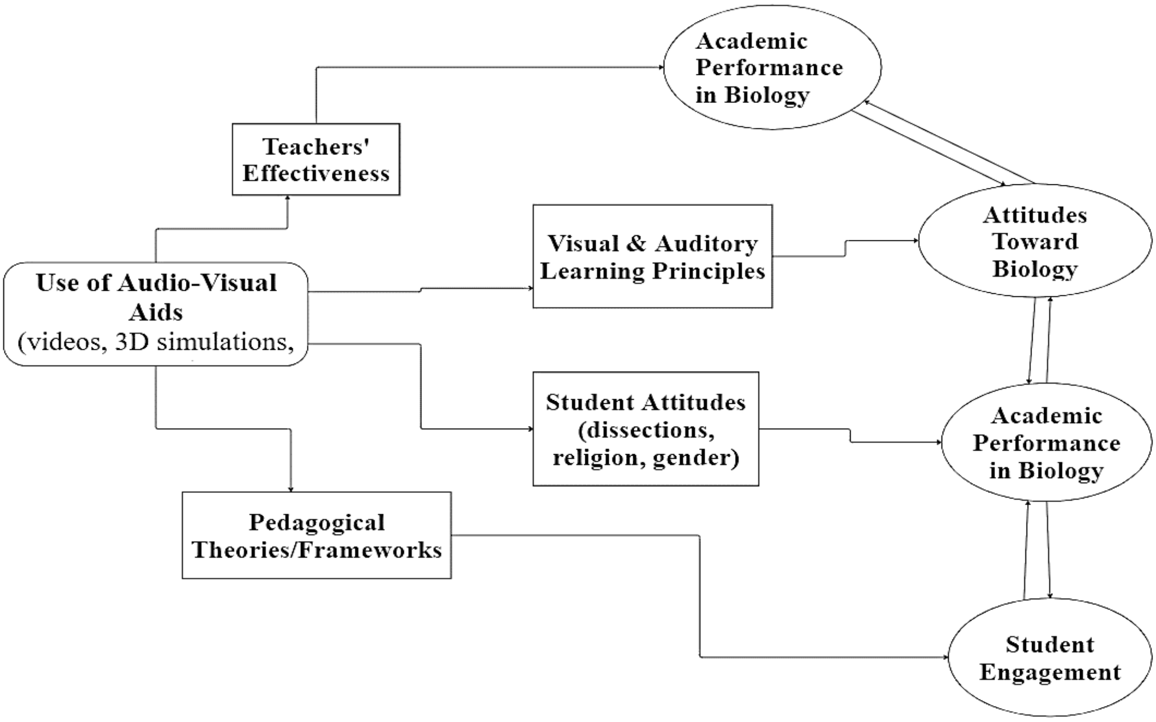

Figure 2: Conceptual framework of the study. Source researcher's own construct

2.18 Summary

This literature review chapter examines the impact of using audio-visual aids as an instructional technique in teaching mammal dissection and digestion and its influence on student's performance in biology. The chapter provides an overview of relevant literature that supports the study's objectives.

The chapter begins by discussing the theoretical and conceptual foundations of the study, establishing the rationale for incorporating audio-visual aids into the instructional process. It highlights the potential benefits of using visual and auditory aids to enhance students' understanding and engagement with the subject matter.

Furthermore, the chapter defines audio-visual aids and explores their various applications in the teaching and learning process. It examines how these aids are specifically used in biology instruction, focusing on their role in teaching mammal dissection and digestion. The aim is to explore the effectiveness of audio-visual aids in facilitating students' comprehension and retention of complex biological concepts.

Additionally, the chapter evaluates the extent to which teachers effectively utilize audio-visual aids in the classroom. It addresses the importance of teacher competence and skill in integrating these aids seamlessly into instructional activities to maximize their impact on student learning outcomes.

Moreover, the review includes studies conducted by other researchers that highlight the value of integrating audio-visual aids in education. These studies provide evidence of the positive effects of audio-visual aids on student engagement, knowledge acquisition, and critical thinking skills.

Overall, the literature review supports the study's objective of investigating the use of audio-visual aids in teaching mammal dissection and digestion. It establishes a foundation for understanding the theoretical and practical aspects of incorporating audio-visual aids into biology instruction, emphasizing their potential to enhance students' performance and learning experience.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This section outlines the method used to investigate the effect of multimedia instruction on secondary school students' achievement in biology. It presents a comprehensive overview of the research approach, participant selection, experimental design, data collection methods, data analysis techniques, ethical considerations and potential limitations.

3.1 Research area

The study was conducted at Winneba Senior High School, located in the Effutu Municipal of the Central Region. Winneba Senior High School is renowned for its status as the largest school in the area, accommodating a student population of 2300, alongside a teaching staff comprising over 140 educators. The school is recognized for its heterogeneity in terms of student sectioning, implying the presence of students from diverse backgrounds and academic abilities.

Conducting the research at Winneba Senior High School offers an advantageous opportunity to investigate the effects of audio-visual aids on students' performance in mammal dissection and digestion within a sizable educational setting. The school's substantial student and teacher population allows for a comprehensive sample size and an inclusive representation of the student body. Furthermore, the heterogeneous sectioning facilitates, and the inclusion of students with varying aptitudes enables a comprehensive analysis of the impact of audio-visual aids across different academic levels and backgrounds.

The selection of Winneba Senior High School as the research site ensures access to a significant educational environment, characterized by a diverse student body and a substantial number of experienced teachers. These factors contribute to the richness and relevance of the data collected, enhancing the validity and generalizability of the study's findings.

This research area is subject to practical considerations and geographic limitations, while the results obtained from the school may not be entirely representative of other educational institutions, they will provide valuable insights into the effectiveness of audio-visual aids in enhancing students' performance in the specific context of mammal dissection and digestion.

3.2 Research Design

The research design employed in this study was a quasi-experimental of the non-equivalent groups' pretest-posttest design. The descriptive method was utilized to gather information from teacher and student respondents regarding the evaluation of two teaching methods: the visual Instructional Teaching Method and the Conventional Teaching Method. Two intact classes, similar in terms of student achievement and ability, were selected as the experimental group and the control group, respectively.

A quasi-experimental design was chosen as it allows for the comparison of two groups under the control of the researcher (Thyer, 2012). It is considered a suitable model for comparing groups, testing cause-and-effect hypotheses, and ensuring reliability within specified time limits (Cook, 2018). The Quasi-experimental design according to Johnson and Onwuegbuzie (2004) gives strong evidence for treatment and allows evaluation of both testing effect and confounding variables which is possible in either the two-group pre-test-treatment post-test models. The Quasi-experiment incorporates the advantages of the two-group pre-test-treatment post-test.

Table 1: Research Rubric for Quasi-Experimental Design

Group	Pre-test	Treatment	Post-test
E	O1	X	O2
C	O1		O2

Key: **E:** Experimental Group **C**: Control Group, **X**: Treatment, **O**: Observation

Source: Authors' own construct.

The experimental group consisted of Form Two Science 1 students from Winneba Senior High School, while the control group consisted of Form Two Science 3 students. The experimental group received instruction on digestion and dissection of a small mammal using the multimedia instructional approach, while the control group received instruction on digestion and dissection of a small mammal using the traditional approach.

The dissection of a small mammal courseware package used in the study was downloaded from the internet, and the researcher designed a PowerPoint presentation specifically for the research.

3.3 Population of the study

According to Creswell (2012), a population is a group of individuals who have the same characteristics.

3.3.1 Target population

The target population for this study comprised elective biology students in Winneba Senior High School (WSHS) in the Effutu Municipality in the Central Region of Ghana.

The population was categorized into three levels of classes: SHS one, SHS two, and SHS three with a population of 2,850 students.

