UNIVERSITY OF EDUCATION, WINNEBA

ENHANCING THE CONCEPTUAL UNDERSTANDING AND PERFORMANCE OF STUDENTS IN "BLOOD CIRCULATORY SYSTEM IN HUMANS" USING MULTIMEDIA INSTRUCTIONAL METHOD (MMIM)

DIANA AKANTAGRIWON

MASTER OF PHILOSOPHY

2021

UNIVERSITY OF EDUCATION, WINNEBA

ENHANCING THE CONCEPTUAL UNDERSTANDING AND PERFORMANCE OF STUDENTS IN "BLOOD CIRCULATORY SYSTEM IN HUMANS" USING MULTIMEDIA INSTRUCTIONAL METHOD (MMIM)

DIANA AKANTAGRIWON

(8180130001)

A thesis in the Department of Science Education, Faculty of Science Education submitted to the School of Graduate Studies in partial fulfilment

of the requirements for the award of degree of

Master of Philosophy

(Science Education)

in the University of Education, Winneba

AUGUST, 2021

DECLARATION

Candidate's Declaration

I, Diana Akantagriwon, declare that this Master of Philosophy thesis, with the exception of quotations and references contained in published works which have 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 hereby declare that the preparation and presentation of this Master of Philosophy thesis was supervised in accordance with the guidelines on supervision of thesis laid down by the School of Graduate Studies, University of Education, Winneba.

Name of Supervisor: Associate Professor Victor Antwi

Signature: ……..…………………

Date: …………………………….

DEDICATION

I dedicate this MPhil thesis to the Almighty God and to my adorable daughter, Yovela and my ever-assuring hub.

ACKNOWLEDGEMENTS

I am highly indebted to all those who helped me in one way or the other throughout the preparation of this Master of Philosophy (MPhil) thesis. However, my special and respectful thanks go to the following:

First and foremost: to my Principal Supervisor, Professor Victor Antwi, an Associate Professor in the Department of Science Education, University of Education, Winneba for his guidance and excellent supervision, patience and enabling assistance throughout the development and realisation of this thesis.

Second to: all my dedicated Lecturers of the Science Department for their unique suggestions and assistance.

Finally, to the Principal of the St. Vincent College of Education, Yendi and all the academic and senior management staff of the College whose tremendous encouragement and support made this research journey possible. To all my Level 200 students at the St. Vincent College of Education, Yendi, I wish to express my profound gratitude for your effective participation in this research through your regularity and active engagement in class.

TABLE OF CONTENTS

Title Page

Contents

List of Figures

LIST OF TABLES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

MMIM	**Multimedia Instructional Method**
CATML	Cognitive Achievement Theory of Multimedia Learning
BCHCT	Blood Circulation in Humans' Concept Test
SKBCHT	Students' Knowledge of Blood Circulation in Humans Test
TIA	Test Instrument A
TIB	Test Instrument B
TLMs	Teaching and learning materials

ABSTRACT

This study revealed various misconceptions held by Level 200 students of Integrated Science at the St. Vincent College of Education, Yendi on blood circulation system in humans. The use of the multimedia instruction method (MMIM) in teaching the blood circulatory system in humans not only resolved their previously held misconceptions, but also enhanced the students' conceptual understanding of the topic and improved, as well their academic performance in the related topic taught. The research design for this study was the action research. The purposive sampling and census technique were used to select the Science 2A class, comprising 200 students of the St Vincent College of Education, Yendi. The study demonstrated that the use of the MMIM boosted students' enthusiasm and interest in the topic, promoted and enhanced their comprehension of blood circulatory system in humans. The comparison of students' pre-intervention misconceptions about the topic and their pre-test scores with post-test scores and post intervention responses to short essay-type questions and questionnaire established that the MMIM intervention improved students' understanding of the topic and their performance. This study will serve as a teaching tool for teachers of Biology in the teaching of blood circulatory system in humans and similar biology topics. The MMIM can reduce or eliminate students' misconceptions on topics learnt.

Key words/phrases: Multimedia instruction method, blood circulatory system in humans, students, misconceptions.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter comprises information on the background to the study, the statement of the problem, the purpose of the study, objectives of the study, the research questions that guided the study, research hypotheses, and the educational significance of the study. The chapter discusses the delimitations and limitations of the study and concludes on the definition of some relevant terms to the study.

1.2 Background to the study

Any experienced teacher of biology who would have taught students the blood circulatory system in humans might have noticed that students have various misconceptions regarding the subject. While some use arteries and veins interchangeably others erroneously believe that blood flows from the body to the heart, or from the heart to the body (Pelaez, Boyd, Rojas, & Hoover, 2005).

Some Researchers declare that one of the possible causes of students' misconceptions in the study of the blood circulatory system in humans is the fact that biology teachers prioritise the use of the lecture method with teaching and learning aids, in place of more interactive methods of teaching (Loveland, 2014), such as the multimedia instructional method. Sometimes, students, instead of making additional efforts to grasp the content being taught would rather resort to learning by rote method, and this worsens their confusion of the relevant terms that relate to human blood circulatory system (Aleven, Mclaren, Sewall, & Koedinger, 2009).

Some students of biology perceive human blood circulatory system as a complex concept to grasp but this perception can be remedied when students learn through operational thinking (Aleven et al., 2009; Loveland, 2014). Thus, when students are involved in practical activities that are linked to a concept that may appear abstract, they are able to understand the concept better (Harrison & Treagust, 2000). For example, to sustain life and promote all healthy tissues in the human body, the blood circulatory process is inevitable. The process is made possible by the pumping of oxygenated blood from the lungs by the heart (the aorta) to all the tissues, and the expelling of the body's waste products, including carbon dioxide with the aid of blood veins (Molnar & Gair, 2019; WebM.D, 2016).

This process explained orally may seem abstract to the student yet, the student's grasp of the process is enhanced when the student views and interacts personally with the blood circulatory process via a multimedia model such as a video clip and an interactive dummy (Harrison & Treagust, 2000).

Some of the basic scientific concepts investigated in biology, such as the human blood circulatory system cannot be ordinarily accessed through touch or sight. These concepts may appear complex and difficult for beginning students in science to grasp readily through the usual lecture method (Nuanmeesri, 2018). The medium of multimedia in the teaching of biology becomes an apt means to assist and guide these students to understand such concepts and perform better in the subject (Khoiriah, Jalmo, & Abdurrahman, 2016; Nuanmeesri, 2018).

There are many ways to improve learning and to make learning more meaningful and interesting to students. The appropriate access and use of instructional technologies by both teachers and students are one relevant way of empowering students to learn better and achieve higher academic outcomes (Jones & Scaife, 2000; Khoiriah et al., 2016). Instructional technologies which include the different forms of multimedia, if well utilised can play a vital role in teaching and learning just as in the learning of the blood circulatory system in humans (Grabe & Christopherson, 2005). Instructional technologies help to provide students with the necessary experiences. For instance, a student who has interactive experience through the medium of well-selected instructional technologies during learning will learn more effectively and faster than those students taught mostly through exclusive verbal information. This is reiterated by Heinich, Molenda, and Russell (2000) and by Hani (2010) who explained that multimedia can help students make more efficient use of their senses in learning. Most instructional media are effective in the delivery of content and help sustain learners' interest (Kemp & Dayton, 1985).

The use of instructional media promotes timely and relevant sharing of ideas, thoughts, feelings and knowledge. According to Khoiriah et al. (2016), visuals in any form, and most especially when aided and enhanced through information technology such as tapes, records, films, transparencies, filmstrips, and slides, attract the keen attention of learners, which is paramount in learning. They further observed that many distractions compete for students' attention making it important to employ attention-catching devices that compel students to focus on the lesson.

Clearly, the importance of instructional media in the teaching-learning process cannot be overemphasised. The use of instructional technologies can serve as a key ingredient in teachers' development of a positive attitude towards teaching. Undoubtedly, the use of multimedia in the teaching of biology and the human blood circulatory system would be useful in teaching students who usually have serious challenges in understanding some basic concepts in biology. It is in line with this that this study seeks exclusively to explore the effect of the multimedia teaching and learning approach to enhancing students' conceptual understanding and performance in the blood circulatory system in humans. Thus, this Master of Philosophy research aims at "assessing the conceptual understanding and performance of students during the teaching and learning of blood circulatory system in humans using Multimedia Instructional Method (MMIM)".

1.3 Statement of Problem

Integrated Science students of St Vincent College of Education, Yendi like other student teachers in some sister Colleges of Education have difficulty in understanding some key topics or concepts in biology, despite the committed efforts of their teachers.

As a Biology Tutor of St Vincent College of Education, Yendi, who noticed the protracted difficulty some of the students have in grasping especially, the various concepts of blood circulatory system in humans, the Researcher thus, opted to use the Multimedia Instructional Method (MMIM) as an intervention tool to enhance students' conceptual understanding and performance in the blood circulatory system in humans, and remedy consequently this learning difficulty.

The main purpose of this study was to examine the effect of a specific teaching strategy, the use of the Multimedia Instructional Method (MMIM) in enhancing the academic performance of students at the St Vincent College of Education, Yendi in the learning of the blood circulatory system in humans.

It has been emphasised by various Researchers that when blood circulatory system in humans like other scientific concepts are taught in abstract terms it forces students to resort to rote-learning without understanding (Aleven et al., 2009). This practice that often results in low performance of students in biology in most educational institutions in Ghana, also pertains at the St Vincent College of Education, Yendi.

Students' poor performance in biology can be traced to students' inability to grasp properly the fundamental concepts in the subject and teachers' failure to communicate the fundamental concepts via the appropriate and engaging method of teaching Biology (Aleven et al., 2009).

Some colleague teachers of biology in St. Vincent College of Education, Yendi as well as some examiners in the subject area from sister colleges, and local universities attribute the low achievement in biology mainly to the use of inappropriate methods of teaching the subject.

Most biology teachers including the Researcher have adopted various methods of teaching the subject in the hope of communicating effectively to students the core concepts of the discipline. The common methods of teaching employed for past years are mainly, the traditional or lecture method of teaching, inquiry method, and the collaborative method, among others. These methods, even with the addition of charts and improvised teaching and learning materials failed tin many instances to explain effectively concepts such as the circulation of blood in mammals, digestion in mammals, transpiration in plants, fertilisation process in plants, and so on (Molnar & Gair, 2019).

To overcome some of the challenges to effective learning, especially when some of these traditional methods of teaching showed limited impact on learning, Bolkan (2019) and Ludwig, Daniel, Froman, and Mathie (2004) proposed the use of appropriate multimedia to enhance the presentation and to captivate and sustain students' attention and participation. That is the import of this study.

1.4 Purpose of Study

The main purpose of the study is to ascertain the usage of Multimedia Instructional Method (MMIM) in enhancing the conceptual understanding and performance of students at the St. Vincent College of Education, Yendi during the teaching and learning of circulation of blood in humans.

1.5 Objectives of the Study

The study seeks to achieve the following objectives;

1. Assess the misconceptions of students about blood circulatory system in humans.

2. Examine the effect of the use of Multimedia Instructional Method (MMIM) of teaching on students' conceptual understanding and performance in the blood circulation system in humans.

3. Assess the perceived impact the use of Multimedia Instructional Method (MMIM) of teaching has on students' interest in the blood circulatory system in humans

1.6 Research Questions

The following research questions were formulated.

1. What are the misconceptions of students about the blood circulatory system in humans?
2. What effect does the use of the Multimedia Instructional Method in teaching have on enhancing students' conceptual understanding and academic performance in the blood circulatory system in humans?
3. What perceived impact does the use of Multimedia Instructional Method (MMIM) of teaching have on students' interest in the blood circulatory system in humans?

1.7 Research Hypotheses

The following hypotheses were formulated to guide the study;

1. There is no statistically significant difference in the pre-tests and post-tests performance of all participants in circulation of blood in humans.
2. There is no statistically significant difference in the conceptual understanding and academic performance of students exposed to the multimedia teaching approach.

Hypothesis 1

H_o: There is statistically significant difference in the pre-tests and post-tests performance of all participants in circulation of blood in humans.

H_1: There is no statistically significant difference in the pre-tests and post-tests performance of all participants in circulation of blood in humans.

Hypothesis 2

H_o: There is statistically significant difference in the conceptual understanding and academic performance of students exposed to the multimedia teaching approach.

H_1: There is no statistically significant difference in the conceptual understanding and academic performance of students exposed to the multimedia teaching approach.

1.8 Significance of the Study

The Researcher believes that the findings of this research will encourage fellow Researchers, science teachers, and supervisors/heads of science departments, headmasters and policy makers in science education to consider the adoption of multimedia in teaching the blood circulatory system in mammals and biology concepts in general, as an important alternative teaching method. This may also influence future reviews of relevant science curriculum and syllabus. This study will also encourage science teachers to employ modern technologies such as the multimedia in teaching. Further, science students may also become enthusiastic in using the internet, audio-visual means rather than textbooks only in learning.

This study will also highlight the impact of teaching with multimedia on students' learning. It will as well help biology teachers overcome the difficulties they encounter when teaching certain concepts in the subject area. This will give biology teachers an alternative teaching tool in the presentation of their lessons.

1.9 Delimitations

The study was delimited to only level 200 science students of St. Vincent College of Education, Yendi and hence the findings will not be generalised to all students in the whole region or country. The study was further delimited to only blood circulation of living mammals and not any other living organism.

1.10 Limitations

This study is limited by the fact that only one college of education was involved as a case, and the scope of the study would have been broadened to other colleges in the Northern Region, yet this is not feasible due to financial and time constraints. Also, the Researcher did the teaching herself in this study hence she may be biased in observing her own students in the study.

1.11 Definition of Terms

Multimedia is defined as the combination of computer hardware and software that allows you to integrate video, animation, audio graphics and text resources to develop effective presentations (William, Michael, & Gartner, 2007). Multimedia refers to computer-mediated information that is presented concurrently in more than one medium. It consists of some, but not necessarily all, of the following elements: text; still graphic images; motion graphics; animations; hypermedia; photographs; video; audio (i.e., sounds, music, and narration). Multimedia can support multiple representations of the same piece of information in a variety of formats. This has several implications for learning (Ke, 2008; Nusir, Alsmadi, Al-Kabi, & Sharadgah, 2013).

Interactive Multimedia

By interactive multimedia, educators unusually refer to the use of multimedia and ICT equipment to offer an effective dialogue between the instructor and the students, in comparison with traditional methods of teaching which may lack such interactivity.

However, supporters of traditional methods of teaching argue that the face-to-face communication can be more interactive.

Science is the pursuit and application of knowledge and understanding of the natural and social world following a systematic methodology based on evidence or as a body of knowledge gained by observation and experiment(Patton, 2018).

Biology is a science that gathers knowledge about the natural world. Specifically, biology is the study of life (Molnar & Gair, 2019).

Essence of blood circulation: In addition to carrying fresh oxygen from the lungs and nutrients to your body's tissues, it also takes the body's waste products, including carbon dioxide, away from the tissues. This is necessary to sustain life and promote the health of all the body's tissues (WebM.D, 2016).

Schema: A schema is a network of abstract mental structure for organising knowledge, or a system around which behaviour is organised" (Travers, 1977).

Concept: A concept in science is a formally and logically developed idea about classes of phenomena about nature (Goguen, 2005).

Teaching: It is the way a teacher effectively and efficiently interacts within the classroom environment to bring about quality learning of a subject among students (Woolfolk Hoy, Davis, & Anderman, 2013).

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

The review of literature focused on works done by other Researchers in related fields. This chapter presents the theoretical framework of the study which is related to the essential aspects of the research, the conceptual framework that informs the methodology of the study, and examines the issues raised by key Researchers who studied and used multimedia as a key mode of teaching that facilitates learning of students in science related subjects, including biology and specifically, the blood circulatory system in humans.

2.1 Theoretical framework

The theoretical framework that underpinned the study was hinged on the cognitive theory of multimedia learning which was popularised by the work of Mayer (2005b) and other cognitive Researchers who argue that multimedia supports the way that the human brain learns. They assert that people learn more deeply from words and pictures than from words alone, which is referred to as the multimedia principle (Mayer, 2005b). Multimedia Researchers generally define multimedia as the combination of text and pictures; and suggest that multimedia learning occurs when we build mental representations from these words and pictures (Mayer, 2005b). The words can be spoken or written, and the pictures can be any form of graphical imagery including illustrations, photos, animations, or videos. Multimedia instructional design attempts to use cognitive research to combine words and pictures in ways that maximise learning effectiveness.

The theoretical foundation for the Cognitive Achievement Theory of Multimedia Learning (CATML) draws from several cognitive theories including Baddeley's model of working memory (1986), Paivio's dual coding theory (1986), and Sweller's Theory of

Cognitive Load (1994). As a cognitive theory of learning, it falls under the larger framework of cognitive science and the information-processing model of cognition. The information processing model suggests several information stores (memory) that are governed by processes that convert stimuli to information (Moore, Burton, & Myers, 2004).

Cognitive science studies the nature of the brain and how it learns by drawing from research in several areas including psychology, neuroscience, artificial intelligence, computer science, linguistics, philosophy, and biology. Cognitive scientists seek to understand mental processes such as perceiving, thinking, remembering, understanding language, and learning (Stillings et al., 1995).

Thus, cognitive science can provide powerful insight into human nature, and, more importantly, the potential of humans to develop more efficient methods using instructional technology (Sorden, 2005). The Cognitive Achievement Theory of Multimedia Learning (CATML) centres on the idea that learners attempt to build meaningful connections between words and pictures and that they learn more deeply than they could have with words or pictures alone (Mayer, 2003). According to CATML, one of the primary aims of multimedia instruction is to encourage the learner to build a coherent mental representation from the presented material. The learner's job is to make sense of the presented material as an active participant, ultimately constructing new knowledge.

According to Moreno and Mayer (2000) and Mayer (2003), CATML is based on three assumptions: the dual-channel assumption, the limited capacity assumption, and the active processing assumption. The dual-channel assumption is that working memory has auditory and visual channels based on Baddeley's (1986) theory of working memory and Paivio's (1986) Clark and Paivio (1991) dual coding theory. Second, the limited capacity assumption is based on cognitive load theory (Sweller, 1994). This states that each subsystem of working memory has a limited capacity. The third assumption is the active processing assumption which suggests that people construct knowledge in meaningful ways when they pay attention to the relevant material, organise it into a coherent mental structure, and integrate it with their prior knowledge (Mayer, 1999).

2.2 Conceptual framework of the Study

The conceptual framework for the study was adopted from the work of Yu-Hsin, Ju-Tzu, and Deng-Jyi (2012). He conducted a study on the effect of multimedia computer assisted instruction and learning style on learning achievement. When students are exposed to confusing or complex concepts, they are thrown into a state of disequilibrium. Multimedia instructional packages, however, enable students to develop cognitive structures or mental models to reorganise their already existing ones to better understand confusing and complex concepts in biology and other subjects (Yeboah, 2010). Some Researchers (Gardner, 1996; Pintrich, Marx, & Boyle, 1993; Von Glasersfeld, 1993) have noted that, the constructivists' position that students should have access to multiple viewpoints and representations of information is partially satisfied by well-constructed simulations and other multimedia packages. The adopted conceptual framework for the study is presented in **Figure 1**.

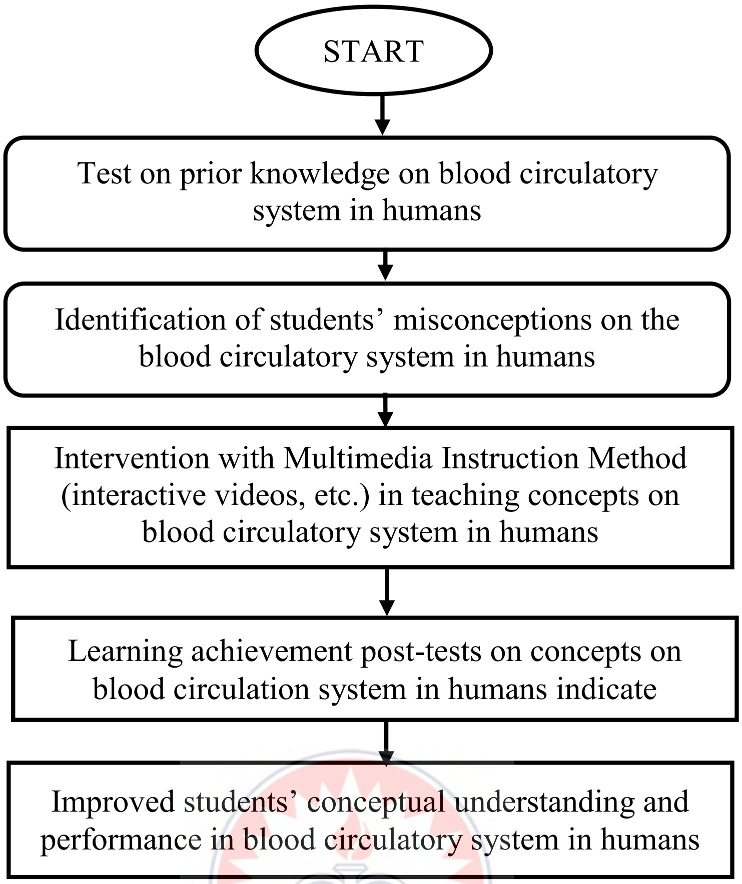


Figure 1: Conceptual Framework of the Study (Designed by the Researcher)

Other researchers like Ramasundaram, Grunwald, Mangeot, Comerford, and Bliss (2005) observed that, simulations have the potential to make learning of confusing and complex or difficult concepts more interactive, authentic, and meaningful. Computer simulations and multimedia instructional packages, therefore, seem to give students experiences that facilitate conceptual development leading to increased understanding of difficult concepts.

2.3 What is Multimedia?

Multimedia is a term frequently heard and discussed among educational technologists today. Unless clearly defined, the term can alternately mean a judicious mix of various mass media such as print, audio and video or it may mean the development of computer-based hardware and software packages produced on a mass scale and yet allow individualised use and learning. In essence, multimedia merges multiple levels of learning into an educational tool that allows for diversity in curricula presentation. Multimedia is the exciting combination of computer hardware and software that allows you to integrate video, animation, audio, graphics, and test resources to develop effective presentations on an affordable desktop computer (Fenrich, 2005).

Encyclopaedia Britannica defines multimedia as a "Computer-delivered electronic system that allows the user to control, combine, and manipulate different types of media, such as text, sound, video, computer graphics and animation. The most common multimedia machine consists of a Personal Computer with a sound card, MODEM, digital speaker unit, and CD-ROM. The word 'multimedia' is coined from two separate terms like 'Multi' (means 'many') and 'Media' (means 'a channel through which something is conveyed'). Multimedia is a powerful tool, which can provide individual and interactive instructions as well as motivation for practice in an entertainment environment. Multimedia also provides students with different learning style, the opportunity to learn, share, communicate and grow using all their faculties (Das, 2014).

Multimedia is characterised by the presence of text, pictures, sound, animation and video; some or all of which are organised into some coherent program (Philips, 1997). Today's multimedia is a carefully woven combination of text, graphic art, sound, animation, and video elements. When you allow an end-user that is the viewer of a multimedia project, to control 'what' and 'when' and 'how' of the elements that are delivered and presented, it becomes interactive multimedia. Consequently, multimedia can be defined as an integration of multiple media elements (audio, video, graphics, text, animation etc.) into one synergetic and symbiotic whole that results in more benefits for the end user than any one of the media elements can provide individually. Besides being a powerful tool for making presentations, multimedia offers unique advantages in the field of education. Multimedia enables teachers to provide a way by which learners can experience their subject in a vicarious manner. The key to providing this experience is having simultaneous graphic, video and audio, rather than in a sequential manner. The appeal of multimedia learning is best illustrated by the popularity of the video games currently available in the market. These are multimedia programmes combining text, audio, video, and animated graphics in an easy-to-use fashion.

With multimedia, the process of learning can become more goal oriented, more participatory, and flexible in time and space, unaffected by distances and tailored to individual learning styles, and increase collaboration between teachers and students. Multimedia enables learning to become fun and friendly, without fear of inadequacies or failure.

It is possible to say that the introduction of multimedia into the classroom has a profound impact on styles of teaching and learning (Slack, 1999). Students are seen to be more motivated when using multimedia, which one teacher described as 'using the multimedia "hook". According to Slack (1999), teachers have stated that multimedia enables students to work at a different pace, and some packages can be tailored to student needs. Teachers have also suggested that they regard students as learning co-operatively when multimedia is used. The teacher becomes a facilitator, problem setter and guide as opposed to taking a central role.

2.4 Multimedia and Education

The advancement of technology has made a significant impact on the evolvement of teaching methods from traditional face-to-face teaching to computer-based learning (CBL) or e-learning systems at all levels of education. Modern education and communication environments can offer alternative ways in the learning process. Multimedia has been widely used in educational technologies. It is also expected that the future will see more utilisation of such tools in education. Some argue that multimedia and e-learning tools should be used as a supplement to traditional classes (and not as a replacement). Using interactive multimedia in the teaching process is a growing phenomenon. It plays a very important role in assisting students in learning processes. Therefore, it can be concluded that multimedia enhances and enables students to learn in a more effective way. More efforts are needed to create new programs using multimedia elements and multimedia authoring tools to provide content-rich learning software and courseware to different students. By multimedia, here we don't mean only animation, or image- and video-related products, although these maybe incorporated with programming and other methods to provide a portal or an application, etc., in which data, video and images are mixed (Nusir et al., 2013).

2.5 History of multimedia in teaching

The multimedia concept in teaching came into existence in early 1990s. The early years of an educational institution having an isolated audio-visual department are long gone! The growth in use of multimedia within the education sector has accelerated in recent years and looks set for continued expansion in the future. Teachers basically need access to learning resources, which can support concept development by learners in various ways to meet individual learning needs. The development of multimedia technologies for learning offers new ways in learning which can take place in both school and home.

According to Butzin (2000) and Erickson and Lehrer (2000), the use of computer information technology in education, more especially in the teaching and learning process will definitely result in academic improvements globally. As a result, there is concern for those who have had little or no experience with computer technology, most of whom are in the developing countries (Cawthera, 2003), such as Ghana. The advent of computers and the internet is an indication of a new phase in the instructional technology.

By the mid-1980s, the internet had gained acceptance in business and was finding its way into education in the United States (Daniel, 1999). In addition to the internet, instructional materials such as CD-ROMs and other computer associated programmes have been introduced and are widely used in education. Computer mediated instruction and programs have introduced a level of interactivity and immediate response that most instructional television and radio do not offer.

Computer-based technology allows teachers to move from the role of dispenser of knowledge to a facilitator or coach, allowing the teacher to encourage and guide students in becoming active learners. David (1991) stated that "teaching must change from dispensing information and rewarding right answers to the creation of activities that engage students' minds and present complex problems with multiple solutions". Computer-based technology will permit the teacher to present more complex material and expect more from the students (OTA, 1995).

The computer allows the teacher to easily keep track of grades, and individual student report can be generated very quickly. There are several perceptions by teachers in the use of computer- based technology that seem to be significant: (a) technology do support superior forms of learning (Collis, Oberg, & Shera, 1988), (b) computer-based technology can change the way teaching and learning occurs (Compeau & Higgins, 1995; OTA, 1995), (c) computer-based technology helps teachers to accomplish things that they cannot do by themselves (Wild, 1995), (d) computer-based technology enhances teacher and student productivity (OTA, 1995), and (e) computer-based technology prepares students for the work world (Yuen & Ma, 2002).

Teachers who hold the above perceptions tend to be the most successful in adopting and using computer-based technology. The perception that technology supports superior forms of learning comes from cognitive psychology (Veen, 1993). Advanced skills of comprehension, reasoning, and experimentation are acquired through the learners' interaction with content. Drawn from the constructivist view of learning, teaching basic skills within authentic contexts (hence more complex problems), for modelling expert thought processes, and for providing for collaboration and external supports permit students to achieve intellectual accomplishments which they could not do on their own.

It also provides the wellspring of ideas for many of this decade's curriculum and instruction reform efforts by: (1) a move from the teacher as the dispenser of knowledge to the teacher as a facilitator or coach, (2) teachers expected more from students and presented more complex material, (3) more opportunity for individualised instruction, (4) spend less time lecturing to the whole class, (5) more comfortable with small-group activities, (6) team teaching, (7) interdisciplinary project- based instruction, and (8) altering the master schedule.

Studies conducted by many Researchers at different levels of education revealed the effect of multimedia teaching in different subject areas like Mathematics, Science, Environmental Science, Physics, Biology (Yaspal Sudhanshu, 2014). These studies showed that multimedia approach to teaching is more effective than traditional approach to teaching. Taking the findings of such experiments into account, many schools have also started using the multimedia approach to teaching in their classrooms.

As multimedia teaching technologies become more widely advocated and employed in education, Researchers strive to understand the influence of such technologies on student learning. Advances in technology enable pedagogical enhancements that some believe can revolutionise traditional methods of teaching and learning. When viewed collectively, these studies reported that advanced technologies, especially multimedia instruction, which often involves introducing or enhancing the visual aspects of the presentation of course contents, created an active learning environment, improved students' performance, fostered positive attitudes toward learning complex concepts, increased communication and could be adapted to all learning styles and levels of instruction. Researchers suggest that, compared to classes with a traditional teacher-leading approach, those using multimedia are better liked by students and yield slight but statistically significant improvements in student learning as measured by both student self-report and objective outcome testing. Such encouraging findings have precipitated the adoption of these technologies on a widespread basis. Therefore, there is a need to further educators' understanding of the effect of multimedia technologies on students' learning quality.

The combined outcomes of the majority of studies across disciplines indicated that multimedia-based delivery systems offered ways to optimise the advantages and minimise the disadvantages of traditional methods of teaching and learning. These are expected to be true in biology. Biology laboratories are designed to help students understand the basic concepts and their applications by experiments, collecting specimens, using specimens to know the parts and functions, and drawing and writing a laboratory report. Many factors such as the time limit for setting up, the unavailability of specimens in the traditional laboratories. However, the disadvantages elicited by these factors can be addressed with the use of multimedia-based delivery systems.

2.6 Nature and Characteristics of Multimedia Approach

When text, pictures, sound, animation and video; some or all are organised into a coherent form or program, then we are using multimedia (Philips, 1997). Thus, the multimedia combines text, graphic art, sound, animation, and video elements. So, it is an integrated system of multiple media elements - audio, video, graphics, text, animation, etc. that results in enhanced benefits for the user. (Kapri, 2016).

- Multimedia approach uses a number of media, devices, and techniques in the teaching-learning process.
- Multimedia approach has come out of research and experiments in educational technology utilised to improve the process of teaching-learning.
- Multimedia approach aims at providing meaningful learning experiences.
- Select the media carefully so that one does not hamper or reduce the effect of the other i.e., each media must complement the other.
- Use media sequentially and judiciously. Then it would be possible to make optimum use of them in a most economical manner.

2.7 Impact of Multimedia Technology in Teaching of Biological Science

Shortly after the internet explosion of the 1990s, technology was immediately integrated into the classrooms. Many efforts have been established to help educators realise the benefits of technology and ways of implementing them in the classroom. Multimedia technology can be used to support and enhance learning. Some examples of technologies used in the education system are video content and digital movie making, laptops, computers, and handheld technologies. New uses of technology, for example, podcasting and tablets are constantly being created. Many students are growing up in a digital age where they have constant exposure to a variety of media that is impacting on the way they interact and use information. It is clear that the use of multimedia teaching in the classroom helps the students to have more fun during lessons, become more enthusiastic, have increased engagement in learning, be more interested in learning, become more self-directed in learning, have greater self-confidence and self- esteem, focus on improving performance, have greater ICT skills, increase their research skills, improve problem solving and critical thinking skills, write more extensively with improved quality, have increased access to information, present information more effectively, and enjoy learning actively.

Multimedia is changing the way we communicate with each other. The way we send and receive messages is more effectively done and better comprehended. The inclusion of media elements reinforces the message and the delivery, which leads to a better learning rate. The power of multimedia lies in the fact that it is multi-sensory, stimulating the many senses of the audience. It is also interactive, enabling the end-users of the application to control the content and flow of information. Children can use technology individually, through computer-assisted instruction, to learn biological science concepts. Meyers and Jones (1993) find that active learning "involves providing opportunities for students to meaningfully talk and listen, write, read, and reflect on the content, ideas, issues, and concerns of an academic subject" and this quote from Bonwell and Eison (1991) reminds us that, "Learning is not a spectator sport. Students do not learn much just sitting in class listening to teachers, memorising pre-packaged assignments, and spitting out answers. They must talk about what they are learning, write about it, relate it to past experiences, apply it to their daily lives." The move to active learning methods can be costly, especially to the economist who traditionally uses the lecture method (Becker & Watts, 1996) and who does not use class discussions, case studies, simulations, or cooperative work (Siegfried, Saunders, Stinar, & Zhang, 1996).

2.8 How does multimedia learning work?

The promise of multimedia learning - that is, promoting student understanding by mixing words and pictures - depends on designing multimedia instructional messages in ways that are consistent with how people learn. Mayer (2003) presented a cognitive theory of multimedia learning that is based on three assumptions suggested by cognitive science research about the nature of human learning - the dual channel assumption, the limited capacity assumption, and the active learning assumption. The dual channel assumption is that humans possess separate information processing systems for visual and verbal representations and is derived from the research of Paivio (Clark & Paivio, 1991; Paivio, 1986, 1990) and Baddeley (Baddeley, 1986; Baddeley & Hitch, 1994; Baddeley & Logie, 1999). For example, animations are processed in the visual/pictorial channel and spoken words (i.e., narrations) are processed in the auditory/verbal channel. The limited capacity assumption is that the amount of processing that can take place within each information processing channel is extremely limited (Baddeley, 1986; Baddeley & Hitch, 1994; Baddeley & Logie, 1999; Chandler & Sweller, 1991; Van Merriënboer, 1997). For example, learners may be able to mentally activate only about a sentence of the narration and about 10 seconds of the animation at any one time. The active learning assumption is that meaningful learning occurs when learners engage in active cognitive processing including paying attention to relevant incoming words and pictures, mentally organising them into coherent verbal and pictorial representations, and mentally integrating verbal and pictorial representations with each other and with prior knowledge (Mayer, 1999, 2003, 2005a, 2005b, 2005c; Mayer & Moreno, 1998; Moreno & Mayer, 2000; Wittrock, 1989). This process of active learning results in a meaningful learning outcome that can support problem-solving transfer through the instrumentality of MMIM is captured in a framework for the cognitive theory of multimedia learning as presented in **Figure 2.**

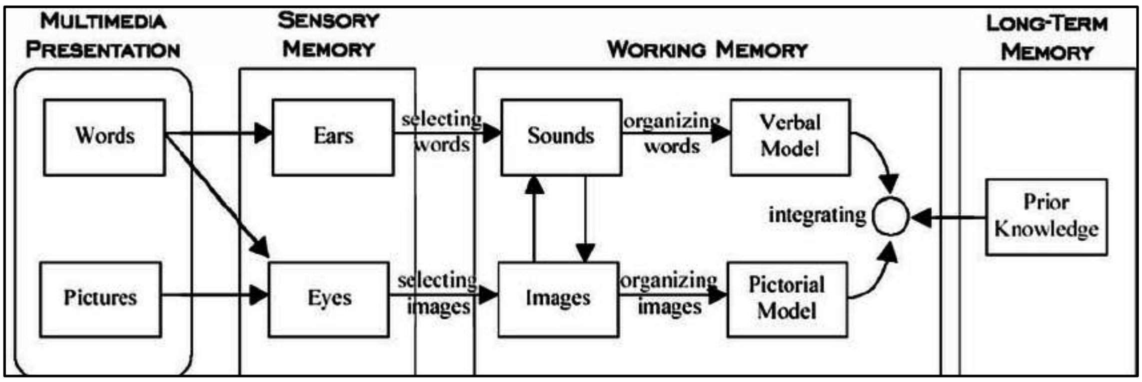


Figure 2: A framework for the cognitive theory of multimedia learning proposed by Mayer (2003)

2.9 The Effect of Multimedia as a Teaching Tool in Biology Education

The science education community emphasises the implementation of inquiry-based instruction in both primary and secondary schools. Teaching science via inquiry involves engaging students in the kinds of processes used by scientists. These processes include asking questions, making hypotheses, designing investigations, grappling with data, drawing inferences, redesigning investigations, and building and revising theories (Kubasko, Jones, Tretter, & Andre, 2008).