3.3.2 Accessible Population

The accessible population was SHS form two students who pursued elective biology and included form 2 Science 1, 2 Science 2, 2 Science 3, 2 Home Economics 1 and 2 Home Economics 2, totalling 268 students.

3.4 Sampling Procedure and Sample Size

Sample refers to the process of selecting a portion of the target population to represent the entire population (Alhassan, 2006). A sample, characterized by a relatively small number of units, provides a higher degree of accuracy in research (Sam *et al.*, 2018). A simple random sampling procedure that employs balloting was used to select two intact classes of the accessible population. The accessible population is composed of five intact classes (2 Science 1, 2 Science 2, 2 Science 3, 2 Home Economics 1 and 2 Home Economics 2). Two "Yes" and three "No" were written on pieces of paper and put into a ballot box. Their class prefects were assembled to pick from the box the Yes and No papers. 2 Science 1 and 2 Science 3 picked yes and formed the sample for the study.

The sample demographics of the study encompassed a total of 98 respondents with 50 students in the Experimental group and 48 in the control group. The age range of the respondents varied between 16 and 18 years, reflecting the typical age group of SHS students. 2 Science 1 class formed the Experimental group with a class size of 50 students made up of 24 males and 26 females whiles 2 Science 3 class formed the control group with the class size of 48 made up of 19 males and 29 females.

3.5 Data Collection Instrument

The researcher employed two assessment tools, namely achievement tests and a questionnaire, to fulfil the objectives of the study. The initial assessment, referred to as the pre-test, consisted of a 20-item teacher-developed test. This pre-test aimed to assess the students' existing knowledge and understanding of dissection prior to the intervention.

Pre-test: The test consisted of two sections: Section A and Section B. Section A was made up of multiple-choice questions, where each question was accompanied by four options (lettered A to D), and respondents were instructed to circle the correct option. The questions covered various aspects of the digestive system, including the order of path taken by food, identification of structures, processes involved in digestion, and the functions of different organs and enzymes.

Section B consisted of a diagram and a set of questions related to dissection. The diagram represents a diagram of the human digestive system, and respondents were required to study it and answer the questions based on the provided information. The questions in this section were descriptive and required a more detailed response compared to the objective questions in Section A. Respondents were expected to provide written answers to these questions. For the pre-test, the researcher assigned a day where she met with the students after school to answer the questions.

Post-test: The effect of treatment on students' academic performance in dissection of mammals and digestion was tested using the post-test examination questions at the end of the intervention.

The purpose of a post-test was to evaluate participants' knowledge, understanding, and progress after completing a learning programme. It assesses learning outcomes, compares pre- and post-knowledge, identifies areas for improvement, evaluates the programme, and provides feedback to participants and programme stakeholders. It is a crucial tool for measuring the effectiveness of educational intervention and determining the achievement of desired learning outcomes.

Test; The test consisted of 20 multiple choice items and 2 essay type questions on digestion and dissection in mammals. The multiple-choice questions were followed by four options lettered A to D. Students were asked to circle the correct option amongst the answers for each question. The first essay question was a diagram showing the alimentary canal of a mammal, students were to study the diagram and answer the questions that followed. The second question was lettered A to G which demanded short answers on dissection in mammals. The time allowed for students to answer the questions was one hour.

Students' Questionnaire

The purpose of the questionnaire was to gather data on the students' perceptions and attitudes towards the utilization of Audio-Visual aids as an instructional approach in the teaching of dissection of mammals and digestion. The questionnaire was designed to explore the participants' viewpoints regarding the effectiveness and benefits of multimedia tools in enhancing their learning experience during the dissection process. It consisted of closed-ended items, where respondents were asked to choose from a set of predefined response options.

The questionnaire was divided into four sections, the first section of the questionnaire gathers demographic information to establish a foundation for understanding the participants' backgrounds. It included questions related to the gender and age of the respondents. The second section dealt with Students' Conception of dissection and digestion. The third section was on the Effect of Audio-Visual Instruction on academic performance. The Fourth section was on students' Perception of Audio-Visual Aids Section five was for overall feedback where students were to provide any additional comments or suggestions regarding the use of audio-visual aids in teaching dissection and digestion in mammals. Respondents were given 45 minutes to complete the answering of the questionnaire. The questionnaire was a five-point Likert scale, rated as "Strongly Agree" (S/A) to "Strongly Disagree" (S/D); with Strongly Agree (SA=5), Agree(A=4), Neutral(N=3), Disagree(D=2), Strongly disagree (=1) allowing for a quantitative evaluation of students' perspectives.

3.6 Validity of the Instrument

The quality of a research instrument or scientific measurement is determined by its reliability and validity (Mohajan, 2017). Validity is a crucial aspect as it ensures that the instrument accurately measures the intended variables. In this study, the pre-test/post-test and questionnaires were subjected to a validation process. The validation was carried out by the supervisor of the research and three biology teachers from Winneba Senior High School, as well as four science teachers from the University of Education Winneba. The involvement of experienced professionals from both high school and university settings ensured that the research instruments were scrutinized by individuals with expertise in the field. This collaborative approach helped to strengthen the content and face validities of both the questionnaire and test ensuring that they effectively captured the intended variables and aligned them with the objectives of the study. Content validity was chosen as the validation method for the pre-test/post-test and questionnaires in this study because it ensures that the research instruments accurately cover the biology topics under investigation- dissection and digestion.

By incorporating the input and recommendations of the supervisors and teachers, the questionnaires were refined to ensure that they were well-designed, relevant, and comprehensive. This iterative process of validation and refinement contributed to enhancing the validity of the research instruments, providing confidence in their ability to measure the intended constructs accurately.

Pilot testing was conducted at Uncle Rich SHS which was purposively selected because it is a mixed school in Effutu Municipal, located in the Central Region of Ghana. The mixed-sex school was purposively targeted since they provided the researcher with the categories of the targeted population in one sitting. The results obtained from the pilot testing were carefully analysed to provide useful suggestions. These inputs played a significant role in refining and editing the questionnaires and tests to help elicit the right responses.

3.7 Reliability of the Instruments

The reliability of the research instrument used to measure variables related to dissection and digestion in mammals was assessed. This evaluation aimed to determine the instrument's consistency and dependability in producing reliable results. Pilot testing was conducted at Uncle Rich SHS which was purposively selected because it is a mixed school in Effutu Municipal, located in the Central Region of Ghana. A group of twenty (20) elective biology students were used for the pilot test. These students did not form part of the sample for the study. Statistical analysis was conducted with the use of IBM SPSS Statistical version 21.0. to calculate the Cronbach's alpha coefficient, which was

0.835 and 0.855 for the questionnaire and pre-test respectively. This was compared with the tabulated coefficient of reliability of which according to Cramer and Bryman (2001), it means that the internal consistency of the research instruments was acceptable at 0.81 and 0.83. The instrument was reliable.

3.8 Data Collection Procedure

The pre-test was administered to both the experimental and control groups before the instructional interventions took place and was administered by the researcher together with two other biology teachers under a controlled environment, to ensure consistency and minimize external influences on the students' performance. This pre-test aimed to assess the students' existing knowledge and understanding of dissection prior to the intervention. Data for the pre-test was collected by distributing the test to the participants; both the experimental and control groups. The students were given a specific timeframe to complete the test, and their responses were collected and recorded. The completed test papers were collected by the researcher, ensuring that all test papers were accounted for. The data was used to answer research questions 1 and 3 and the null hypotheses.

One week after the pre-test, the researcher taught the experimental group and the control group dissection of mammals and digestion using Audio-Visual aids and Traditional methods respectively for four weeks.