Stuckey-Mickell and Stuckey-Danner (2007) conducted a study to investigate student perceptions of Virtual Biology labs used in two online introductory Biology courses. Students completed an online survey containing Likert type and open-ended items, about perceptions of the CDROM based Virtual Biology laboratories and face-to-face (F2F) laboratories. These findings indicated that though most students (86.9%) perceived the F2F laboratories as more effective than the virtual laboratories across several criteria, many of them (60.8% on one criterion) perceived the virtual laboratories as effective as well. The authors discuss how student identified issues related to interactivity and feedback could be influenced by the design of the learning experience, virtual laboratory tool, and/or the use of synchronous collaboration tools. Additionally, the authors include suggestions for future research on the use of virtual Biology laboratories in the online setting.

Hennessy, Deaney, and Ruthven (2006) discussed ways teachers make use of computer-based technologies to support the learning of science and suggested that technology supports stepwise knowledge building and application. Such applications have implications for both curriculum-related science activities and emerging computer-based learning technologies. Technology helps students construct links between theories and phenomena by extending the human capacity.

Chi-Yan and Treagust (2004) suggested that Biology educators are increasingly using technology to supplement their teaching. A variety of computer technologies has been used over the past two decades to enhance student learning of many of the biological sciences in colleges and universities. Computer technology and educational software has provided new learning opportunities that can change the look and feel of traditional science classrooms. This does not necessarily imply that learning in traditional education is ineffective. However, traditional methods sometimes fail to reflect skills and interests of students who have grown up in the digital age. Technology can enhance learning environments and increase opportunities for authentic hands-on experiences (Zumbach, Schmitt, Reimann, & Starkloff, 2006). Computer technologies support the development and implementation of teaching and learning strategies that support many important science skills (Maor & Fraser, 1996).

Angadi and Ganihar (2015) mentioned that technology and multimedia facilitate the knowledge-construction process for students by allowing learners to construct links among their prior knowledge and the new concepts. This assertion supports research suggesting that science education should include both constructivist methodologies and technology integration as a natural part of its ideology.

Computerised magnification systems and video-based virtual experiences have been studied in the attempt to improve areas such as the ease of viewing, interactivity, and improvement of group learning activities within the context of science education. Bockholt, West, and Bollenbacher (2003) in the of study of a student-centred instructional module exploring the use of multimedia to enrich interactive, constructivist learning of science showed that multimedia has the potential of providing bioscience education novel learning environments and pedagogy applications to foster student interest, involve students in the research process, advance critical thinking/problem-solving skills, and develop conceptual understanding of biological topics.

Klein and Koroghlanian (2004) examined the effects of instructional mode (text vs. audio), illustration mode (static illustration vs. animation) and spatial ability (low vs. high) on practice and post-test achievement, attitude, and time in high school biology. The results indicated that spatial ability was significantly related to practise achievement and attitude. Participants with high spatial ability performed better on the practice items than those with low spatial ability. Participants with low spatial ability responded more positively than those with high spatial ability to attitude items concerning concentration, interest, and amount of invested mental effort. Findings also revealed that participants who received animation spent significantly more time on the program than those who received static illustrations. Implications for the design of multimedia are discussed.

Sivin-Kachala and Bialo (2000) reviewed 311 research studies on the effectiveness of technology on student achievement. Their findings revealed positive and consistent patterns when students were engaged in technology-rich environments, including significant gains and achievement in all subject areas, increased achievement in preschool through high school for both regular and special needs students, and improve attitude toward learning and increased self-esteem. Paris (2004) stated that e-Learning can improve school results. Furthermore, a simple multimedia presentation helped the students to better understand a subject without the help of a teacher particularly for shy and weak students.

Sangodoyin (2010) also confirmed this in his studies on computer animation and the academic achievement of Nigerian senior secondary school students in Biology. This study investigated the effects of computer animation on the academic achievement of

Nigerian senior secondary school students in Biology. The moderating effects of mental ability and gender were also investigated. The pre-test and post-test, control group, quasi-experimental design with a 2x2x2 factorial matrix was adopted for the study. One hundred and eighty-nine senior secondary school Year II Biology students from two randomly selected Federal Government Colleges in two states in South-Western Nigeria were the participants. Findings showed that there was a significant main effect of treatment on students' achievement in Biology.

The computer animation was effective in improving students' achievement therefore, computer animation is recommended as a means of teaching Biology to students in Nigerian secondary schools.

Ali and Elfessi (2004) revealed in their study that the significant role of technology in teaching and learning is limited as an instructional delivery medium and not a key determinant of learning. It can only support the classroom learning. Thus, there is empirical evidence to suggest both the positive and negative effects of multimedia. The key issue is to analyse these findings and find out the precise reasons and the situations in which multimedia is useful and in which it is not. While Multimedia seems to be improving the learning rate, it is not a universal fact.

Nevertheless, today's teachers are concerned with how to use technology to enhance and enrich their learning environment. According to Cline (2007), the role of technology in the classroom is not to replace traditional educational methods, it does act as an enhancement for teaching students to think critically, communicate creatively and solve problems in analytical way. Students can learn "from" computers – where technology is used essentially and serves to increase students' basic skills and knowledge; and students can learn "with" computers- where technology is used as a tool that can be applied to a variety of goals in the learning process and can serve as a resource to help develop higher order thinking, creativity, and research skills.

2.10 Advantages or Benefits in Using Multimedia Method of Teaching and Learning

Multimedia is immensely helpful and fruitful in education due to its characteristics of interactivity, flexibility, and the integration of different media that can support learning and consider individual differences among learners and increase their motivation. The provision of interaction is the biggest advantage of the digital media in comparison with other media. It refers to the process of providing information and response. Interactivity allows control over the presented content to a certain extent: learners can change parameters, observe their results or respond by choosing options. They can also control the speed of applications and the amount of repetition to meet their individual needs. Furthermore, the ability to provide feedback tailored to the needs of students distinguishes the interactive multimedia from any other media without a human presence. Dyslectic students can use synthetic speech to become familiar with the content of digital texts. Autistic children show an increase of phonologic awareness and word reading by using multimedia according to Heimann et al., as cited in Andresen and van den Brink (2002). Students with severe speech and physical impairments gain from learning with multimedia because the computer is flexible enough to meet individual needs. Ideas and words can be repeated as often as they wanted, and students could hear these, as loud as they wanted said Steelman, as cited in Andresen and van den Brink (2002). For deaf students, the visual presentation of content improves their motivation to learn according to Voltena et al., as cited in Andresen and van den Brink (2002). The computer can noticeably improve student access to information. Such delivery platforms as the World Wide Web provide 24-hour access to information.

2.11 Advantages of Multimedia

Multimedia can be used for drill and practice, to master basic skills, development of writing skills, problem solving, understanding abstract science concepts, simulation in science, manipulation of data, acquisition of computer skills for general purposes, business and vocational training, access and communication to understand populations, students access for teachers and students in remote locations individualised and cooperative learning, management and administration of classroom activities, to take into account different learning styles, to allows self-pacing and development. It provides the students the flexibility of anywhere and anytime learning. Multimedia can bridge language barriers as audio is not the only means of communications. It has been proven by research that multimedia in schools is effective for students to learn both 'from' and 'with' it. The focus is now on media and technology because of their advantages in terms of repeatability and equity of access. Multimedia helps students to construct knowledge actively (Satyaprakasha & Behera, 2014), work in groups and use multi-senses at the same time,

The growth of information and communication technology (ICT) in society is reflected in policies to encourage the use of ICT in education and the development of educational multimedia. Government policy on the National Grid for Learning is driving the use of multimedia and internet in schools. The use of CD-ROM and the internet is becoming an integral part of the curriculum in all areas. The introduction of multimedia into the classroom has a profound impact on teachers' role and on students' learning and motivation. Multimedia can mean any kind of file or document, either a text or spreadsheet that have audio / video effects or 'an interactive information café'. It certainly is the most promising technology in education. Teachers, however, must use their imagination, ingenuity in order to take full advantage of the multimedia in teaching and learning. It means an integration of sound, still Images, animation, video, and text along with computing technology. It helps learning, browsing through encyclopaedia and reference materials starting from the circulatory system to an automatic explosion in commercial presentation, official exposition, and in creating 3D effects in many ways. It also helps learners in mastering various languages.

In order to make education meaningful, exciting, interesting and accessible to all, a new technology needs to be linked with the process of learning. The new technology is not only capable of overcoming the barriers that distance presents, but also changes the very nature of the instructional process. Modern communication technologies have the potential to bypass several stages and sequences in the process of development encountered in early decades. Modern educational technologies must reach the most distant areas and benefit the most deprived sections of beneficiaries. Simultaneously, in order to avoid structural dualism, web technology is the only technology that serves all the above purposes at less cost. Distance educators can use web to build classroom home page. The web provides a new opportunity for distance teaching and learning.

2.12 Educational Implications of the use of Multimedia

Multimedia enables students to represent information using several different media. Hypermedia links allow students to organise information in meaningful ways, can take into account different learning styles - some students learn by interpreting text, while others require more graphical or aural representations, allows for self-pacing and discovery. Students can take the time they need and choose the path of learning, making learning meaningful and pleasurable, helps in development of higher order thinking skills.

Interactive multimedia encourages students to seek information, apply knowledge and reattempt tasks (based on feedback given), behaviours that are associated with higher order learning, provides the students the flexibility of 'anywhere', 'any time' learning, helps in developing group and interpersonal skills. Better communication between students via e-mail, chat sessions etc., can encourage collaborative learning and enhance student/teacher interactions, can bridge language barriers since audio is not the only means of communications, and helps students to learn the content in each discipline. It helps students to think effectively, practice problem solving and decision making. It has been proved by research that multimedia in schools is effective for students to learn both 'from' and 'will' it. The focus is now on media and technology because of their advantages in terms of repeatability, transportability, and equity of access. Multimedia helps students to construct knowledge actively, work in groups and use multi-senses at a time. Student's exposure to such technologies will result in better teaching-learning as compared to traditional method and it also equips them in using the same in their future. It will help the students to accept the fast. To improve upon the quality of information presented various techniques are to be implemented and growing changes in the field of science and technology, multimedia merges multiple levels of learning into an educational tool that allows for diversity in curricula presentation (Satyaprakasha & Behera, 2014).

2.13 Challenges on the Use of Multimedia Instruction in Developing Countries

As cited from the ICSU report of 2011, Teachers play a key role in inspiring and mentoring future scientists, using constructivism and other recommended teaching practices for effective student learning (ICSU, 2011). Unfortunately, in many developing countries, teachers are not well prepared to teach scientific subjects and indeed, may be unwillingly driving students away from scientific disciplines than attracting them because of their lack of basic scientific tools and equipment in teaching these subjects. Some teachers lack the basic understanding of the mathematical and scientific concepts that will serve as the foundation for preparing the scientists of tomorrow.

Quality professional development, continuing education and support for science teachers are needed to prepare them to effectively guide their students to become scientifically literate, and to make science attractive to their students. Furthermore, in some countries and at some grade levels, it is important to ensure that scientific content is presented in a way that considers cultural context, so that appreciation of the material is optimised for teachers, students, and their families.

Inadequate numbers of well prepared and highly motivated science and technology teachers: At the moment, almost 50% of teachers at the senior secondary level are not professionally trained. Most basic education teachers are ill-prepared to teach science and technology. Science teachers are poorly motivated and resourced resulting in appreciable numbers leaving the teaching profession for other occupations. Information available indicates that a sizeable percentage of students enrolled in master's in business administration programmes at the University of Ghana are science and technology graduates (Entsua-Mensah, Doku, & Adzamli, 2012).

Inadequate funding of science and technology education in the country: It is estimated that resource allocation to science and technology constitute only 0.3-0.5 per cent of GDP which is far below the decision taken by the signatories to the Lagos Plan of Action to spend at least 1.0% of GDP. This has resulted in poor infrastructure including laboratory and workshop facilities for the teaching of science and technology in the schools in Ghana (Anamuah-Mensah, Mereku, & Asabere-Ameyaw, 2003).

Okello and Kagoire (1996) said: "The quality of education of a country largely depends on the quality of teachers." In other words, the quality of education is as good as the quality of the teacher. Thus, if the quality of science teachers is poor, the quality of science education will be poor. What this means is that the quality of teachers will determine the effectiveness of teaching and learning of science. Science teaching and learning needs adequately trained and motivated teachers in order to succeed and this is what the current Ghana education system lacks.

2.13 The Concept of the Blood Circulatory System in Humans

The blood circulatory system (cardiovascular system) which comprises the heart and the blood vessels delivers nutrients and oxygen to all cells in the body. The arteries carry oxygenated blood away from the heart to other parts of the body while the veins carry poor oxygenated blood back to the heart to be oxygenated via the lungs for arteries to carry back to all parts of the body So, the cycle continues, hence the name, blood circulatory system in humans (Armentano, Cabrera Fischer, & Cymberknop, 2019; my.clevelandclinic.org, 2022; Zimmermann, 2019).

In other words, the blood circulatory system in humans which comprises the heart and the blood vessels pumps blood from the heart to the lungs to get oxygen. The heart then sends oxygenated blood through arteries to the rest of the body. The veins carry oxygen-poor blood back to the heart to start the circulation process all over. Thus, the circulatory system helps remove carbon dioxide from respiration/breathing, other chemical by-products from the organs, and waste from food and drink consumed, so that the body can dispose of them. It is critical to healthy organs, muscles and tissues (Oliver, Francis, Stanley, & Entman, 2022).

How does the Circulatory System Work?

The circulatory system functions with the help of blood vessels that include arteries, veins and capillaries. These blood vessels work with the heart and lungs to continuously circulate blood through the body. The heart's bottom right pumping chamber (right ventricle) sends blood that's low in oxygen (oxygen-poor blood) to the lungs. Blood travels through the pulmonary trunk (the main pulmonary artery). Blood cells pick up oxygen in the lungs. Pulmonary veins carry the oxygenated blood from the lungs to the heart's left atrium (upper heart chamber).The left atrium sends the oxygenated blood into the left ventricle (lower chamber). This muscular part of the heart pumps blood out to the body through the arteries. As it moves through your body and organs, blood collects and drops off nutrients, hormones and waste products. The veins carry deoxygenated blood and carbon dioxide back to the heart, which sends the blood to the lungs. The lungs get rid of the carbon dioxide when we exhale.

The heart is a muscular organ that pumps blood throughout the body. Blood itself is made up of red and white blood cells, plasma and platelets and the blood vessels that transport or circulate the blood include arteries, veins, and capillaries.

The blood circulatory system has three continuous circuits through which the heart, the blood, the veins (, the arteries, and the lung effect their respective functions nonstop. These are:

The pulmonary circuit: This circuit carries blood without oxygen from the heart to the lungs. The pulmonary veins return oxygenated blood to the heart.

The systemic circuit: In this circuit, blood with oxygen, nutrients and hormones travels from the heart to the rest of the body. In the veins, the blood picks up waste products as the body uses up the oxygen, nutrients, and hormones.

The coronary circuit: Coronary refers to the heart's arteries. This circuit provides the heart muscle with oxygenated blood. The coronary circuit then returns oxygen-poor blood to the heart's right upper chamber (atrium) to send to the lungs for oxygen.

There are three main types of blood vessels:

Arteries: Arteries are thin, muscular tubes that carry oxygenated blood away from the heart and to every part of your body. The aorta is the body's largest artery. It starts at the heart and travels up the chest (ascending aorta) and then down into the stomach (descending aorta). The coronary arteries branch off the aorta, which then branch into smaller arteries (arterioles) as they get farther from your heart.

Veins: These blood vessels return oxygen-depleted blood to the heart. Veins start small (venules) and get larger as they approach your heart. Two central veins deliver blood to your heart. The superior vena cava carries blood from the upper body (head and arms) to the heart. The inferior vena cava brings blood up from the lower body (stomach, pelvis and legs) to the heart. Veins in the legs have valves to keep blood from flowing backward.

Capillaries: These blood vessels connect very small arteries (arterioles) and veins (venules). Capillaries have thin walls that allow oxygen, carbon dioxide, nutrients and waste products to pass into and out of cells (Oliver et al., 2022).

2.14 The Importance of Multimedia Instruction in Understanding the Blood Circulatory System in Humans

Biology which is an integral part of science, and which focuses on living things (plants and animals), is a highly popular subject amongst Senior High Students in Ghana. In the Ghanaian educational system, it is compulsory that every science student in the Senior High School studies at least Biology or Geography in addition to Chemistry, Physics and Elective Mathematics. Over the years, the trend has been that most students choose Biology over Geography in the field of science. The performance of students in Biology has, however, been very poor. Investigations have revealed quite a number of reasons; one is that some concepts are very difficult to teach as well as for students to learn and understand (Bangkok, 2004; Bordens & Abbott, 2002). Some of these concepts include the blood circulatory system of humans, DNA, RNA and protein synthesis, and these topics end up being neglected sometimes by teachers (Ertmer, 2003).

Other studies have shown that difficulty of learning the blood circulatory system in humans is a common phenomenon, because the concept is abstract and the processes involved are not physically observable (DeMarrais & Lapan, 2003). Therefore, their teaching and learning tools should be provided to make learning biological concepts easier and concrete. One of such tools is multimedia, a package designed to teach Senior High School students' concepts in biology.