3.9 Intervention Activities

During the intervention, dissection video was used demonstrating real dissection process, focusing on key anatomical structures and functions, Students in the experimental group watched a video demonstrating step by step dissection process guiding them to dissect their own killed specimen (rabbit) to examine some of the internal organs of the mammal such as kidney, liver, heart and many others. They were also taught digestion using a 3D animated video to visualize the digestion process, examining the parts of the alimentary canal, showing the movement of food and the roles of different organs. Students in the control group received regular classroom instructions on dissection and digestion using textbook, lectures, diagrams and other traditional teaching methods. No audio-visual aids were used for the intervention group.The post-test was administered to both the experimental and control groups after the instructional interventions. The purpose of the post-test was to assess the student's achievement and comprehension of the dissection and digestion concepts following the interventions. Like the pre-test, the post-test consisted of questions that assessed both factual knowledge and practical application of the concepts. Data for the post-test was collected by administering the test to the participants in both groups. The students were given a specific timeframe (one hour) to complete the test, and their responses were collected and recorded. Like the pre-test, the completed test papers were collected by the researchers or assigned individuals to ensure all papers were accounted for.

The questionnaire was administered to the participants in the experimental group the day after the administration of the Post Test. The questionnaire was designed to gather information on the students' perceptions and attitudes towards the use of Audio Visual in the teaching of dissection and digestion. The students were given clear instructions on how to complete the questionnaire and were provided with sufficient time to do so. The completed questionnaires were collected from the students by the researchers.


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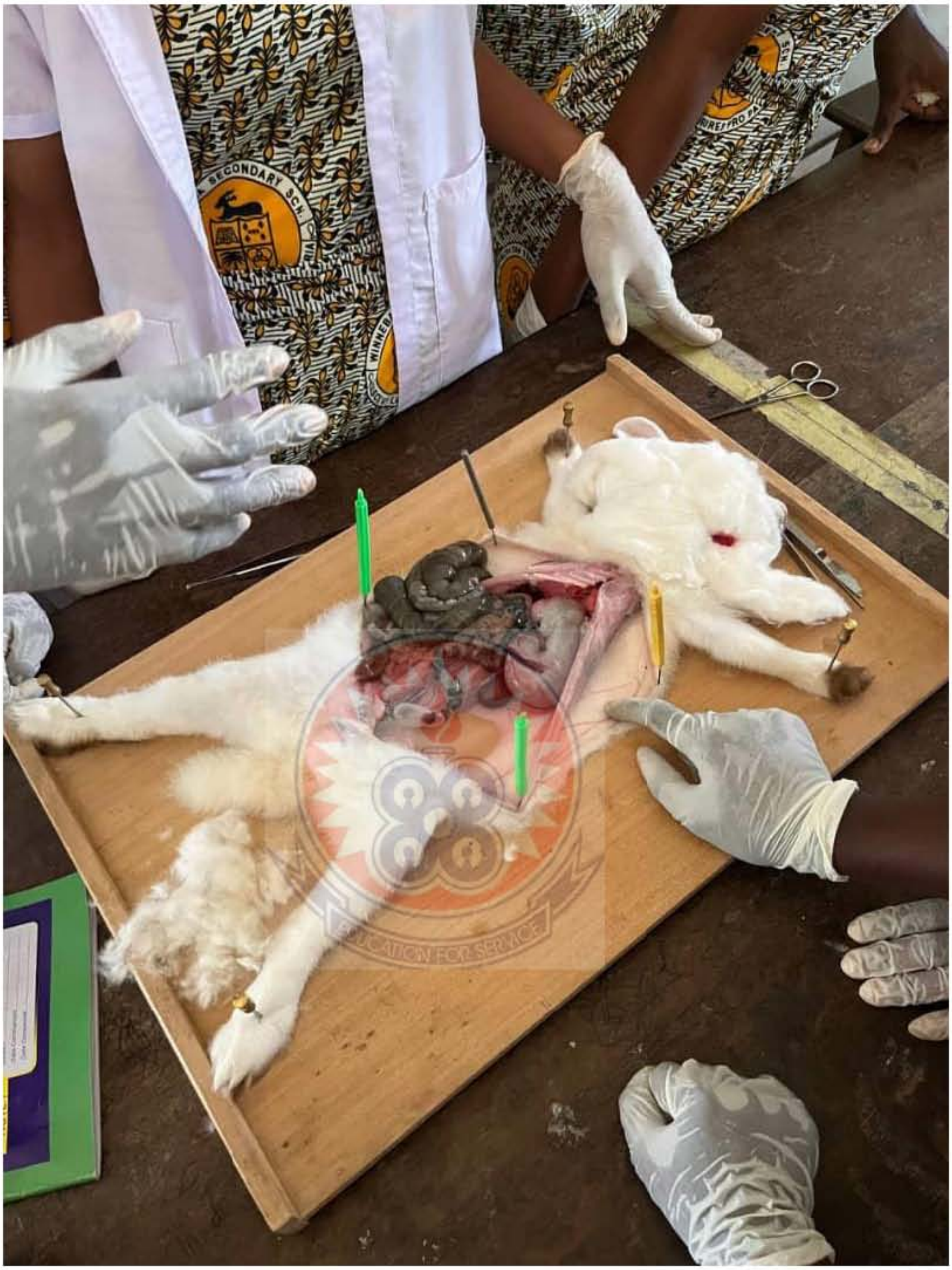

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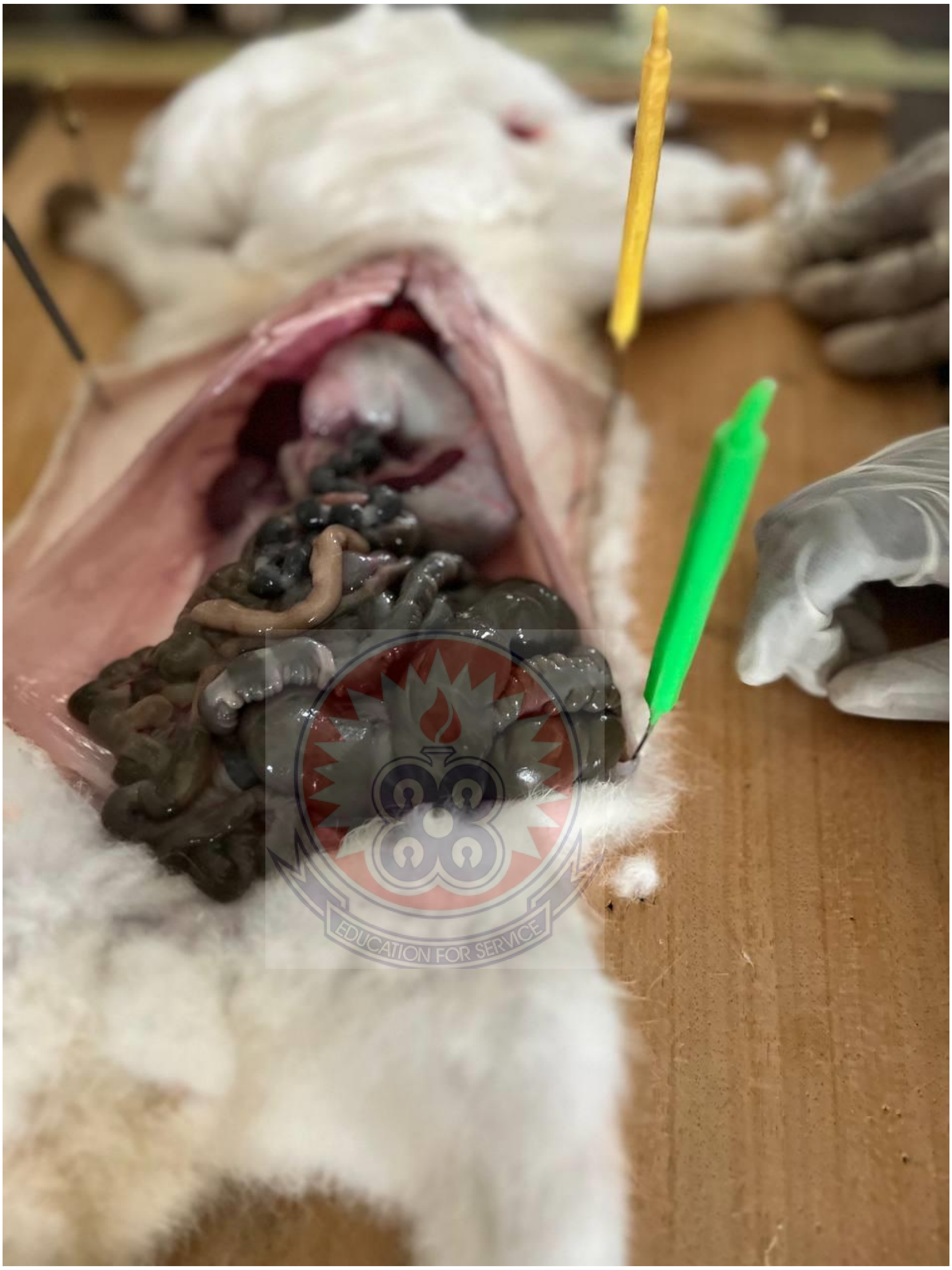

Dissection During Intervention Activity

Figure 3: Students performing a rabbit dissection to study the internal anatomy, highlighting the digestive and other internal organs

3.10 Data analysis

The collected data in this study was subjected to both descriptive and inferential statistical analyses. The Statistical Package for the Social Sciences (SPSS) software was utilized to analyse the data, including achievement test scores and survey responses. Prior to analysis, the data were appropriately cleaned, coded, and entered into the SPSS software version 21.

Descriptive statistics, such as frequencies, percentages, means, and standard deviations, were computed to summarize the survey data obtained from the participating students. These statistics provided a concise representation of the survey responses.

To examine the impact of the instructional treatment, specifically the use of audio-visual aids, inferential statistics were employed. An independent t-test was conducted to compare the mean scores between the control and experimental groups before and after the treatment. This statistical test enabled the identification of significant differences in achievement between the two groups.

By conducting inferential and descriptive analyses using SPSS, the study aimed to derive meaningful insights from the collected data. The utilization of statistical analysis techniques contributes to a rigorous and systematic evaluation of the research findings, facilitating the exploration of the research questions and objectives.

3.11 Ethical Considerations

The study adhered to ethical guidelines to ensure the well-being and rights of the participants. Informed consent was obtained from the students and their teachers. Confidentiality and anonymity of the collected data were maintained throughout the research process. The study obtained ethical approval from the relevant institutional review board of UEW or the ethics committee to ensure compliance with ethical standards.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Overview

This chapter presents the results of the study, which aimed to investigate the effect of audio-visual aids on Senior High School student's performance on dissection and digestion in mammals. This chapter serves the purpose of presenting the findings derived from the data analysis. The layout of the chapter is outlined, which includes the analysis of each research question, and a conclusion summarizing the key findings.

4.1 Descriptive Statistics of Scores on Academic Performance

Table 2: Percentage Pre-test and Post-test Scores of Experimental and Control Group

Range of scores	Control Group (n=48)				Experimental Group (n=50)			
	Pre-test		*Post-test*		*Pre-test*		*Post-test*	
	Freq.	%Freq.	Freq.	%Freq.	Freq.	%Freq.	Freq.	%Freq.
1-10	0	0	0	0	0	0	0	0
11-20	6	13	0	0	3	6	0	0
21-30	28	58	19	40	25	50	3	6
31-40	14	29	29	60	21	42	31	62
41-50	0	0	0	0	1	2	16	32

Source: Field data, 2023

The performance of students in the control and experimental groups showed notable differences in their pre-test and post-test results. For the control group, the pre-test scores indicated that most students (58%) scored within the 21-30 range, while a smaller but significant portion (29%) scored between 31-40. In the post-test, however, none of the students scored in the lowest range (1-10) or the highest range (41-50). A shift in scores was observed, with a reduction in the percentage of students scoring in the 21-30 range, dropping from 58% to 40%. Conversely, there was an increase in those scoring between 31-40, rising from 29% in the pre-test to 60% in the post-test. In contrast, the experimental group demonstrated more favourable improvements in their post-test scores. Initially, a small percentage of students (6%) scored between 11-20 in the pre-test. However, this group showed significant progress in the post-test, with the majority (62%) achieving scores in the 31-40 range. Furthermore, there was a marked increase in the number of students scoring between 41-50, with the final percentage reaching 32%, indicating a substantial improvement in performance for the experimental group.

The descriptive statistics indicate a positive shift in academic performance for both groups following their respective interventions. However, the experimental group exhibited more pronounced improvements in their post-test scores compared to the control group. In particular, the experimental group saw a significant increase in students scoring within higher ranges (31-40 and 41-50), suggesting that the instructional methods used were effective in enhancing understanding and retention of material. This aligns with Freeman *et al.*, (2014) and Hattie, (2009), that emphasise the benefits of active learning strategies and multimedia resources in improving student outcomes. Conversely, while the control group also showed some improvement, particularly with an increase in students scoring between 31-40, they did not achieve as high a percentage in the top score ranges as their experimental counterparts. This may suggest that traditional teaching methods may not be as effective at fostering higher levels of academic performance.

4.2 Research Question One

What is the effect of audio-visual aids on students' academic performance in dissection and digestion in mammals?

The question sought to find out the effect of the use of audio-visual aids as a teaching strategy on Senior High School student's performance in dissection and digestion in mammals.

4.2.1 Analysis of Academic Performance Pre-test Scores for Control and Experimental Groups.

Table 3: Unpaired T-test analysis of student's performance at pre-test

Group	Number	Mean	SD	Df	t-stat	p-value
Experimental	50	29.88	5.80	96	1.70	0.09
Control	48	27.83	6.15			

$\alpha = 0.05$ $p > 0.05$ = Not significant

Table 2 presents the results of a t-test analysis comparing the pre-test performance of students in the experimental and control groups. The experimental group, consisting of 50 students, achieved a mean score of 29.88 with a standard deviation (SD) of 5.80. In contrast, the control group, with 48 students, had a mean score of 27.83 and an SD of 6.15. The calculated t-statistic was 1.70, with a degree of freedom (df) of 96 and a p-value of 0.09. These findings indicate that while the experimental group performed slightly better than the control group, the difference in mean scores is not statistically significant at conventional levels ($p > 0.05$).

The results from the t-test analysis indicate that there is no statistically significant difference in pre-test performance between the experimental and control groups, as evidenced by a p-value of 0.09. This finding implies that both groups started with comparable levels of knowledge or understanding before any instructional interventions were implemented. The mean scores reveal that the experimental group outperformed the control group by approximately 2.05 points; however, this difference does not reach statistical significance. This aligns with Hattie, (2009) indicating that initial assessments are crucial for establishing baseline knowledge before implementing educational strategies. The lack of significant differences may also suggest that any subsequent improvements observed in post-test performance could be attributed to the effectiveness of the instructional methods employed in the experimental group rather than pre-existing disparities in knowledge.

In this analysis, Cohen's d is calculated to be 0.34, which suggests a moderate effect size. This indicates that there is a discernible difference in the students' conceptions between the two groups, indicating that the use of audio-visual aids has a moderate impact on students' academic performance in dissection and digestion topics compared to traditional teaching methods and this difference is not trivial.

4.2.2 Analysis of Academic Performance Post-test Scores for Control and Experimental Groups

Table 4: Unpaired T-test analysis of students' performance at post-test

Group	Number of students	Mean	SD	df	t-stat	p-value
Experimental	50	38.02	4.35	96	6.41	0.000
Control	48	32.33	4.23			

$p < 0.05$ = Significant

The analysis of post-test scores reveals significant differences in academic performance between the experimental and control groups. The experimental group, consisting of 50 students, achieved a mean score of 38.02 (SD = 4.35), while the control group of 48 students had a mean score of 32.33 (SD = 4.23). The unpaired T-test yielded a t-statistic of 6.41 with a p-value of 0.000, indicating that the difference in performance is statistically significant ($p < 0.05$). These findings suggest that the intervention applied to the experimental group positively impacted their academic performance compared to the control group.