However, the importance of using the multimedia in teaching blood circulation is so diverse that it is almost impossible to list all possible applications. Taylor (2003) recognised three roles of computers in a classroom as tutor, tool, and tutee. Introduction of multimedia in the concept of blood circulation will raise not only the level of knowledge but students attitudes toward biology as well (Kubiatko & Haláková, 2009). Biology (science) teachers distinguish between generic applications which is used in all subjects, like word-processing, searching for information, communication using e-mails, and multimedia presentations. In this case, if a science teacher does not use ICT in a classroom, the damage to the students will be limited because they can achieve missing skills with their work in other subjects at home (Kuhlemeier & Hemker, 2007).

The other applications are adapted or developed to be used in science teaching (McFarlane & Sakellariou, 2002), like imaging systems in microscopy (Fiche, Bonvin, & Bosman, 2006; McLean, 2000), virtual dissections (O'Byrne, Patry, & Carnegie, 2008), simulations (Ramasundaram et al., 2005), virtual laboratory (Jenkins, 2004), and real laboratory exercises with data acquisition systems (Conway & Zhao, 2003). The most important difference among these two groups of applications is that if a science teacher does not use such applications in teaching students in most cases will not be able to compensate loss with work in other subjects or at home.

The introduction of computers into the teaching and learning in Slovenian Secondary Schools has followed the introduction of the compulsory subjects, Computer Science and/or Informatics, into the curriculum. The second approach involved the use of computers in a rainbow of different subjects. The introduction of computers into student work in other subjects is encouraged by the government, but the final decision about their use in teaching is left to the discretion of the teachers. Cox, Cox, and Preston (2000) indicates that many teachers are integrating ICT into Science teaching in a way that motivates pupils and enriches learning or stimulates higher level thinking and reasoning. These teachers tend to be those with an innovative pedagogical outlook. Multimedia for teaching blood circulation can support both the investigative (skills and attitudes) and more knowledge-based aspects (concepts) of biology teaching. To achieve successful integration of multimedia into blood circulation teaching and learning, it must depend on an appropriate pedagogy and clear and concrete curriculum focus which supports and enhances teaching and learning with the use of multimedia in various schools.

2.15 Conclusion

Fenrich (2005) in his study revealed that the media a teacher selects does not determine whether learning will occur. The media simply carries the teacher's information to the learner. For learning to occur, the information must be received and understood by the student. This is usually independent of the media, however, the media one may use can influence the amount of learning that can occur. If teachers combine the media's strengths with instructional methods that take advantage of these strengths, this can positively influence learning. Complete multimedia packages can, but should not necessarily, include all the different media.

On the other hand, some research also revealed that Learning from materials made with more than one medium is usually more effective than material comprised of only one medium. This is partly because different parts of the brain process different information. For example, some parts of the brain process text while other parts process visuals. When multimedia packages activate more regions of the brain, there are increases in learning and retention of information.

In many situations, you may and should use more than one medium to teach the skill however using too many media at one time can impede learning. Although multi-sensory learning experiences tend to be effective, learners can only process a limited amount of information at one time. Media mix decisions should be based on what is being taught, how it is being taught, how it will be tested, and the previously specified target audience characteristics. Different media may be needed for different groups of learning outcomes. For example, video may be appropriate for the attitude component, but video may not provide the corrective feedback necessary for the intellectual skills component. Do not select media simply to dazzle or for convenience.

Using multimedia often means there are more student-centred work and flexible schedules. The teacher's role is often changing from being an authority or the source of knowledge to be a facilitator or a conductor of the learning process. Students have to find their own individual access to the fast-changing world and, therefore, they need a huge pool of appropriate individualised strategies, which enable them to be active and critical learners. The ability to share knowledge collaboratively with others in a world where most products are the result of teamwork having the appropriate strategies and knowing why and how to apply them, will be one of the most important qualifications in lifelong learning.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter covers the research methods employed to gather relevant data for the study. This chapter focuses mainly on the research design, the study area, the study population, sampling design technique, study variables, instrumentation, intervention, reliability of the research instruments, and methods of data collection as well as methods of data analysis.

3.1 Research Design

The research design for this study was the action research design. Sagor (2000) states that, action research focuses on the development, implementation and testing of programme, product, or procedure. Other Researchers emphasised the problem solving focus of action research (Sanders, Lewis, & Thornhill, 2009). Action research has grown in popularity throughout the past two decades (Fleming, 2000).

Calhoun (1994) gives a comprehensive explanation to what action research is. He stated that action research involves teachers identifying a school-based topic or problem to study; collecting and analysing data to solve or understand a teaching problem or helping teachers understand aspects of their practice. Also, according to Ferrance (2000), action research specifically refers to a disciplined inquiry done by a teacher with the intent that the research will inform and change his or her practices in the future. This research is carried out within the context of the teacher's environment – that is, with the students and at the school in which the teacher works – on questions that deal with educational matters (such as the teaching of Integrated Science) at hand. Action research has become a more efficient and accepted tool for teachers to assess their strategies and reflect positively upon their effectiveness.

The choice of action research design for this study was based on the following considerations:

First of all, action research design remedies problems in a specific situation or somewhat improves a given set of circumstances at a single level. Again, action research design serves as a means of in-service training thereby equipping the teacher with new skills and methods, sharpening her analytical skills and heightening self-awareness. Finally, it is a means of providing to the Researcher and teacher, a preferable alternative to the more subjective, impressionistic approach to problem-solving in her own classroom.

Following from these perspectives, the action research design approach was more suitable for this study. The design gave the Researcher a better and in-depth understanding of the extent to which practical approach to the teaching of blood circulatory system in humans and Integrated Science generally can improve the performance of students.

3.2 The Study Area

The study was conducted at the St. Vincent College of Education Yendi, in the Northern region of Ghana. The College is located in the teak grove that is situated to the right upon entering Yendi from Tamale. Yendi is the capital of the Yendi Municipality of the Northern Region of Ghana. The College is the only tertiary education institution in the Yendi Municipality. It offers Bachelor of Education in Primary Education, Junior High School Education, and Early Childhood Education and it is affiliated with the University for Development Studies (UDS), Tamale. It is still a young institution, as it was established only in the year 2016.

3.3 Research Population

A research population is a large well-defined collection of individuals or objects with similar characteristics (Castillo, 2009). The target populations usually have varied characteristics (Gill & Johnson, 2002).

The total target population for this study was 500 students. This comprised all levels 100, 200 and 300 students of St. Vincent College of Education, Yendi. According to the students' data obtained from the College Secretariat, the total number of levels 100, 200 and 300 students at the College for the 2019/2020 academic year was 500.

The accessible population was 60 students. This comprised all level 200 students who belonged to the Science 2A class of the 2019-2020 academic year.

3.4 Sample and Sample Technique

The sampling techniques that were used for the study were the purposive and the census sampling techniques. The purposive sampling technique was used to select the Science 2A class because the Researcher through its prior lessons with the class perceived the class as having attained a considerable level of knowledge in biology, and how the human body functions. Again, the census technique was also used to sample all the members of the Science 2A class.

A sample is a finite part of a statistical population whose attributes are studied to gain information about the larger population (Webster, 1985). A sample offers more detailed information of the research group, and a high degree of accuracy, as it deals with a relatively small number of units (Gravetter & Forzano, 2006; Sarantakos, 1998).

The Researcher used the convenience non-probability sampling for this study. Convenience sampling is a type of non-probability sampling method that involves the sample being drawn from that part of the population that is close to handle. (Gill, Johnson, & Clark, 2010). The Researcher is a tutor at St. Vincent College of Education, Yendi hence this choice would allow the Researcher ample time and convenience as well as easy access to the students for this study.

3.5 Variables for the study

The independent variable in this study was a 4-week intervention instructional strategy, the Multimedia Instructional Method (MMIM) that was administered to an intact Level 200 (Science 2A) class of St. Vincent College of Education, Yendi. The dependent variable was students' performance in terms of scores obtained in a test on the blood circulatory system in humans using Multimedia Instructional Method (MMIM).

3.6 Research Instruments

A research instrument is a device used to collect data to answer the research questions. In this study, three instruments were used to collect data. In this study, the instruments that were used by the Researcher to collect data for the study were conception instrument, achievement tests (pre-test and post-test), and structured self-administered questionnaire.

3.7 Conception Instrument

For identification of the students' misconceptions, a Conception Instrument (**Appendix A**) was administered in the first phase. The instrument contained 13 statements, each of which was an incorrect statement about blood circulatory system in humans. However, the study participants were asked deliberately to indicate which of the statements were correct. Based on the students' responses, remedial materials were designed, developed, and field-tested to assess their effectiveness in correcting the misconceptions. Remedial materials are basically conceptual change texts which address the learning difficulties of students and incorporate suitable learning and instructional strategies. The MMIM model of Instructional Design was used to develop the remedial materials which focused on:

i. correcting wrong notions or ideas of students
ii. providing fine structure of each learning concept

iii. relating one concept to another, and

iv. the historical development of concepts or theories.

3.7.1 Achievement Tests

The achievement tests consisted of pre and post intervention tests. The tests were categorised into two; General Pre-test and Post-test Items (BCHCT and SKBCHT) and Weekly evaluation Test Instruments (TIAs and TIBs). The two (2) general pre-test and post-test items were "Blood Circulation in Humans' Concept Test (BCHCT)" – (Appendix B) and "Students' Knowledge of Blood Circulation in Humans Test (SKBCHT)" – (Appendix C). The three (3) weekly evaluation pre-test were TIA1, TIA2, and TIA3 (Appendices D, E, and F) while the three (3) weekly post-test instruments were TIB1, TIB2, and TIB3 (Appendices G, H, and I). All the tests' items were constructed based on students' responses to the conception instrument.

3.7.2 General Pre-test and Post-test Items (BCHCT and SKBCHT)

The two test instruments; "Blood Circulation in Humans' Concept Test (BCHCT)" – (Appendix B) and "Students' Knowledge of Blood Circulation in Humans Test (SKBCHT)" – (Appendix C), were both developed by the Researcher. The BCHCT and SKBCHT were used as the pre-test and post-test instruments, respectively.

The general pre-test data collecting instrument (BCHCT) was used to ascertain participants' knowledge and their level of difficulty in respect of the concept of the blood circulatory system in humans.

Prior to administering the general pre-test, all 60 participants were given two weeks to revise before the tests. The post-test data collecting instrument (SKBCHT) on the other hand was used to measure students' achievement after implementing the interventions. It was also used to assess the performance of students after they have been taught the blood circulatory system in humans using Multimedia Instructional Method (MMIM) of teaching and learning. Both tests were constructed with reference to the syllabus structure for the teaching of the concept of blood circulatory systems in humans for Level 200 Bachelor of Education programme as designed by the Institute of Education of the University of Cape Coast. All the topics from which the questions were drawn are listed in the Level 200 Bachelor of Education programme syllabus.

The test items tested students understanding of concepts and interpretation participants give to scientific phenomena in blood circulatory system in humans. The BCHCT and SKBCHT tests were both composed of 20 multiple choice questions, numbered as items 1 to 20. Each of the multiple-choice questions in the BCHCT and SKBCHT was followed by four (4) options lettered A to D. The options comprised one correct answer and three plausible distracters from which a student was to select and circle the correct answer. Each correct answer circled or chosen was awarded one mark, resulting in a total score of 20 marks on each test. Both the pre and post-tests lasted for twenty-five (25) minutes. The test items were scored over twenty. Preceding the questions on each test instrument was a portion that asked participants to provide personal data, such as student ID, gender, and a class of participant. This portion also contained general instructions to answering items in the test instruments. The data obtained from the pre and post intervention test was used to answer research question two.

The general post-test items had the same format as the general pre-test items. Marking schemes for both the general pre-test and post-test items are provided in Appendix J.

3.7.3 Weekly Evaluation Test Instruments (TIAs and TIBs)

The syllabus structure for the teaching of the concept of blood circulatory systems in humans for Level 200 Bachelor of Education programme was divided into three subtopics.

1. The structure and functions of the blood circulatory system in humans.

2. The composition and functions of the blood circulatory system in humans.

3. The disorders associated with the blood circulatory system of humans.

For the four-week intervention, the first three weeks were devoted to teaching one of the three subtopics on the concept of the blood circulatory system in humans using the Multimedia Instruction Method (MMIM). The three weekly pre-intervention tests (TIA1, TIA2, and TIA3) and post-intervention tests (TIB1, TIB2, and TIB3) instruments were administered respectively at the commencement and the conclusion of each subtopic throughout the three weeks except during the fourth week which was used for revision of the entire topic, after which the final general post-intervention test instrument (SKBCHT) was administered. While the weekly Test Instruments A (TIA1, TIA2, and TIA3) were administered to the students as the pre-tests at the beginning of each week's lesson, the weekly Test Instruments B (TIB1, TIB2, and TIB3) were administered as the post-tests at the end of each week's lessons. Each lesson lasted two hours each week, twice weekly. Each of three weekly pre-tests (TIA1, TIA2, and TIA3), one for each of the three subtopics (teaching units) had a total of ten (10) multiple-choice questions. Each correct answer circled or chosen was awarded one mark, resulting in a total score of 10 marks on each test.

The tests were used to monitor the progress of the students and identify gaps in them, for teachers to modify instruction to suit learners' needs. Students' growth scores are required to be a factor in evaluating teachers and to hold them accountable for making content knowledge accessible to their students (Mathis, 2012). On the other hand, each of the three (3) delayed weekly post-tests (TIB1, TIB2, and TIB3) had theory-type questions to be answered by the student for a total score of 10 marks, each test was to help assess the student's understanding and progress of each subtopic.

All the six weekly test instruments (TIA1, TIB1, TIA2, TIB2, and TIA3, TIB3) were structured to apply two basic principles: (a) to fully cover the content of each unit, and (b) the questions were of escalating difficulty. Both the pre and post-tests lasted for fifteen (15) minutes. Marking schemes for both the weekly pre-test and post-test items are provided in Appendix K.

3.8 Multimedia Instructional Method (MMIM)-Based Research Questionnaire

A questionnaire is a data collection tool for collecting and recording information about an issue of interest (Wong, 2012). According to Dawson (2002) a questionnaire consists of a set of questions presented to a respondent for answers. The respondents read the questions, interpret what is expected and then write down the answers themselves. It is called an Interview Schedule when the Researcher asks the questions (and if necessary, explains them) and records the respondent's reply on the interview schedule. Because there are many ways to ask questions, the questionnaire is very flexible (ibid, 2002). The questionnaire allows the respondent to give answers to the question raised which facilitate the easy collection of the data. According to (ibid 2002) there are three basic types of questionnaires: closed-ended, open-ended and combination of both.

A designed questionnaire was used to collect data from the students regarding the effectiveness of Multimedia Instructional Method (MMIM) in understanding blood circulatory system in humans (Appendix L). Additionally, the questionnaire sought information about student's perception of the multimedia teaching and learning method and student's preference for the intervention. The questionnaire consists of a list of questions which related to the aims, objectives, and the research questions of the study. The questionnaire was made of two sections; Section A was on the bio-data of the student which consisted of two (2) questions while Section B consisted of twenty (20) five-point Likert-type questions (1 = strongly agree, 2 = agree; 3 = neutral; 4 = disagree and 5 =

strongly disagree) which the student was to choose one option by circling a numerical value allocated to the right of each of the statements as shown in Appendix L. The information obtained was used to answer the research question three. The validated two-sectioned questionnaire instrument was administered to all 60 participants. Preceding the questions on the questionnaire instrument was a portion that briefly stated the purpose of the study and asked participants to provide honest answers and assured participants of utmost confidentiality. Each of the two sections of the questionnaire began with specific instructions regarding how to respond to items in that section.

3.9 Validity of Instruments

According to Golafshani (2003), validity describes whether the means of measurement are accurate and whether they are measuring what they are intended to measure. Nitko (2001) notes that validity is the soundness of the interpretations and uses of student's assessment results. It can also be defined as the appropriateness or correctness of inferences, decisions, or descriptions made about individuals, groups, or institutions from test results. Validity primarily aims at determining whether the instruments measure what they intend to measure (Golafshani, 2003).

To ensure the validity of the data collected for this study, peer reviews were employed. Fellow graduate students at the Department of Science Education, University of Education, Winneba, and two (2) science teachers from a different school were contacted to scrutinise the test items (pre-intervention and post-intervention, questionnaires) for ambiguity, and suggestions were offered for improvement. Further, the Supervisor of the Researcher and two other professors of Science Education were also contacted to establish the validity of the instruments for data collection before the commencement of the observation in the target College of Education. This helped to improve the validity of the instruments.

3.9.1 Pilot Testing

The questionnaire was pre-tested at Bimbilla College of education in the northern region of Ghana. It was selected because it shares similar characteristics with the school selected for the study. The pilot study helped the Researcher to restructure the instruments to help elicit the correct responses from the students.

3.9.2 Reliability of the Instrument

Reliability refers to the consistency and dependability of test results. It is often defined as the degree to which a test is free from errors of measurement (Ebel & Frisbie, 1991). Reliability is often defined as a measure of the degree to which an instrument yields consistent results or data after repeated trials (Mugenda & Mugenda, 1999). In reliability, one seeks to find out how consistent scores obtained are for each individual from one administration of an instrument to another and from items to another. The reliability of the test items was improved by stating the items in a clear and simple language with no ambiguities. These techniques did not solve all reliability problems; hence another technique that was adapted to cross-check the reliability of the measure was the test-retest method. To ensure the reliability of the research instrument, the test items were administered to a group of students outside the research area. The pilot test was carried out on Level 200 students of E.P. College of Education, Bimbilla. The Level 200 students of E.P. College of Education, Bimbilla were used in the study because they had the same characteristics as the actual participants of the study in terms of the learning environment. The pilot study was used by the Researcher to restructure some of the instruments so that they would help elicit the appropriate responses from the students.

The students used for the pilot test did not form part of the sample for the study. Data from the pilot test were statistically analysed to determine the reliability of the test instruments using the Spearman-Brown prophecy formula (Eisinga, Te Grotenhuis, &

Pelzer, 2013) since all items on both the pre-intervention test and post-intervention test were dichotomously scored. The analysis yielded a reliability co-efficient of 0.76 and 0.88 for the pre-intervention test and post-intervention test respectively.