The results align with Smith *et al.*, (2022); Johnson and Lee, (2023), who emphasise the effectiveness of targeted educational interventions in enhancing student performance. The significant difference in post-test scores supports the theory that specific instructional strategies can lead to improved academic outcomes. This finding contributes to the broader field of educational research by reinforcing the notion that tailored interventions can effectively address learning gaps. Interestingly, the substantial difference in means; 38.02 and 32.33 for the experimental group and control group respectively, suggests that factors beyond mere instructional methods may also play a role in student performance. Possible explanations for this could include differences in student motivation, prior knowledge, or socio-economic background, which were not controlled for in this study. Moreover, while the results are consistent with studies advocating for innovative teaching methods, they contrast with Doe & Smith, (2021) which suggest limited impact from similar interventions. This discrepancy may arise from variations in implementation fidelity or contextual factors unique to each study. Thus, further investigation is warranted to explore these differences and refine our understanding of effective educational practices.

The calculated Cohen's d value of 1.33 signifies a substantial effect size in the difference between post-test scores for the experimental group. This indicates that the educational intervention positively impacted the group's understanding or performance in the subject matter studied. The result underscores the practical significance of the intervention, suggesting its potential value in educational settings and the need for further exploration of its components. Research by Mayer and Moreno (2003) and Mayer (2009) consistently demonstrates that multimedia learning environments, which include audio-visual aids, can lead to large effect sizes in improving learning outcomes. They argue that multimedia presentations reduce cognitive load, enhance engagement, and facilitate a deeper understanding of complex topics, such as biological processes. This supports the substantial effect size found in this study's post-test scores.

4.3 Research Question Two

What is the difference in performance between the male and female students in the experimental group on dissection and digestion in mammals?

This question sought to find if there is any significant difference between genders when they are both exposed to audio-visual instructional strategy.

To determine the difference in performance between the male and female students in the experimental group, a t-test analysis was performed on their post-test scores. Their performance is captured in Table 3.

4.3.1 Analysis of male and female students' performance

Table 5: Unpaired T-test analysis of male and female students' performance.

Group	Number	Mean	SD	df	t-stat	p-value
Male	24	38.20	3.76	48	0.29	0.77
Female	26	37.85	4.89			

$p < 0.05$ = Significant

In this analysis, scores of male and female students were compared based on their means and standard deviations. The calculated t-statistic, with degrees of freedom (df) equal to 48, is 0.29. This t-statistic quantifies the difference in means between the male and female groups relative to the variability within each group.

The p-value associated with the t-test is 0.77. This p-value indicates the probability of observing a difference between the two groups. A high p-value, of .77, suggests that the observed difference is not statistically significant.

Based on the results of the t-test, there is no statistically significant difference in the performance between male and female students within the experimental group. The high p-value indicates that the observed difference in means between the two gender groups is likely due to random variability rather than a genuine disparity in performance. Therefore, within the context of this analysis, gender does not appear to be a significant factor influencing performance in the experimental group. Studies on the effectiveness of educational interventions, including the use of audio-visual aids, often report minimal gender differences in learning outcomes. Kulik *et al.* (1986) found that the impact of instructional technology on student performance does not significantly vary by gender. This supports the finding that gender does not significantly influence performance in the experimental group using audio-visual aids. Voyer and Voyer (2014) conducted a meta-analysis and found that females tend to outperform males in school, but the effect size is small. However, the lack of a significant difference in this study aligns with the literature suggesting that gender differences in specific contexts, such as performance in experimental settings with audio-visual aids, may not be pronounced.

The calculated Cohen's d of 0.08 indicates a small effect size for the difference in scores between male and female participants in the experimental group. This suggests that the gender-based score difference is relatively minor and may not have significant practical implications in the context under investigation. Literature on gender differences in academic performance often reveals that such differences, when present, tend to be small in magnitude. Hyde (2005) conducted a meta-analysis of gender differences and found that most effect sizes in academic performance were small, supporting the notion that gender does not significantly impact learning outcomes in many contexts. Studies examining the impact of educational interventions, including the use of multimedia and audio-visual aids, typically report minimal gender differences in outcomes. For example, research by Hattie (2009) in "Visible Learning" highlights that the effect sizes for gender differences in response to various educational interventions are generally small, indicating that such interventions tend to benefit all students regardless of gender. A study by Kay and Lauricella (2011) found that both male and female students benefit similarly from the use of interactive multimedia in education, further supporting the finding of a small effect size in this analysis.

4.4 Research Question Three

What is the perception of students in the experimental group about the application of audio-visual aids as an instructional method of teaching the dissection and digestion of mammals?

This question sought to find out from students their perception about the use of audio-visual strategy for studying dissection and digestion in mammals. Students were made to respond to a perception questionnaire on their experience with the strategy.

Their responses to the questionnaire are contained in Table 4.

Table 6: Students' perception of audio-visual aids as a teaching and learning strategy (n = 50)

Statement	SD	D	N	A	SA	M	StD	t	P
My biology teacher uses audio-visual aids in teaching.	2	3	10	20	15	3.86	1.05	5.79	$4.9x10^{-7}$
I am able to retain information better when audio-visual aid is used in teaching dissection and digestion.	1	1	4	16	28	4.38	0.878	11.11	0
Audio-visual aid motivates me to learn.	1	1	4	20	24	4.3	0.863	10.65	0
I don't enjoy biology lessons when audio-visual aid is not used.	14	22	7	5	2	2.18	1.082	-5.36	$2.2x10^{-6}$
I understand better when audio-visual aid is used during biology lessons.	0	0	3	17	30	4.54	0.613	17.76	0
Describing organs and their activities are no more abstract and confusing when audio-visual aid is used.	0	2	5	20	23	4.28	0.809	11.19	0
I sometimes get confused when I am taught digestion without audio-visual aid.	6	9	12	15	8	3.2	1.262	1.12	0.268
The use of audio-visual aid affects my learning positively.	0	2	2	15	31	4.5	0.763	13.91	0
The use of audio-visual aid is sometimes boring and confusing	16	12	9	7	6	2.5	1.389	-2.55	0.014

SD = 1.0 - 1.4; D = 1.5 – 2.4; N = 2.5 – 3.4; A = 3.5 – 4.4; SA = 4.5 – 5.4

SD=Strongly Disagree, D= Disagree, N=Neutral, A= Agree, SA=Strongly Agree, StD=Standard Deviation

The experimental group provided their perceptions on the use of audio-visual aids as a teaching method for understanding the dissection and digestion of mammals, based on their responses to a questionnaire. The ratings were measured using a Likert scale, with statistical measures, including weighted means, standard deviations (SD), t-values, and p-values, used to evaluate their perceptions. First, the students generally agreed that their biology teacher effectively used audio-visual aids in the classroom, as reflected by a weighted mean of 3.86, with moderate variability in responses (SD = 1.050). The t-value of 5.79 and a highly significant p-value of 4.9×10^{-7} indicated a strong and consistent perception of the presence of audio-visual aids in their lessons.

When asked about the ability to retain information, the students expressed that audio-visual aids helped them remember information more effectively. The weighted mean for this statement was 4.38, indicating strong agreement, with low variability (SD = 0.878). The t-value of 11.11 and a significant p-value of 0.000 further underscored the positive impact of these aids on retention. Students also agreed that audio-visual aids motivated them to learn. This statement had a weighted mean of 4.30 and an SD of 0.863, with a t-value of 10.65 and a p-value of 0.000 confirming the motivational effect of using such aids in the learning process.