According to Miles and Huberman (1994), if the measurement results are to be used for making a decision about a group or for research purposes, or if an erroneous initial decision can be easily corrected, then the scores with modest reliability co-efficient in the range 0.50 to 0.60 may be acceptable. The reliability co-efficient for the pre-intervention test was 0.76 and that of the post-intervention test was found to be 0.88. This signifies that both test instruments are considered acceptable and reliable. Also, the coefficients agreed with the recommendations of Wiseman (1999) that reliability has to do with the accuracy and precision of a measurement procedure, a high-reliability value of 0.70 or higher shows that the test is reliable (accurately) measuring the characteristic it was designed to measure, therefore, indicating a high level of consistency of the instrument.

3.9.3 Intervention strategy

Level 200 science 2A class of students at the St. Vincent College of Education, Yendi who comprised the sample for the study were taught in topics in the blood circulatory system in humans using Multimedia Instructional Method (MMIM) during a three-week period. The syllabus structure for the teaching of the concept of blood circulatory systems in humans for Level 200 Bachelor of Education programme as designed by the Institute of Education of the University of Cape Coast details three subtopics which include.

1. The structure and functions of the blood circulatory system in humans
2. The composition and functions of the blood circulatory system in humans
3. The disorders associated with blood circulatory system of humans

Two sessions of one hour every week for three weeks were used for teaching the three different subtopics for the entire study. The participants were taught by the Researcher herself who is a tutor of the school. The lessons were divided into divided into three segments, for the three-week lesson period. The group of 60 students of Level 200 participated fully in the six lessons spread over three weeks. Each week comprised two sessions of one-hour duration. As a result, each subtopic on the blood circulatory system in humans was taught during two sessions of one hour each week.

3.9.4 Teaching using the Multimedia Instructional Method (MMIM)

The entire intervention was constituted into two segments, Segment I and Segment II. Segment I comprised the first three weeks of the intervention while Segment II was the fourth week which was dedicated to revision. Each week of the first three weeks (Segment I) was dedicated to the teaching of one of the three subtopics on the blood circulatory system in humans using Multimedia Instructional Method (MMIM) integrated with group work and rich teaching and learning materials (TLMs).

3.9.5 Segment I: MMIM Intervention procedure for Weeks 1, 2, and 3

At the commencement of the study, the general pre-test data collecting instrument; Blood Circulation in Humans' Concept Test" (BCHCT) (Appendix B) was used to assess the participants' knowledge and difficulty with the concept of the blood system in humans in order to establish a baseline (pre-intervention) characteristic and ascertain the academic equivalence of all the students before the implementation of the interventions.

3.9.6.1 Week One of the Intervention

Topic: The structure and functions of the blood circulatory system in humans

The first subtopic, the structure, and functions of the blood circulatory system in humans was taught in the first week using exclusively multimedia instructional method (MMIM). The lesson began with the conduct of the weekly evaluation pre-test (TIA1) (Appendix

D) which covered items on the subtopics for week one (the structure and functions of the blood circulatory system in humans). This class test consisted of 10 multiple-choice questions. From the view of T. W. Smith (1995), the closed ended questions were appropriate for this study since it allowed respondents to choose between options provided by the Researcher. Once the pre-test was completed, the students' responses were collected, marked later, and recorded. After the Week one pre-test (TIA1) was executed, the Researcher gave a brief presentation on the structure and functions of the blood circulatory system in humans (the first subtopic), and then engaged the students through questions and answers that included students' misconceptions on the topic.

Some of these misconceptions frequently expressed by the students were; "Blood is produced in the heart", "There is dirty blood in all veins", "The functions of the heart is to clean blood", "There is clean blood in all arteries", "The heart produces the necessary energy for our body", "The centre of our feelings is the heart", "Arteries in the body are closer to the heart", "There is clean blood in the left part of the body and dirty blood in the right part of the body" This helped students to realise the falsehood of their misconceptions and adhere to the correct conceptions henceforth. In doing so, the Researcher ensured that only plausible and intelligent responses of students were discussed and emphasised to aid memory and learning in a bid to resolve the misconceptions held.

After the short question and answer session on the topic, the Researcher then engaged further the students using interactive learning media, a 3-dimensional video clip that demonstrates what constitutes the structure and functions of the blood circulatory system in humans. The heart, its chambers, arteries, veins, and capillaries, and the link with the lungs, were all captured vividly in the video clip. This video clip was developed by the BodhaGuru team (Youtube, 13th June 2018) titled "How does human blood circulatory system work - 3D animation" (https://www.youtube.com/watch?v=46u2ON6d4mg). You find below a screen shot of the video clip that illustrates what constitutes the structure and functions of the blood circulatory system in humans in **Figure 3.**

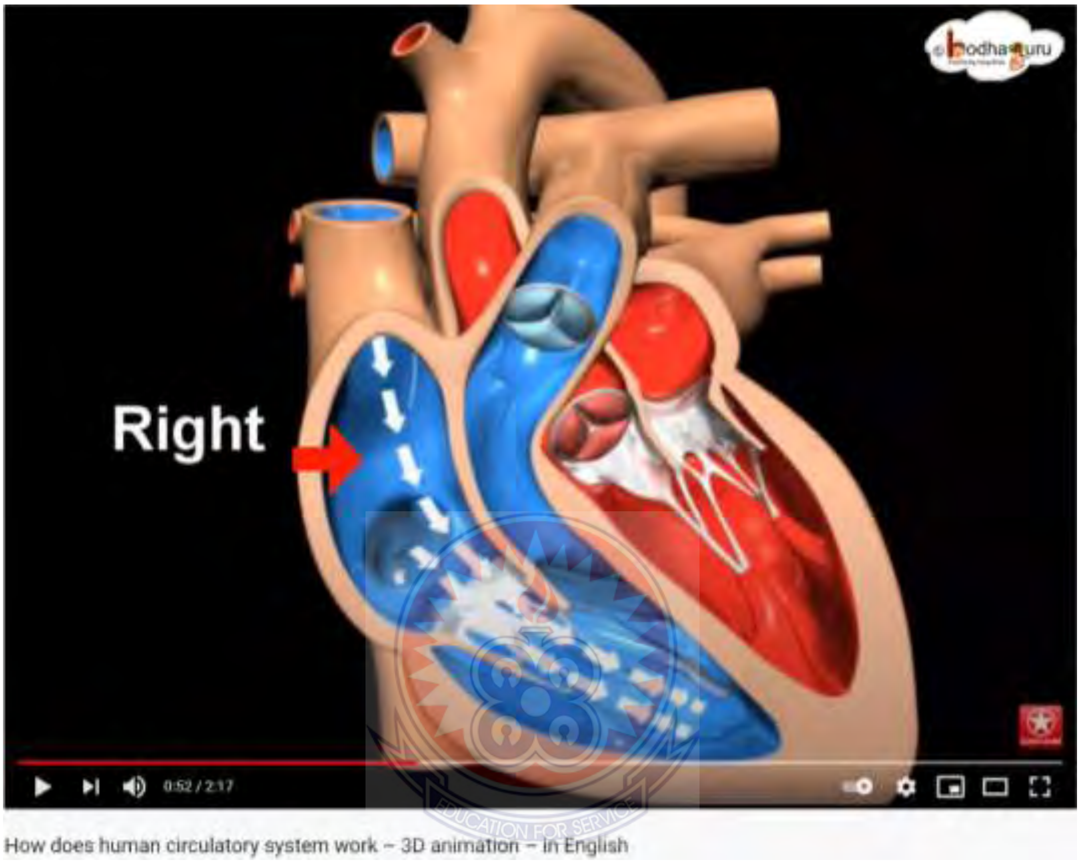


Figure 3: A screen shot of video on what constitutes the structure and functions of the blood circulatory system in humans

Subsequently, after the viewing of the above video clip, and to reinforce what was visualised, the Researcher explained further the various parts of the heart with the use of an elaborate diagram that highlighted mainly *the four separate chambers of the heart*, namely: the two upper chambers; the right atrium and the left atrium (the atria) which receive the blood entering the heart, and the two lower ones (right ventricle and the left ventricle which pump blood out of the heart. This was depicted using **Figure 4** below.

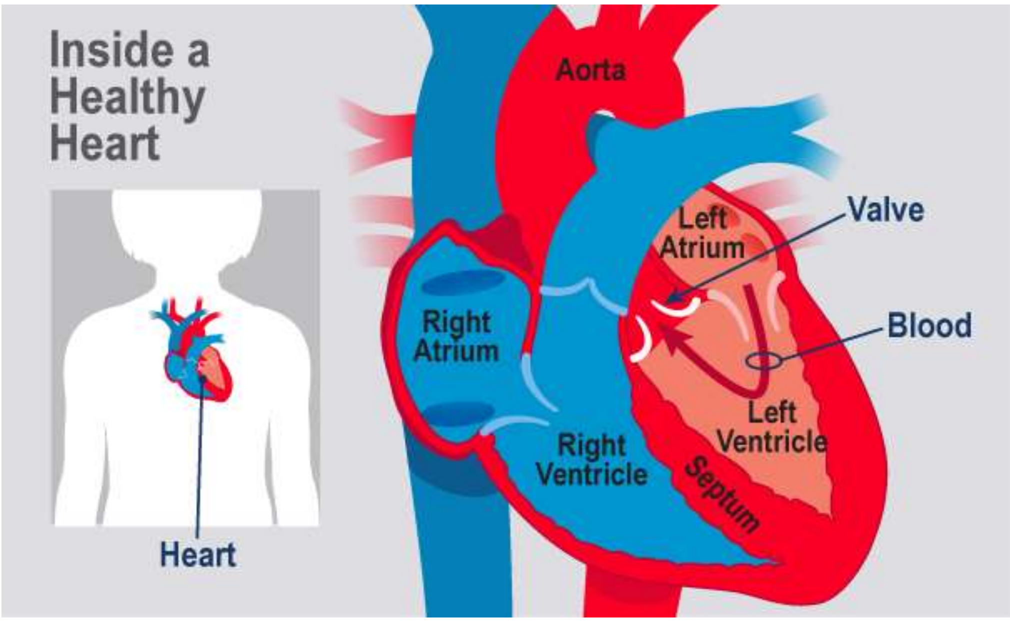


Figure 4 Diagram of the four separate chambers of a healthy heart

The Researcher explained further that the blood circulatory system consists of three independent systems that work together: the heart (cardiovascular), lungs (pulmonary), and arteries, veins, coronary and portal vessels (systemic). The system is responsible for the flow of blood, nutrients, oxygen, and other gases, and as well as hormones to and from cells.

The human heart is an organ that pumps blood throughout the body via the blood circulatory system, supplying oxygen and nutrients to the tissues and removing carbon dioxide and other wastes. An adult heart pumps about 6 quarts (5.7 litres) of blood, which is made up of plasma, red blood cells, white blood cells and platelets throughout the body and beats about 60 to 80 times per minute.

The Researcher through a step-by-step presentation described in details the heart, as the muscular organ with four chambers, located just behind and slightly left of the breastbone, which pumps blood through the network of arteries and veins called the cardiovascular system.

The systemic blood circulation is thus, a major portion of the blood circulatory system in humans. The network of veins, arteries and blood vessels transports oxygenated blood from the heart, delivers oxygen and nutrients to the body's cells and then returns deoxygenated blood back to the heart. Arteries carry oxygen-rich blood from the heart through the body. Veins carry oxygen-poor blood back to the heart.

The superior vena cava carries oxygen-poor blood into the heart. The aorta carries oxygenated blood from the heart to organs and tissues.

Having noticed the difficulty of some students in correctly identifying orally and labelling the various parts and of the human heart and their functions, the Researcher sought to resolve this by using a well labelled diagram on the anatomy and function of the human heart that clearly identified the four chambers, arteries, veins, and so on. The diagram is found below in **Figure 5**.

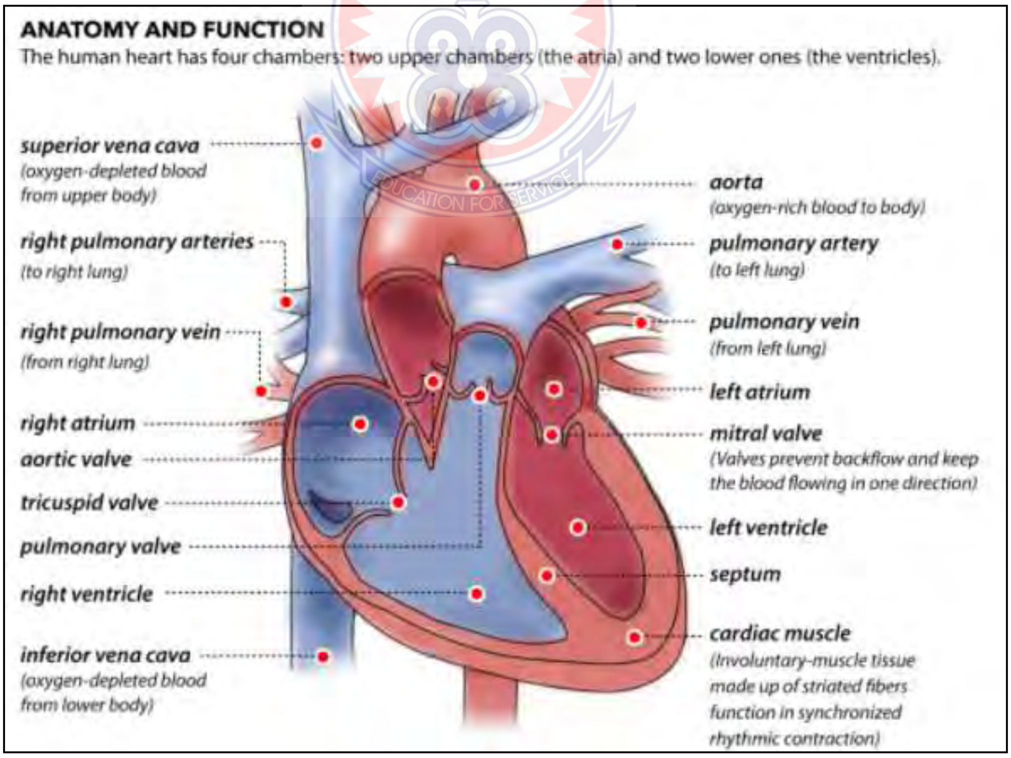


Figure 5 Labelled diagram of the anatomy and function of human heart by infographic artist, Ross Toro of LiveScience, 2019)

To deepen their understanding of the circulatory system in humans, the Researcher further showed animations developed by the *GetSchooledNow* (2013) with the aid of a second video clip on the circulation of blood through a network of blood vessels (https://www.youtube.com/watch?v=_qmNCJxpsr0**)**. This video clip depicted how blood circulates through a network of vessels throughout the body to provide individual cells with oxygen and nutrients and helps dispose of metabolic wastes. A screen shot of the video presentation on the circulation of blood through a network of blood vessels (https://www.youtube.com/watch?v=_qmNCJxpsr0**)** is shown below in **Figure 6.**

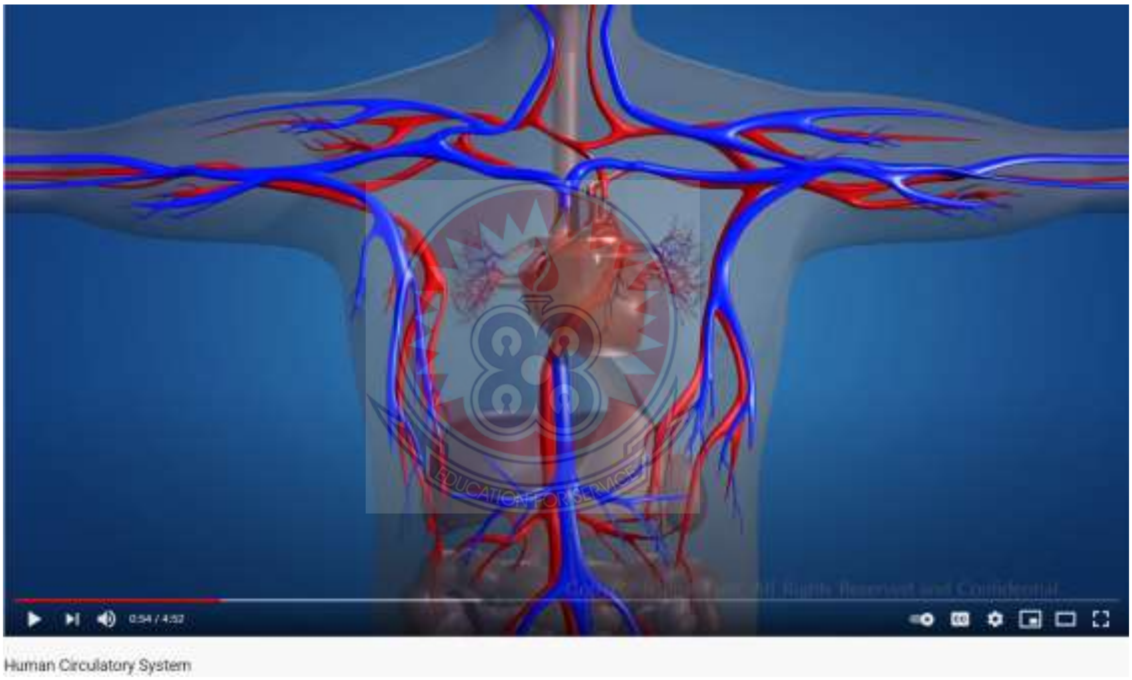


Figure 6 Screen shot of the circulation of blood through a network of blood vessels (GetSchooledNow, 2013)

After students watched the second video clip, the Researcher led the students through questions and answers to ascertain students' understanding of the two video clips each of which explains the same concept with similar words and illustrations. This helped to clarify any lingering students' misconceptions on the topic. All correct answers given by the students were discussed and explained further. The Researcher ensured that students' responses were discussed and emphasised to aid understanding.

All the students were then divided into groups, and each group was composed of six (6) students. Each group was given a copy of the diagram of the human circulatory system that was displayed on the white board, this time without the labelling of the various parts. Students in their groups were to identify by labelling on the diagram they were given, the various parts of the blood circulatory system in humans without referring to any online source, but their notes, taken during the lesson.

After a short period, each group was to pair with another group to discuss in turns their respective answers in order to correct any wrongly labelled part of the diagram of the structure and functions of the blood system in humans. A group leader from the combined group then presents to the entire class their work, and any further corrections were provided by any student in the class after each combined group presented its responses.

The presentations were done in form of sketching on the white board, the heart diagram with the blood vessels that indicate through their colouring, those that are arteries, and those that are veins, and the roles they played respectively.

The Researcher after the group work, and plenary presentations, summarised the lesson in restating that the blood circulatory system or the cardiovascular system consists of the heart, the blood, and the blood vessels. The heart, the organ that pumps the oxygen-rich blood from the lungs through the arteries and pumps out carbon dioxide via the oxygen poor blood vessels called veins to the lungs where the deoxygenated blood is refuelled with oxygen and transported back to the heart, and through the arteries to the entire body. The four valves of the heart and the two atriums (Right and Left) and the two ventricles (Right and Left) played a key role in preventing oxygen-poor blood from passing through the wrong blood vessels and vice versa.

Prior to the administration of the post-test item (TIB1) (Appendix G) at the close of the last lesson on the subtopic, the Researcher gave the opportunity to students to ask any further questions for clarifications or comprehension, and answers were provided by both students and the Researcher. The use of a variety of multimedia through rich TLMs, including the Researcher's own sketches, and the use of diagrams by experts in blood circulatory system, interactive videos and animations helped in enhancing students' active participation in the lessons.

The lesson on the first subtopic on circulation of blood in humans, titled: *the structure and functions of the blood circulatory system in humans* was *co*ncluded with a final video clip which shows a three-dimensional illustration of how the human heart works *with intermittent spoken explanations*

(https://www.pbslearningmedia.org/resource/tdc02.sci.life.stru.circulator/from-the-heart/).

This video was intended to solidify the knowledge gained on the topic in the course of the lesson. Thus, this particular video clip does not only use a 3-dimensional presentation to demonstrate the structure and functions of the human hearts and the blood circulatory system but also, accompanies each stage of the processes with succinct intermittent spoken explanations to enhance students' comprehension. The *intermittent spoken words* enabled students who might have forgotten the names and functions of some of the labelled parts of the circulatory system and their functions, as treated, might have had another opportunity to recall these parts and their functions. Find below **Figure 7** which shows a screen shot of the video on the blood circulatory system of humans with intermittent explanatory spoken words.

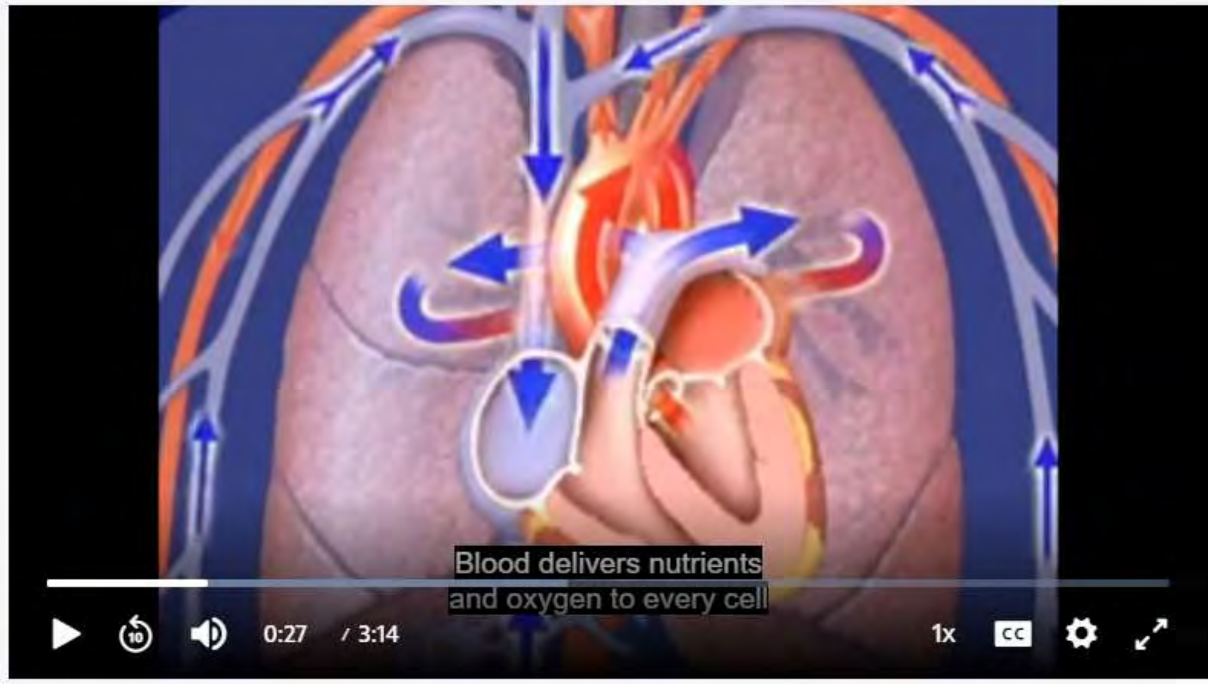


Figure 7 A screen shot of the blood circulatory system of humans with intermittent explanatory spoken words

The Post-test item (TIB1) (Appendix G) was administered soon after the viewing of the last video clip which marked that end of the two lessons on the first subtopic at the end of the first week of the treatment. The first post-intervention test was corrected and recorded accordingly.

3.9.6.2 Week Two of the Intervention

Topic: The composition and functions of the blood circulatory system in humans

The above second subtopic on blood circulatory system in humans was taught in the second week of the intervention. Same procedure used in the first week to teach the first subtopic was followed. Thus, the first lesson on the second subtopic began with the administration of the pre-intervention test (TIA2) (Appendix E) on blood system in humans. Once the test was conducted, collected, and put securely away for correction later, the Researcher introduced the second topic on blood circulation, which is on the composition and functions of the blood circulatory system in humans.

The lesson began with the revision of the various parts of the heart and its blood circulatory system through the display of the illustrated diagram of a dissection of the human heart with its arteries and veins, etc.

Students in turns, were asked to identify to the class any part of the diagram that each can name, and another student would then explain the function of the part mentioned by his or her colleague. In this way, each student was attentive and engaged right from the beginning of the lesson. It was only then that the Researcher explained specifically the topic of the lesson, which was *the composition and functions of the blood circulatory system in humans*. This topic is meant to reiterate and revise what the students might have already learnt when the previous topic; the structure and functions of the blood circulatory system was taught.

An earlier video clip developed by the BodhaGuru team (Youtube, 13th June 2018) titled "How does human blood circulatory system work - 3D animation" (https://www.youtube.com/watch?v=46u2ON6d4mg) which explains *the structure and functions of the blood circulatory system* was found as a useful aid in illustrating and reiterating what the composition of the circulatory system is, and its functions are. Its screen shot was earlier captured in **Figure 3.**

Upon viewing the earlier visualised video clip now for the second time, though in two different lessons, each group of the six already consisted groups discussed and noted five vital things it has learnt from the video clip on the heart and the blood circulatory system and shared with their neighbouring group. While some named the four cardiovascular chambers, and their functions, others stated with conviction what constitute arteries and veins, and their roles.

Further, each of the six groups was given a microscope to view a blood specimen and to note whatever their eyes were able to capture and to share with their group members. This was simply to help sustain students' interest in the lesson. Some had never seen a blood specimen under the microscope.

The lesson continued by the presentation of a heart model that could be opened into two dissections to view the Right atrium, and the Right Ventricle as well as the Left Atrium and the Left Ventricle and the four heart valves with varied colouring depicting oxygen-rich blood, and oxygen-poor blood. Each group was given model to examine and discuss by identifying/naming the parts and elements and their respective functions. This helped students to familiarise with the composition of the human heart and its blood circulatory functions.

The variety of TLMs used in consonance with the multimedia tools and items helped the students to develop great interest in the lesson to the point that many students readily and promptly raised their hands to respond to the questions asked by the Researcher at the close of the lessons. As, most of the responses given were correct the Researcher summarised the lesson by asking in turns one student at a time and randomly to mention one of the constituents of the human blood circulatory system, the roles the heart plays, and the names and functions of the relevant blood vessels involved in the blood circulatory system. Majority of the students' responses were accurate and a great number of them readily responded to questions without any form of coercion.

Once again, at the end of the teaching of the second subtopic using MMIM the post-test instrument B (TIB2) (Appendix H) was administered, the responses were corrected and recorded accordingly.

3.9.6.3 Week Three of the Intervention

Topic: The disorders associated with blood circulatory system of humans

The teaching methodology and procedure varied slightly from the previous format while teaching the first two subtopics, as the third subtopic dealt exclusively with diseases of the heart, and blood circulatory system and not structures and functions of the heart, and the blood circulatory system. Thus, the use of questions and answers, TLMs, and video clips were more dominant as compared to illustrations and diagrams.

The third subtopic the disorders associated with blood circulatory system in humans was taught in the third week of the study to the same group of sixty Level 200 students during two lessons. At the commencement of the lesson, the Researcher conducted the Pre-intervention test using week 3 test TIA3 (Appendix F), collected the responses and kept them securely for later correction and recording.

The Researcher continued the lesson by briefly presenting the subtopic of the day which was the disorders associated with the blood circulatory system Overview of heart disease (*https://www.verywellhealth.com/overview-of-heart-disease-4160961* (Richard N. FOGOROS, June 2020) The Researcher then asked the students to mention at random any disorders or illnesses they could associate with the blood circulatory system in humans. Most of the students mentioned hypertension or high blood pressure, though they could only state one of the causes of this unhealthy heart condition, or heart diseases. The Researcher distributed to the class a diagram as shown in **Figure 8** that indicated different cardiovascular diseases.

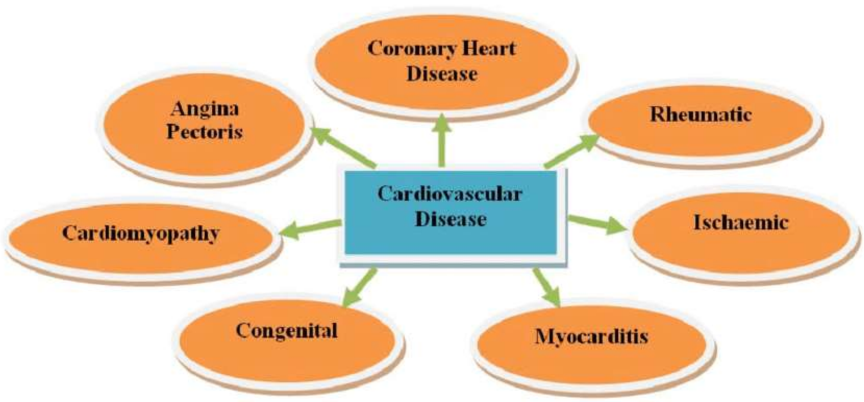


Figure 8 : Types of Heart Diseases (Suseendran G.; January, 2017

The diseases associated with the blood circulatory system in humans were unmatched but labelled haphazardly. After individual study of the distributed diagrams, the students were asked to group into 10 groups and study the diagram, discuss and label correctly by matching which disease is caused by what condition of the blood vessels and/or the heart. The groups were paired to discuss answers together in their combined groups. The combined group leaders presented their responses, and these were discussed thoroughly in the plenary, while the Researcher corrected any incorrect answers.

It is only after the group work that a video clip with graphic details on *disorders of the blood circulatory system in humans*, their causes and preventive remedies (https://www.youtube.com/watch?v=6QaGyW-jkLY, Best Studies, 2018) was visualised and discussed. A screen shot of the video clip on types of blood circulation disorders is captured in **Figure 9** below.

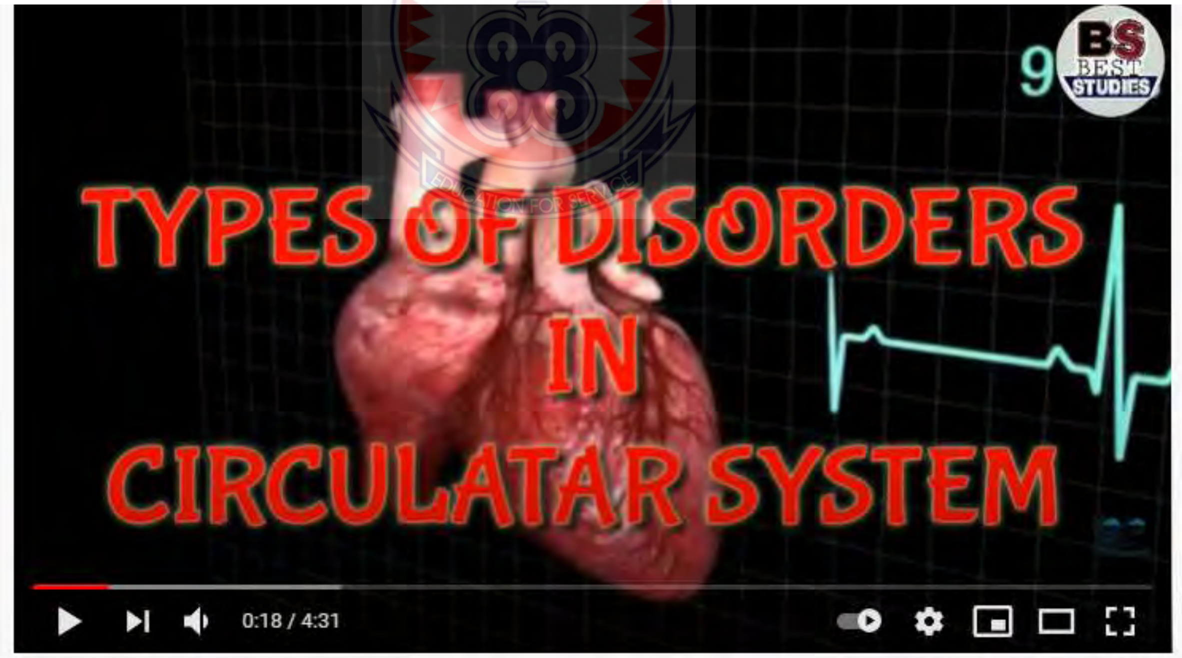


Figure 9: A screen shot of types of blood circulatory disorders (Best Studies, 2018)

Students were asked to list individually any new diseases associated with the blood circulatory system in humans that they failed to mention earlier. Thus, by the end of the lesson students correctly through questions and answers listed hypertension or high blood pressure, coronary artery disease, angina, and heart failure, among others, as disorders associated with the blood circulatory system in humans. Some also identified their causes as blocked arteries, due to too much fatty foods, excessive salt intake, excessive alcohol, lack of physical exercises, and high cholesterols. Thus, the students participated effectively in the lesson that closed with the administration of the Post-test item B (TIB3) (Appendix I). The answers were collected and recorded.

3.9.6.4 Segment II: MMIM Intervention procedure for Week 4

3.9.6.5 The last one week – Week 4 of the study

Lesson Procedure Using MMIM to review the blood circulatory system in humans, with emphasis on each of the three subtopics.

The Segment II represented the last one week, used for the revision and final delayed post-test on all the three subtopics on the blood circulatory system in humans. Thus, the one-week Segment II was the last week of the treatment and used mainly to revise the entire treatment and administer the final overall post-test intervention test instrument; Students' Knowledge of Blood Circulation in Humans Test (SKBCHT) (Appendix C). The Researcher did not administer any pre-test prior to the start of this last lesson which is a revision of all the three subtopics on the blood circulatory system in humans, namely, the structure and functions of the blood circulatory system in humans, the composition, and functions of the blood circulatory system in humans, the disorders associated with blood circulatory system of humans.

The Researcher began the last lesson of the study by writing on the white board the topic under discussion and its three subtopics.

The Researcher then engaged the students through a random question and answer session on each of the subtopics. Some students were asked to sketch the dissection of the heart and some blood vessels on the white board, and others were asked to label any parts or sections of the diagram they could identify. These tasks were executed with fair accuracy. Other students also participated by listing on the white board some of the disorders associated with the blood circulatory system of humans. No other TLM or MMIM tool was used. The Researcher only intervened when an incorrect answer or partial answer was given to any of the questions asked by either students or the Researcher.

The revision lesson ended with the administration of the final overall post-test; Students' Knowledge of Blood Circulation in Humans Test (SKBCHT). The overall post-test was like the other post-tests and composed of 20 multiple choice questions. Each of the 20 multiple choice test items had one correct answer and three distractors which comprised mainly students' misconceptions in explaining the blood circulatory system in humans, its structures and functions, and associated disorders. Students were to answer all questions in the test. The test was scored over 20 marks.

3.10 Data Collection Procedure

The data were collected by the Researcher herself who is a tutor of the school. The research took place in the first semester of the 2019/2020 academic year, specifically from 18th November 2019 to 13th December 2019 (four weeks in total). Two sessions of one hour every week for four weeks were used for the entire study. For the data collection prior permission was sought from the Headteacher of St. Vincent College of Education, Yendi. Data of this study were collected in three stages.

The first stage involved collection of data using a pre-intervention test before the implementation of the interventions. The pre-test was given to all participants prior to the multimedia interventions. This pre-intervention test was marked, and the data was collected. The second stage was the collection of data on the series of normal classroom tests during the intervention period. After the pre-intervention exercise, students were introduced to the intervention weekly tests. Students were made to understand that the weekly tests were to help them learn and improve their understanding of that they were taught in the current term.

The class of 60 participants was taught using the Multimedia Instructional Method (MMIM) the pre-test. For the entire study, the students were taught for a period of four weeks in two sessions of one hour every week. At the beginning and end of each subtopic introduced for the week, topic-based pre-test and post-test were also administered to the students. The tests were marked, and the results were collected to check students' improvement in their performance.

The final stage involved the post-intervention test. At the end of the teaching period, the participants were given a post-test and the data collected were used to test the hypotheses. The test was marked, and the results collected for data analysis. At the end of the study, a questionnaire survey was introduced to all participating students to gather information regarding their understanding of the blood circulatory system in humans using the Multimedia Instructional Method (MMIM) in the science classroom. The questionnaire was administered a day after the post-intervention test.