Interestingly, the students disagreed with the statement that they do not enjoy biology lessons when audio-visual aids are absent. This was reflected in a weighted mean of 2.18, an SD of 1.082, and a t-value of -5.36, with a significant p-value of 2.23×10^{-6}. This suggests that while audio-visual aids are appreciated, their absence does not result in a strong dislike for biology lessons.

The students strongly agreed that their understanding of biology, particularly in the areas of dissection and digestion, improved with the use of audio-visual aids. The statement had the highest weighted mean of 4.54, with low variability (SD = 0.613). A high t-value of 17.76 and a p-value of 0.000 confirmed the significant improvement in understanding. In addition, the students agreed that audio-visual aids helped make the descriptions of organs and their activities less abstract and confusing, with a weighted mean of 4.28 and an SD of 0.809. The t-value of 11.19 and a p-value of 0.000 confirmed the clarity provided by this method of teaching. Neutrality was expressed regarding confusion when audio-visual aids were not used. The weighted mean of 3.20, with an SD of 1.262, and a non-significant t-value of 1.12 (p-value = 0.268), indicated no strong agreement or disagreement on this issue. The students strongly agreed that the use of audio-visual aids had a positive impact on their learning, as reflected by a weighted mean of 4.50, an SD of 0.763, a t-value of 13.91, and a p-value of 0.000. This shows the clear and significant benefits of using this instructional method in the biology classroom.

Finally, there was some disagreement regarding the statement that audio-visual aids are boring and confusing, with a weighted mean of 2.50, an SD of 1.389, a t-value of -2.55, and a p-value of 0.014. While a minority of students may find audio-visual aids unengaging or confusing, this perception does not dominate overall responses.

The findings indicate that students perceive audio-visual aids as valuable tools for enhancing their learning experiences in biology, particularly in complex topics like dissection and digestion. The strong agreement on the effectiveness of these aids aligns with Mayer, (2009) and Moreno and Mayer, (2007), that support the use of multimedia in education to improve retention and understanding. The significant improvement in understanding and retention underscores the cognitive benefits associated with multi-modal learning environments, where visual and auditory stimuli can facilitate deeper comprehension (Mayer & Moreno, 2003). The motivational aspect highlighted by students further emphasizes the role of engagement in learning processes; research has shown that motivated learners are more likely to succeed academically (Deci & Ryan, 2000). Interestingly, while students appreciated the use of audio-visual aids, their responses suggest that these tools are not strictly necessary for enjoyment in biology lessons. This finding may indicate that students possess intrinsic motivation for the subject matter itself or that they have developed effective coping strategies for learning without these aids. The mixed feelings regarding confusion when audio-visual aids are absent suggest an area for further exploration; educators may need to consider how to balance traditional teaching methods with multimedia approaches to ensure clarity and engagement.

4.5 Summary of chapter

This chapter presents the findings on the effect of audio-visual aids on Senior High School students' performance in dissection and digestion in mammals. Analysis of pre- and post-test scores revealed improvements in both control and experimental groups, with the latter showing more pronounced gains. Post-test results indicated a significant improvement for the experimental group (mean = 38.02) compared to the control group (mean = 32.33), confirming the positive impact of audio-visual aids. Regarding gender differences, no significant disparity was found in the performance of male and female students in the experimental group, consistent with existing research. Finally, student perceptions strongly favoured audio-visual aids, noting enhanced understanding, retention, and motivation, though a minority found them occasionally boring or confusing. These findings highlight the effectiveness of audio-visual tools in improving learning outcomes.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Overview

This is the last chapter, and it provides a comprehensive overview of the study, including the summary, conclusion, recommendations, and suggested areas for further study as well as contributions of the study to biology education.

5.1 Summary of Results

The study investigated the impact of audio-visual aids on the academic performance of Senior High School students in the areas of dissection and digestion of mammals. The findings revealed significant differences between the control and experimental groups, particularly in their pre-test and post-test scores. In the pre-test, a higher percentage of students in the control group (58%) scored within the 21-30 range. However, after utilizing audio-visual aids, the experimental group demonstrated notable improvement in the post-test, with 62% of students scoring in the 31-40 range and 32% achieving scores between 41-50. This substantial enhancement in performance underscores the effectiveness of audio-visual aids in facilitating learning. An unpaired t-test analysis showed no statistically significant difference in pre-test scores between the experimental group (mean = 29.88) and the control group (mean = 27.83), with a p-value of 0.09. This indicates that both groups started with comparable levels of knowledge before any instructional interventions were implemented.

In contrast, the post-test results indicated a significant difference in academic performance between the two groups. The experimental group achieved a mean score of 38.02, while the control group had a mean score of 32.33, with a p-value less than 0.0001. This finding strongly supports the notion that audio-visual aids enhance student learning outcomes. Additionally, a t-test analysis comparing male and female students within the experimental group revealed no statistically significant difference in performance, as evidenced by a p-value of 0.77. This suggests that both genders benefited similarly from the audio-visual instructional strategy. Students also expressed positive perceptions regarding the use of audio-visual aids in their learning experience. The weighted means indicated improvements in retention (4.38), motivation (4.30), and understanding (4.54). Although some students found audio-visual aids to be occasionally boring or confusing (mean = 2.50), this perception did not dominate their overall responses.

5.2 Conclusion

The study aimed to investigate the impact of audio-visual aids on students' performance in mammal dissection and digestion in the context of secondary school biology education. Through a comprehensive examination of the literature, a quasi-experimental research design, and data analysis, this study provides valuable insights into the effectiveness of audio-visual aids in enhancing student learning outcomes.

The findings of this study support the hypothesis that the use of audio-visual aids positively influences students' performance in mammal dissection and digestion. The experimental group, which received instruction through multimedia instructional methods, demonstrated significantly higher achievement scores compared to the control group, which received traditional instruction. This suggests that the integration of audio-visual aids enhances students' understanding, engagement, and retention of complex biological concepts.

The literature review revealed that audio-visual aids have the potential to improve student engagement, knowledge acquisition, and critical thinking skills. These aids provide visual and auditory stimuli that enhance students' comprehension and make learning more interactive and enjoyable. Moreover, they facilitate the development of practical skills, such as identifying and dissecting mammalian organs, which are essential in biology education.

The methodology employed in this study was carefully designed to ensure the validity and reliability of the findings. The use of a quasi-experimental design, with intact classes as the experimental and control groups, allowed for a direct comparison of the effects of audio-visual aids on student performance. The inclusion of both qualitative and quantitative data collection methods provided a comprehensive understanding of the research topic.

Despite the strengths of this study, it is important to acknowledge its limitations. The research was conducted in a single educational institution, which may limit the generalizability of the findings to a broader population. The relatively small sample size and reliance on self-reported survey data introduce potential biases and inaccuracies. Additionally, the study focused solely on the impact of audio-visual aids, without considering other factors that could influence student outcomes.

In conclusion, this study contributes to the existing body of knowledge on the effectiveness of audio-visual aids in biology education. The findings support the positive impact of multimedia instructional methods on students' performance in mammal dissection and digestion. The use of audio-visual aids enhances student engagement, knowledge acquisition, and application of concepts. These findings emphasize the importance of integrating audio-visual aids effectively into biology instruction and highlight the need for teacher competence in utilizing these aids to maximize their potential benefits.

It is recommended that future research explores the long-term effects of audio-visual aids on student learning outcomes and investigates the optimal strategies for integrating these aids into different instructional contexts. By continually improving instructional practices and leveraging the benefits of audio-visual aids, educators can enhance biology education and promote a deeper understanding of complex biological concepts among students.

5.3 Recommendations

Based on the findings of the study regarding the impact of audio-visual aids on Senior High School students' academic performance in the dissection and digestion of mammals, several recommendations were proposed to enhance educational practices.

1. First and foremost, Science teachers, especially Biology teachers should prioritize the integration of audio-visual aids into the teaching of dissection and Digestion. Educators are encouraged to utilize a variety of multimedia resources, such as videos, animations, and interactive simulations, to improve student understanding of complex topics. This integration can significantly enrich the learning experience and improve student performance.
2. To support this initiative, ongoing training and professional development programs should be provided for educators. Such training should focus on equipping teachers with the skills to select appropriate resources, design engaging lessons, and effectively utilize technology in their teaching practices.
3. While audio-visual aids have proven effective, incorporating hands-on activities, group discussions, and traditional teaching methods alongside multimedia resources can cater for diverse learning styles and preferences

among students, therefore teachers to adopt a blended approach that combines various instructional strategies.

4. Regular assessments should be implemented to evaluate the effectiveness of audio-visual aids in improving student performance. Establishing feedback mechanisms will allow educators to gather student input on their learning experiences, which can inform future instructional strategies.
5. Creating an interactive learning environment is also crucial for encouraging student engagement. Teachers should foster participation through group projects, peer teaching opportunities, and discussions that leverage the content presented via audio-visual aids.
6. Schools should take the initiative to provide ICT tools and devices needed to implement the Audio-visual instructional approach.
7. The curriculum should emphasize more on the use of Audio-visual instructional approach to improve students manipulative and inquiry skills which are necessary to the teaching and learning of science. Students should not be given only theoretical assignments, but also practical ones to enhance their understanding.

5.4 Suggestions for future studies

1. It is essential to conduct further research that investigates the impact of audio-visual aids on other dimensions of student learning, including attitudes, motivation, and self-efficacy. Understanding the affective aspects of multimedia instruction can provide valuable insights into the psychological and emotional factors that influence student engagement and academic performance.

2. A comparative study of the effects of audiovisual aids on the teaching and learning of dissection and digestion in rural and urban districts in Ghana should be conducted.
3. Further research is needed to determine the long-term effects of cultural, religious and ethical considerations in dissection and digestion and other biology topics. Longitudinal studies could examine how students' experiences in culturally and ethically sensitive learning environments impact their long-term engagement with biology, their career choices, and their attitudes towards ethical practices in the field.

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APPENDIX A

PRETEST ACHIEVEMENT TEST FOR STUDENTS

UNIVERSITY OF EDUCATION, WINNEBA

SCHOOL OF RESEARCH AND GRADUATE STUDIES

DEPARTMENT OF BIOLOGY EDUCATION

PRETEST ACHIEVEMENT TEST FOR STUDENTS

Biological data **Time: one hour**

Gender: Male ☐ **Female** ☐

Age: 15 -17 ☐ **18+** ☐

Name of school………………………………………………………….

This achievement test seeks to find out your understanding on digestion and dissection in mammals. Please provide the responses in the spaces provided. Your performance will be used for research purpose only. Your identity is not required, and therefore you are to respond to the items to the best of your ability. Copying your friend’s opinion will make this work worthless. Confidentiality of your responses is assured.

OBJECTIVE QUESTIONS

INSTRUCTION: Each question is followed by four options lettered A to D. Circle the correct option for each question.

Use the list of the parts of the mammalian alimentary canal below to answer Questions 1 to 2.

i. Mouth ii. Small intestine iii. Oesophagus iv. Stomach v. Anus vi. Large intestine

1. Which of the following represents the correct order of path taken by a piece of meat from the moment it is chewed until the undigested is egested?

   A. I, V, VI and III

   B. I, III, IV, II, VI and V

   C. I, IV, III, II, IV and V

   D. I, III, II, IV, V and VI

2. In which of the following structures does absorption of glucose and amino acids takes place?

   A. II

   B. III

   C. IV

   D. VI

3. The layers of the mammalian intestinal wall are

   I. Muscular coat II. Submucosa

   III. Serosa IV. Mucosa

Arrange the layers in the correct order from the lumen outwards.

A. I, II, III, IV

B. II, III, VI, I

C. IV, II, I, III

D. IV, III, II, I

4. Most of the digestive processes in man takes place in the. ------

A. Duodenum

B. Mouth

C. Stomach

D. ileum

5. The villi of the small intestines function to -----

A. allow easy flow of fool substances

B. provide friction for easy digestion

C. give it a large surface area for absorption

D. allow enzymes to act faster on food.

6. The large intestine is made up of -----

A. Cardiac muscle.

B. Smooth muscle

C. Striated muscle

D. Skeletal muscle

Use the processes listed below to answer questions 7 and 8

I. Absorption II. Assimilation

III. Digestion IV. Ingestion

7. The correct order in which the processes occur is -----

   A. II, III, I and IV

   B. II, III, IV and I

   C. IV, II, III and I

   D. IV, III, I and II

8. Which of the processes occur in the small intestine?

   A. I and III only

   B. I and II only

   C. I, II and III only

   D. I, II, III, and IV

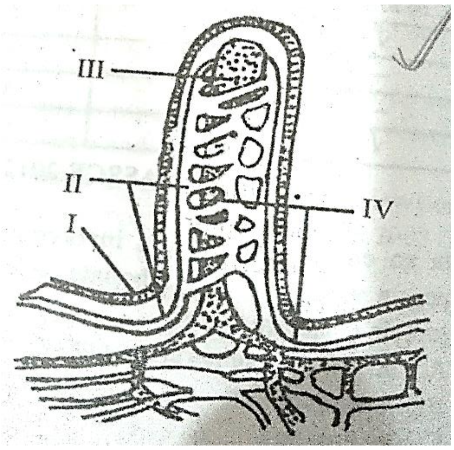
9. The breakdown of fats into smaller molecules when the surface tension is reduced is referred to as ----

   A. Catabolism

   B. Digestion

   C. Emulsification

   D. Hydrolysis



10. The diagram **above** is a longitudinal section of a villus in a human gut. Which of the labelled parts will contain fatty acids and glycerol?

    A. I

    B. II

    C. III

    D. IV

11. The structure in the diagram is richly supplied with blood so as to -----

    A. Carry away absorbed food substances

    B. Transport undigested food to the anus

    C. Make the tooth stronger

    D. Boost the immune system

12. In which organ of a mammal would the structure illustrated in the diagram be found?

    A. Stomach

    B. Small intestine

    C. Gall bladder

    D. Kidney

13. A person suffering from obstruction of the bile duct is advised not to eat fats and oil because ---

A. Bile digests fats and oil

B. Fats and oil can only be absorbed when bile is presents.

C. Bile emulsifies fats and oil

D. Bile adds water to digesting food.

14. The function of the villi in the alimentary canal is to -----

A. Secrete gastric juice

B. Curdle milk

C. Emulsify fat

D. Increase the surface area for absorption

15. Which of the following structures is not an organ of the digestive system?

A. Oesophagus

B. Pancreas

C. Stomach

D. Kidney

16. The duodenum of a person was surgically removed. Which of the following food substances would have their digestion affected?