3.11 Data Analysis

Creswell (2002) expressed that data analysis consist of "taking the data apart" to determine individual response and "putting them together" and to summarise it. Creswell (2002) further stated that analysing and investigating data refers to taking up the response from respondents and drawing final conclusions about it, where conclusions could be clearly seen and explained to any reader, how the conclusions were arrived in words, to provide answers that benefit each research questions raised.

The data collected were examined for consistency and accuracy by reading through all the responses that were provided by the respondents. The Researcher did the raw data entries in order to ensure accuracy of entry of the data. In order to analyse the instructors' implementation of the effectiveness of the multimedia instructional method according to the student views and the relationship; descriptive statistics such as means, standard deviation, frequency, and percentage scores were calculated. Inferences were drawn from the statistically analysed results to answer the research questions.

This study employed both qualitative and quantitative methods of data analysis. Data from the pre-intervention test and the post-intervention test as well as data on questionnaires were analysed quantitatively using SPSS version 17.0 for Windows and Microsoft Excel 2010. An independent sampled t-test was used in analysing the difference in performance of study participants. The t-test enabled the comparison between the performance of the students prior to the intervention and after the intervention. The results from the interview were analysed qualitatively and conclusions made from the response of students in the research.

3.12 Ethical Issues

Ethics refers to the standards and codes of research that the study must put in place. Ethical issues that were considered in this study were the permission to collect data, confidentiality, and the protection of the anonymity of the participants.

3.13 Confidentiality

The participants were assured that all the information obtained would be treated as confidential. That is, the data was only used specifically for the stated purposes and no other person had access to the collected data. The names of students were not needed on the pre-intervention and post-intervention and respondents were informed before they responded to the test items. This was done to avoid biased responses from the participants.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

This chapter deals with the presentation of the data and analysis of the results. The data collected in this study were analysed using percentages, mean, standard deviation, and t-tests. The raw scores of the collected data from students' pre-tests and post-tests were used for the analysis. The presentation, analysis, and discussion of the results were done with respect to the research questions and hypotheses which were postulated for the study. The research questions were tested using a *t*-test of the pre-test mean scores and the post-test mean scores of students taught with the Multimedia Instructional Method (MMIM). The alpha level of 0.05 was used as the acceptable significant level below which an assumption will be statistically significant and above which the assumption will be insignificant.

4.1 Demographic description of study participants

The total number of study participants was 60, out of which 42 were males representing 70.0 % while 18 were females representing 30.0 %. The demographic characteristic of gender is represented in **Table 1** and **Figure 10**.

Table 1: Gender distribution of study participants

Gender	Frequency	Percent
Male	42	70.0
Female	18	30.0
Total	**60**	**100.0**

Source: Field Data, 2021

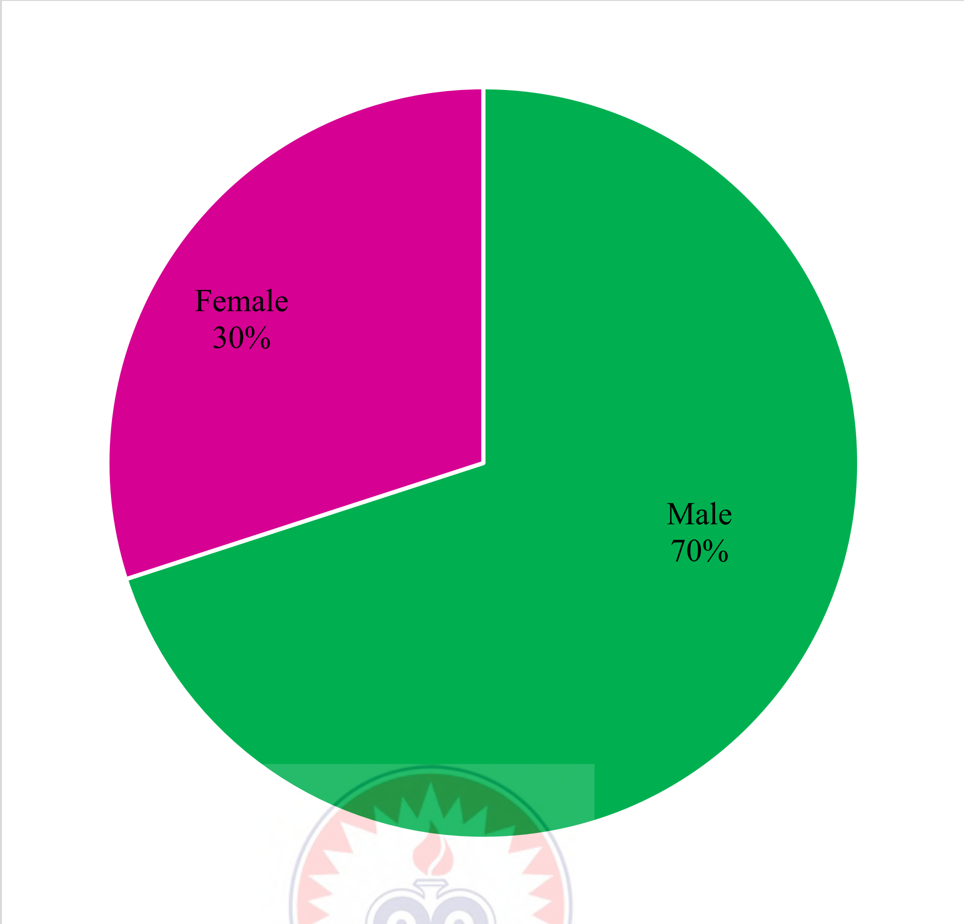


Figure 10: Graphical representations of the gender distribution of study participants

Further, another demographic characteristic that of the age distribution of the 60 study participants was analysed on the basis of four age groupings. The ages of all 60 participants were distributed as follows: 10 participants representing 16.7 % were within the ages of 14 – 15 years, 17 participants representing 28.3 % were within the age group of 16 – 17 years, while 23 participants representing 38.3 % were within the groups of 18 – 19 years, and 10 participants (16.7 %) were 20 years and beyond. The age distribution of all respondents and their percentages are represented in **Table 2** and **Figure 11**.

Table 2: Age group distribution of study participants

Age group	Frequency	Percent
14 - 15 years	10	16.7
16 - 17 years	17	28.3
18 - 19 years	23	38.3
20 + years	10	16.7
Total	**60**	**100.0**

Source: Field Data, 2021

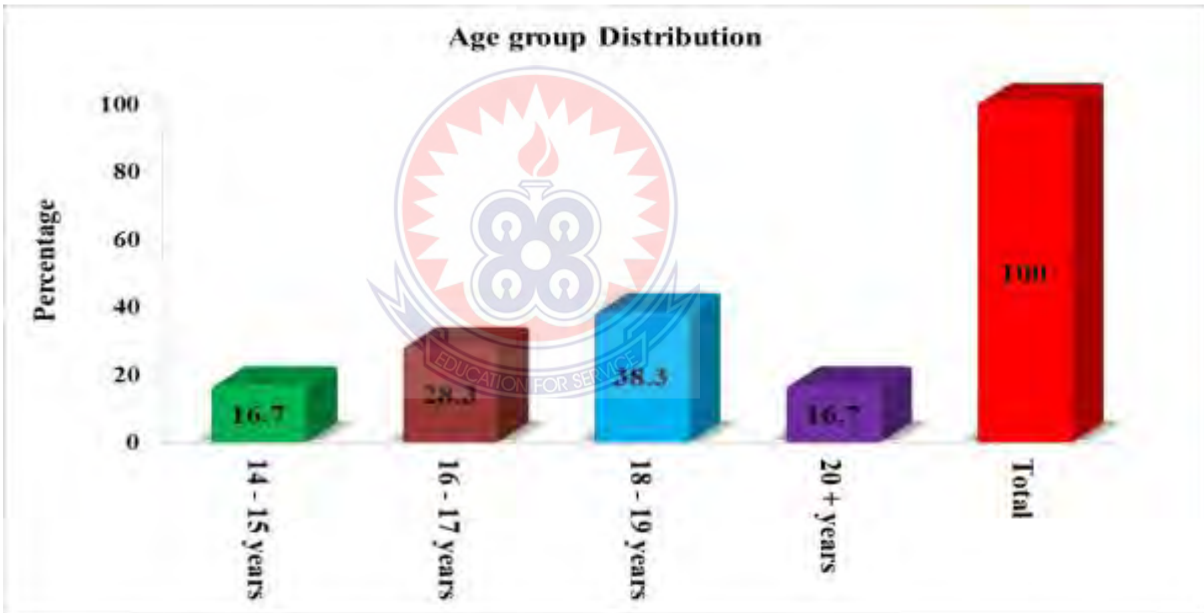


Figure 11: Graphical representations of the age group distribution of study participants

4.2 Research Question 1

What are the misconceptions of students about the blood circulatory system in humans?

4.2.1 Study participants' misconceptions about blood circulatory system in humans

Students' conceptual understanding on the structure, composition, functions, and disorders associated with blood circulatory system in humans were assessed using the conceptions instrument (**Appendix A**) which was designed by the Researcher at the beginning of the study. The instrument contained 13 statements, each of which were incorrect statements about blood circulatory system in humans. However, the study participants were asked deliberately to indicate which of the incorrect statements were correct. Thus, the students' indication of some of *these incorrect statements* as correct was an indication that they held real incorrect notions or misconceptions about blood circulatory system in humans. The responses of students are summarised in **Table 3** and graphically represented in **Figure 12**.

Table 3: Participants' misconceptions about the blood circulatory system in humans before the implementation of MMIM intervention

	Statements	Correct N (%)	Not Correct N (%)
1	The heart is an organ actively responsible for blood formation.	57 (95.0)	3 (5.0)
2	The function of the heart is to clean blood (convert impure blood into pure blood).	50 (83.3)	10 (16.7)
3	The heart is the centre where our emotions and feelings are stored.	49 (81.7)	11 (18.3)
4	All veins contain dirty blood.	52 (86.7)	8 (13.3)
5	All arteries contain clean blood.	53 (88.3)	7 (11.7)
6	The heart produces the necessary energy for the body.	51 (85.0)	9 (15.0)
7	Arteries are closer to the heart in the body.	54 (90.0)	6 (10.0)
8	Systemic circulation is much more important in function than pulmonary circulation.	55 (91.7)	5 (8.3)
9	Systemic and pulmonary circulations are independent from each other, and they take place in different parts of the body.	50 (83.3)	10 (16.7)
10	The function of pulmonary circulation is to help systemic circulation.	38 (63.3)	22 (36.7)
11	Pulmonary circulation takes place in the upper part of	53 (88.3)	7 (11.7)

	the body while systemic circulation takes place in the lower part of the body.		
12	Clean blood circulates in the left side of the body while dirty blood circulates in the right side of the body.	52 (86.7)	8 (13.3)
13	Heart disease is a man's disease	39 (65.0)	21 (35.0)

Source: Field Data, 2021

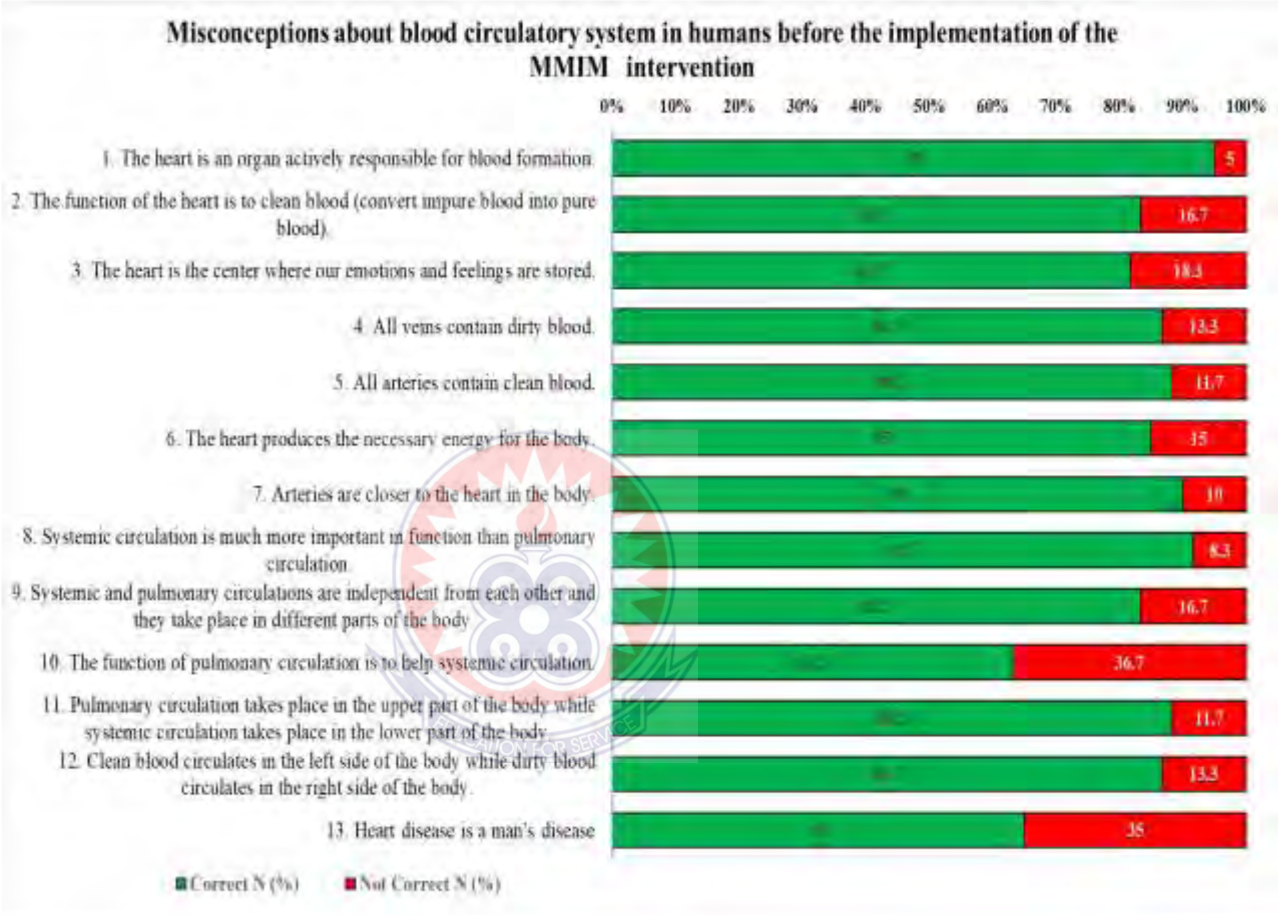


Figure 12: Graphical representations of participants' misconceptions about the blood circulatory system in humans before the implementation of MMIM intervention

4.2.2 Study participants' conceptions about blood circulatory system in humans after the implementation of the MMIM intervention

The results of the pre-and post-intervention tests analysed together with the Multimedia Instructional Method (MMIM)-based research questionnaire data show that MMIM teaching intervention had a more positive impact on students' performance which was directly influenced by improved students' conceptual understanding of the blood circulatory system in humans. However, in order to attribute the reported gain primarily to the MMIM-based instruction, students' conceptual understanding on the structure, composition, functions, and disorders associated with blood circulatory system in humans was again solicited at the end of the MMIM intervention study using the Conceptions instrument (Appendix A) which was used to assess the misconceptions of students, prior to the MMIM intervention. The results on student conceptual understanding after the MMIM teaching intervention are summarised in **Table 4** and **Figure 13**.