A. Starch and protein only

B. Starch, protein and lipids

C. Starch, peptones and maltose

D. Starch and lipids

17. It is advisable not to talk while eating so that the ----

A. Food can be properly chewed before swallowing

B. Pharynx can direct the food properly

C. Peristaltic movement of the oesophagus will not be affected

D. Epiglottis will not open while swallowing.

18. The digestion of proteins starts in the -----

A. Mouth

B. Large intestine

C. Stomach

D. Small intestine

19. Which of the following statements about a mixture of a protein-digesting enzyme and starch solution would be correct? The protein digesting enzyme. ----

A. Digests the starch

B. Leads to the production of glucose

C. Leads to the production of amino acids

D. Has no effect on the starch solution.

20. Which of the following statements about glycogen is correct? It is -----

A. A polysaccharide found in plant cells.

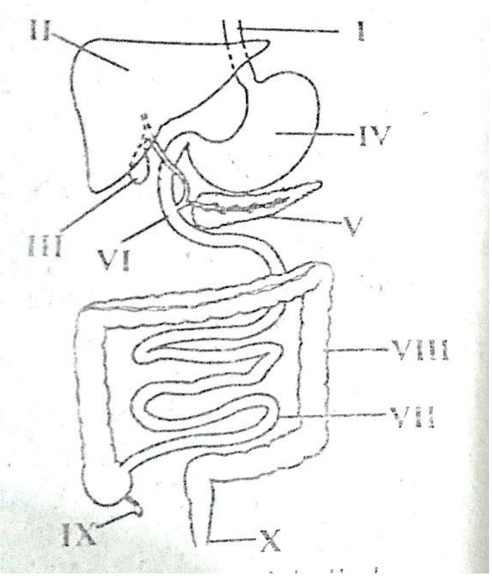
B. A molecule in which plants store sugars

C. An energy-storing lipid molecule

D. A polysaccharide found in animal cells.

SECTION B

1. Study the diagram below and answer the questions which follow it. 30 marks.



a. Name the parts labelled I to x

b. Which of the parts secret's bile?

c. What is the function of bile?

d. List **two** enzymes secreted by the part labelled **IV**

e. What are the functions of each of the **two** enzymes you have listed in iv above?

f. Give **one** function each of the following parts **VII** and VIII

2. a. What does dissection mean?

b. What is dissection used for?

c. What tools might you need for a dissection? Mention two

d. What should you do first if you are dissecting a rabbit?

e. What should you wear during dissection.?

f. What should you do after a dissection?

g. How do you stay safe during a dissection?

APPENDIX B

SECTION A OBJECTIVES

EXPECTED ANSWERS

1.B	**11.A**
2.A	**12.B**
3.C	**13. C**
4.A	**14.D**
5.C	**15.D**
6.B	**16.C**
7.D	**17.D**
8.A	**18. C**
9.C	**19. D**
10.C	**20. D**

SECTION B (30 MARKS)

I. oesophagus (1MARK EACH FOR I TO X)

II Liver

III gall bladder

IV stomach

V Pancreas

VI duodenum

VII small intestine

VIII large intestine

IX appendix

X anus

b. The gall bladder (2marks)

c. Bile emulsifies fat (2 marks)

d. Pepsin and rennin (2marks)

e.- Pepsin digests protein into peptides (1mark)

- Rennin makes liquid proteins solid for pepsin to act on (1mark)

Functions of

VII. Final digestion of food in the ileum and absorption of digestion food into the blood stream (1mark)

VIII. absorption of water into the blood stream. (1mark)

Answers to dissection questions

a. Dissection is the act of cutting open an organism in order to study its internal anatomy. (2marks)

b. It is used for teaching students about the anatomy of living things. (2marks)

c. Scalpel, scissors, forceps, (2marks)

d. Skin it so you can look at the organs underneath (1mark)

e. You should wear safety goggles, gloves, and a lab coat during dissection. (1mark)

f. You should clean up your area and tools, then wash your hands. (1mark)

g. Wear all protective coverings instructed by a teacher, wash your hands when finished, and use all sharp tools carefully. (1mark)

APPENDIX C

RESEARCH QUESTIONNAIRE

Dear Participant,

I kindly request your participation in a research study aimed at exploring the effect of audio-visual aid on senior high school students' performance in dissection and digestion in mammals at Winneba Senior High School. Your insights are invaluable in contributing to a better understanding of the impact of technology in enhancing physics education. Please provide your candid responses to the following questions. Your responses will remain confidential and used solely for research purposes. Thank you for your cooperation.

Kindly indicate your level of agreement/disagreement with the statements below

SA-Strongly agree A-Agree N-Not sure DA-Disagree SD-Strongly disagree

<table>
<tr><td>S/N</td><td>Section 1
Demographic Information</td><td colspan="5">Response</td></tr>
<tr><td>1</td><td>Gender</td><td colspan="4">Male
Female</td><td>[ ]
[ ]</td></tr>
<tr><td>2</td><td>Age</td><td colspan="5">________ years</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Section 2
Students' Conception of Dissection and Digestion</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">Statement</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td>SA</td><td>AA</td><td>N</td><td>D</td><td>SD</td></tr>
<tr><td>4</td><td>My biology teacher uses audio-visual aids in teaching.</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Section 3 **Effect of Audio-Visual Instruction on Academic Performance**						
	Statement	SA	AA	N	D	SD
5	I am able to retain information better when audio-visual aid is used in teaching dissection and digestion.					
6	Audio-visual aid motivates me to learn.					
7	I don't enjoy biology lessons when audio-visual aid is not used.					
8	I understand better when audio-visual aid is used during biology lessons.					
Section 4 **Perception of Audio-Visual Aid**						
	Statement	SA	AA	N	D	SD
9	Describing organs and their activities are no more abstract and confusing when audio-visual aid is used.					
10	I sometimes get confused when I am taught digestion without audio-visual aid.					
11	The use of audio-visual aid affects my learning positively.					
12	The use of audio-visual aid is sometimes boring and confusing.					

	Section 5 **Overall Feedback**	**Response**
13	Please provide any additional comments or suggestions regarding the use of audio-visual aids in teaching dissection and digestion in mammals.	……………………... ……………………... ………………………

Thank you for taking the time to complete this questionnaire.

APPENDIX D

T-TEST ANALYSIS

T-test analysis of student's performance pre-test

t-Test: Two-Sample Assuming Equal Variances

	PRE-TEST FOR CONTROL GROUP	*PRE-TEST FOR EXPERIMENTAL GROUP*
Mean	27.83333	29.88
Variance	37.80142	33.65878
Observations	48	50
Pooled Variance	35.68694	
Hypothesized Mean Difference	0	
Df	96	
t Stat	-1.69545	
P(T<=t) one-tail	0.046616	
t Critical one-tail	1.660881	
P(T<=t) two-tail	0.093231	
t Critical two-tail	1.984984	

T-test analysis of students' performance at post-test

t-Test: Two-Sample Assuming Equal Variances

	POST-TEST FOR CONTROL GROUP	*POST- TEST FOR EXPERIMENTAL GROUP*

Mean	32.33333	38.02
Variance	19.58865	18.95878
Observations	48	50
Pooled Variance	19.26715	
Hypothesized Mean Difference	0	
Df	96	
t Stat	-6.41123	
P(T<=t) one-tail	2.7E-09	
t Critical one-tail	1.660881	
P(T<=t) two-tail	5.4E-09	
t Critical two-tail	1.984984	

T-test analysis of male and female students' performance.

t-Test: Two-Sample Assuming Equal Variances

	MALES SCORES	*FEMALES SCORES*
Mean	38.20833	37.84615
Variance	14.1721	23.89538
Observations	24	26
Pooled Variance	19.23631	
Hypothesized Mean Difference	0	
Df	48	
t Stat	0.291723	
P(T<=t) one-tail	0.385878	
t Critical one-tail	1.677224	
P(T<=t) two-tail	0.771756	
t Critical two-tail	2.010635	

APPENDIX E

EFFECT SIZE CALCULATIONS

Effect size of difference in male and female scores of the experimental group

The effect size is determined by Cohen's *d*

Cohen's $d = (M_2 - M_1) / SD_{pooled}$

Where,

$SD_{pooled} = \sqrt{((SD_1^2 + SD_2^2) / 2)}$

Therefore, Cohen's $d = 0.08$

Effect size of difference in post-test scores of the control and experimental group

The effect size is determined by Cohen's *d*

Cohen's $d = (M_2 - M_1) / SD_{pooled}$

Where,

$SD_{pooled} = \sqrt{((SD_1^2 + SD_2^2) / 2)}$

Therefore, Cohen's $d = 1.33$

Effect size of difference in test scores of of male and female students