Table 4: Results of participants' misconceptions about blood circulatory system in humans after the implementation of the MMIM intervention

	Statements	Correct N (%)	Not Correct N (%)
1	The heart is an organ actively responsible for blood formation.	0 (0.0)	60 (100.0)
2	The function of the heart is to clean blood (convert impure blood into pure blood).	5 (8.3)	55 (91.7)
3	The heart is the centre where our emotions and feelings are stored.	3 (5.0)	57 (95.0)
4	All veins contain dirty blood.	1 (1.7)	59 (98.3)
5	All arteries contain clean blood.	0 (0.0)	60 (100.0)
6	The heart produces the necessary energy for the body.	0 (0.0)	60 (100.0)
7	Arteries are closer to the heart in the body.	6 (10.0)	54 (90.0)
8	Systemic circulation is much more important in function than pulmonary circulation.	2 (3.3)	58 (96.7)
9	Systemic and pulmonary circulations are independent from each other, and they take place in different parts of the body.	10 (16.7)	50 (83.3)
10	The function of pulmonary circulation is to help systemic circulation.	1 (1.7)	59 (98.3)
11	Pulmonary circulation takes place in the upper part of the body while systemic circulation takes place in the lower part of the body.	11 (18.3)	49 (81.7)
12	Clean blood circulates in the left side of the body while dirty blood circulates in the right side of the body.	5 (8.3)	55 (91.7)
13	Heart disease is a man's disease	0 (0.0)	60 (100.0)

Source: Field Data, 2021

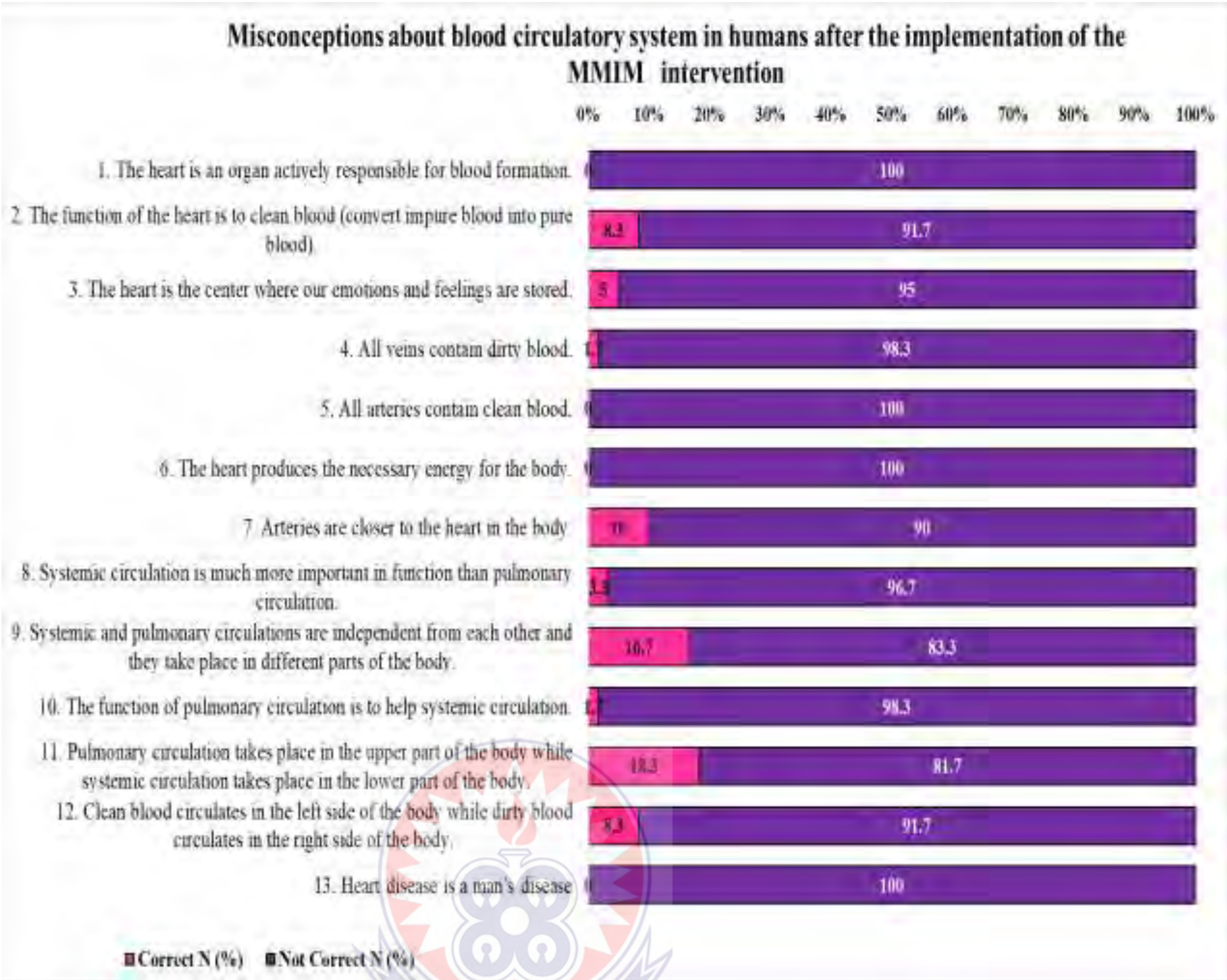


Figure 13: Graphical representations of participants' misconceptions about the blood circulatory system in humans after the implementation of the MMIM intervention

In order to ascertain further the *students' conceptual understanding* that is their ability to clearly identify correctly and explain the functions associated with each of three subtopics on blood circulatory system in humans after the MMIM intervention, the Researcher administered a short essay-type post intervention questions whose responses are represented in **Table 5.**

Table 5: Summary of Students' conceptual understanding of blood circulatory system in humans after the intervention based on responses to short essay-type questions in Appendix M

No.	Statements of students' initial misconceptions in blood circulatory system in humans	Summary of students' statements or conceptions in blood circulatory system in humans after intervention in

	before intervention	response to questions in Appendix M
1	The heart is an organ actively responsible for blood formation.	It's the organ at the centre of the blood circulation system in humans, pumping blood around the body as it beats.
2	The function of the heart is to clean blood (convert impure blood into pure blood).	The function of the heart is to send oxygen and nutrients via blood to all parts of the body and carries away unwanted carbon dioxide and waste products.
3	The heart is the centre where our emotions and feelings are stored.	The heart is the muscle at the centre of the blood circulation system in humans
4	All veins contain dirty blood.	No, as the veins though take oxygen-poor blood (*dirty blood*) back to the heart they as well carry oxygen-rich blood away from the heart to all of the body's tissues
5	All arteries contain clean blood.	Most arteries take oxygenated blood (pure/clean blood) away from the heart to fuel the tissues throughout the body except the pulmonary artery, which carries deoxygenated blood back to the heart from the lungs
6	The heart produces the necessary energy for the body.	No, not the heart but carbohydrates (dietary) are the main energy source of the human body. The metabolic disposal of dietary carbohydrates is direct oxidation in various tissues
7	Arteries are closer to the heart in the body.	Not all. Only elastic arteries (aorta and pulmonary arteries) are closest to the heart but not the muscular arteries
8	Systemic circulation is much more important in function than pulmonary circulation.	Both systemic circulation and pulmonary circulation are important
9	Systemic and pulmonary circulations are independent from each other, and they take place in different parts of the body.	No, both are parts of the same blood circulation process: the systemic circulation is the circuit through the rest of the body to provide oxygenated blood, while the pulmonary circulation, is the circuit through the lungs where blood is oxygenated.
10	The function of pulmonary circulation is to help systemic	The functions of pulmonary circulation and systemic circulation are mutual.

	circulation.	
11	Pulmonary circulation takes place in the upper part of the body while systemic circulation takes place in the lower part of the body.	Both are located in the same parts of the body
12	Clean blood circulates in the left side of the body while dirty blood circulates in the right side of the body.	This is false as clean or oxygenated blood circulates throughout the body just like the less clean or deoxygenated blood does
13	Heart disease is a man's disease	False, as any mammal including human beings have heart disease

Source: Field Data, 2021

From the responses above, it was clear that students' perception of the blood circulatory system in humans had greatly improved, and this could be attributed to the MMIM teaching intervention that was employed as indicated in **Table 5**.

It is still worth stating, as earlier indicated (**Tables 3** and **4)** that between 49 (81.7%) and 60 (100%) participants of the study (**Table 4)** indicated that all the 13 incorrect statements about the blood circulatory system were incorrect statements after the MMIM intervention. Whereas, only 3 to 22 (5% to 36.7%) of the study participants **(Table 3)** at the beginning of the study indicated correctly that the statements were incorrect. These results indicate and confirm that the MMIM-based teaching approach had a high positive impact on students' conceptual understanding of the structure, composition, functions, and disorders associated with blood circulatory system in humans. The MMIM helped study in various ways: helped the participants to become aware of their knowledge deficiencies in the topic of blood circulatory system in humans, helped them to address their misconceptions related to the topic, helped them to develop a better understanding of the topic and helped them to become more confident in their knowledge of the blood circulatory system in humans.

4.3 Research Question 2

What effect does the use of the Multimedia Instructional Method in teaching has on enhancing students' conceptual understanding and academic performance in the blood circulatory system in humans?

This research sought to establish whether the teaching intervention, the Multimedia Instructional Method (MMIM) would yield any significant effect on the conceptual understanding and academic performance of the sampled students that participated in the study. To answer the above research question, a hypothesis was formulated to evaluate the effect of multimedia on enhancing students' performance in blood circulatory system in humans. The hypothesis states that "***there is no significant difference in the conceptual understanding and academic performance of students exposed to multimedia teaching approach***".

4.3 Analysis of test results for the research question formulated

The study administered a series of data collection tests, including the **general pre-test,** at the commencement of the Intervention, named "**Blood Circulation in Humans Concept Test"** (BCHCT). The **general post-test** at the conclusion of the intervention, named "**Students Knowledge of Blood Circulation in Humans Test" (SKBCHT).**

In addition to the general pre-test, three different pre-tests *(test instruments)* tailored to each of the three sub-topics of blood circulatory system in humans named respectively as; TIA1 for week one, TIA2 for week two and TIA3 for week three, were administered at the beginning of each week's lessons. Thus, **TIA1** was used at the commencement of week one lessons on the subtopic: ***the structure and functions of the blood circulatory system in humans*****. TIA2** was administered at the start of the second week lessons on the subtopic: ***the composition and functions of the blood circulatory system in humans***, and **TIA3** was also administered at the commencement of the lessons in the third week of the intervention on the third subtopic***: the disorders associated with blood circulatory system in humans.*** Correspondingly, the specific three post-tests namely, **TIB1, TIB2**, and **TIB3** were each administered at the end of each of the three lessons on the respective three subtopics of blood circulatory system in humans.

Consequently, the Science 2A class of 60 participants was administered pre-test instruments (BCHCT, TIA1, TIA2 and TIA3) and post-intervention instruments (SKBCHT, TIB1, TIB2, and TIB3). These achievement tests were prepared to study the effect of MMIM teaching strategy on enhancing students' performance and, its impact in correcting students' earlier misconceptions about the blood circulatory system in humans. The mean pre-tests and post-tests of participants in the study group were compared to understand students' progress between pre-test and post-test.

Table 6 shows the comparison of the mean pre-test and post-test scores of the study participants (N = 60). The Table gives the means, mean differences, the *t*-values, and the two-tailed significance at 0.05.

Table 6: Comparison of pre-tests and post-tests of all participants in the study

Test Intervention	N	Mean	Std. Deviation	t-values	df	Sig. (2-tailed)
Pre-test (TIA1)	60	5.62	1.678	25.923	59	.000
Post-test (TIB1)	60	7.73	1.483	40.396	59	.000
Pre-test (TIA2)	60	5.05	1.817	21.525	59	.000
Post-test (TIB2)	60	7.08	1.759	31.190	59	.000
Pre-test (TIA3)	60	5.62	2.171	20.036	59	.000
Post-test (TIB3)	60	7.47	1.827	31.657	59	.000
Pre-test (BCHCT)	60	9.43	3.500	20.877	59	.000
Post-test (SKBCHT)	60	16.05	2.890	43.015	59	.000

Note. *p<0.05 significance (α = 0.05)

Source: Field Data, 2021

The pre-test instruments were TIA1, TIA2, TIA3, and BCHCT whereas the post-test instruments were TIB1, TIB2, TIB3, and SKBCHT for weeks 1, 2, 3, and overall tests, respectively. The means in the post-test scores calculated to be TIB1 ($\bar{x}$ =7.73), TIB2 ($\bar{x}$ =7.08), TIB3 ($\bar{x}$ =7.47), and SKBCHT ($\bar{x}$ =16.05) were found to be higher than the pre-intervention means test scores TIA1 ($\bar{x}$ =5.62), TIA2 ($\bar{x}$ =5.05), TIA3 ($\bar{x}$ =5.62), and BCHCT ($\bar{x}$ =9.43), as depicted in **Table 6**. The means for all four post-intervention test scores among all 60 participants were greater than the pre-intervention test means in all instances.

To verify the difference in the conceptual understanding and academic performance in the pre-test and post-test scores among participants, the actual t-test within the group of 60 participants was computed and captured as well, in **Table 6** above. Thus, **Table 6** shows also the calculated *t*-values for all pre-tests and post-tests TIA1 (*t*-value = 25.923, df = 59, *p*-value < 0.001), TIB1 (*t*-value = 40.396, df = 59, *p*-value < 0.001), TIA2 (*t*-value = 21.525, df = 59, *p*-value < 0.001), TIB2 (*t*-value = 31.190, df = 59, *p*-value < 0.001), TIA3 (*t*-value = 20.036, df = 59, *p*-value < 0.001), TIB3 (*t*-value = 31.657, df = 59, *p*-value < 0.001), BCHCT (*t*-value = 20.877, df = 59, *p*-value < 0.001), and SKBCHT (*t*-value = 43.015, df = 59, *p*-value < 0.001). In all instances, the calculated *t*-values were greater than the table *t*-value (*t*-value =2.00) for 59 degrees of freedom at 0.05 level of significance (α = 0.05) for this study. This means that meaningful differences were found between the pre-test scores and post-test scores among all 60 participants. Hence, the null hypothesis is rejected, and an alternative hypothesis that there is a significant difference in the mean pre-tests and mean post-tests performance among all participants in the lessons on the blood circulatory system in humans was formulated.

This shows that there was an enhanced students' performance after the interventions. Consequently, students' performance can be attributed to the effect of the intervention which prioritised the use of multimedia in teaching the concept of blood circulatory system in humans. Thus, it can be concluded that the enhanced students' performance in blood circulatory system in humans is attributable to the impact of the multimedia intervention.

Further, the gain scores between pre-tests and post-tests of students' performances in the blood circulatory system in humans among the 60 participants were obtained by subtracting pre-test scores from post-test scores. The data is presented in **Table 7**. The calculated mean differences for week 1 (TIB1-TIA1), week 2 (TIB2-TIA2), week 3 (TIB3-TIA3), and the final overall test scores (SKBCHT- BCHCT) were 2.12, 2.03, 1.85, and 6.62, respectively. The positive mean gains are an indication that the use of the Multimedia Instructional Method (MMIM) in teaching blood circulatory system in humans enhances and improves students' understanding and academic performance.

Table 7: Differences in Mean gain scores in pre-and post-test in Week 1, 2, 3, and overall interventions

Test Difference	N	Mean	Std. Deviation	t-value	Df	Sig. (2-tailed)
Week 1 (TIB1 – TIA1)	60	2.12	2.233	7.343	59	.000
Week 2 (TIB2 – TIA2)	60	2.03	2.343	6.722	59	.000
Week 3 (TIB3 – TIA3)	60	1.85	2.254	6.359	59	.000
Overall (SKBCHT – BCHCT)	60	6.62	4.787	10.706	59	.000

Note. *$p<0.05$ significance ($\alpha = 0.05$)

Source: Field Data, 2021

From **Table 7** it is also established that there were statistically significant mean changes in all the test items. For week 1, the *t*-value was calculated to be 7.343 which is greater than the *t*-value of 2.00 for 59 degrees of freedom at a 0.05 level of significance. Also, the calculated *p*-value was less than 0.001 which is statistically significant at a 0.05 level of significance, so there exists a significant difference between the week 1 pre-test (TIA1) and post-test (TIB1) scores of performances. For week 2, the mean gain between TIA2 and TIB2 was calculated to be 2.03 (*t*-value = 6.722, *p*-value < 0.001). The mean gain between week 3 pre-test (TIA3) and post-test (TIB3) was 1.85 (*t*-value = 6.359, *p*-value < 0.001). For the overall pre-test and post-test, the mean gain between BCHCT and SKBCHT was 6.62 (*t*-value = 10.706, *p*-value < 0.001).

In all instances, the *t*-values are greater than the table *t*-value of 2.00 for 59 degrees of freedom at 0.05 level of significance. There exists a significant difference between pre-test and post-test with respect to the performance of the students in tests. These results imply that the Multimedia Instructional Method (MMIM) of teaching had a positive impact on students' performance of the blood circulatory system in humans.

4.4 Research Question 3

What perceived impact does the use of Multimedia Instructional Method (MMIM) of teaching have on students' interest in the blood circulatory system in humans?

4.5 Analysis of students' responses on the impact of the MMIM through the use of the Likert-scale questionnaire

In order to ascertain the impact of learning through the use of the Multimedia Instructional Method (MMIM) the Researcher not only taught the 60 participants using primarily the MMIM of teaching blood circulatory system in humans but also, solicited information from students about their perceptions of the effectiveness of the multimedia approach on their learning through a Likert-scale questionnaire (see **Appendix I**).

The post-intervention reflection questionnaire consisted of a bio-data section and 20 items on a five-point Likert scale (strongly agree, agree, neutral, disagree, strongly disagree). It was designed by the Researcher to elicit how the multimedia teaching approach might have helped the participants in a variety of ways and to measure the perceived impact of the MMIM on their learning of the concept of blood circulatory system in humans.

Qualitative descriptive analysis was performed for the Likert scale statements. While **Table 8** below reports the questions and a summary of the responses provided by all 60 participants, **Figure 16** displays a graphical representation of the same summary of the responses to the Likert scale questionnaire. Table 8 and Figure 16 equally capture the response frequency about the effectiveness of the multimedia instructional method (MMIM) in understanding the blood circulatory system in humans among student respondents.

All 60 participants who were taught using the multimedia approach responded to the Likert-scale questionnaire. Of the 60 participants 98.3 percent of the class either strongly agreed (50.0 %) or agreed (48.3 %), while 1.7 % were neutral to the statement that "the multimedia approach to teaching was clear and enjoyable".

On the statement of whether "the multimedia approach explains blood circulatory system in humans better", 53.3 % of the respondents strongly agreed, 43.3 % agreed, and 3.3 % were neutral. No student either disagreed or strongly disagreed with this statement. 55.0 % of students strongly agreed that their "interest in the blood circulatory system in humans increased with the use of multimedia" whereas 41.7 % of respondents agreed and 3.3 % were neutral to the same statement. All respondents (100.0 %) stated that they either agreed or strongly agreed to the statement that "the multimedia approach of teaching and learning the blood system in humans was interesting".

Over 90 percent of the responses either strongly agreed or agreed to the following statements "the multimedia approach actively involved me in what I was learning", "the multimedia approach improved my understanding of the blood system in humans", "the multimedia approach motivates me to learn about the blood circulatory system in humans", and "I learned a lot from the multimedia method of teaching and learning". When asked these two questions, if the "the multimedia approach was a waste of time" and if they "learn better when teachers teach without multimedia", 96.7 % and 95.0 % of the respondents either disagreed or strongly disagreed with each of two statements respectively, while 3.3 % of the respondents each were neutral for both statements. 1.7 % strongly agreed that they learn better when teachers teach without multimedia.

Out of the 60 respondents who were administered with the questionnaire, as many as 41 representing 68.3 % strongly agreed with the statement that "the multimedia approach was helpful to them because they are visual learners", while 17 (28.3 %) agreed and the remaining 3.3 % of respondents were neutral. All respondents either strongly agreed (63.3 %) or agreed (36.7 %) that they would prefer the multimedia method again and would prefer it if was available for all other integrated science lessons.

Four statements in the questionnaire were meant to assess the respondents' opinion of the instructor's approach and effectiveness of the multimedia Instructional Method (MMIM). The statements were "the multimedia instruction method was more useful compared to other ways of instruction", "the instructor was able to make multimedia presentations clear and understandable", "the instructor used examples or illustrations to clarify the topic", and "the instructor was willing to listen to students' questions and opinions". The respondents' responses were either "strongly agreed" or "agreed" to these respective statements.

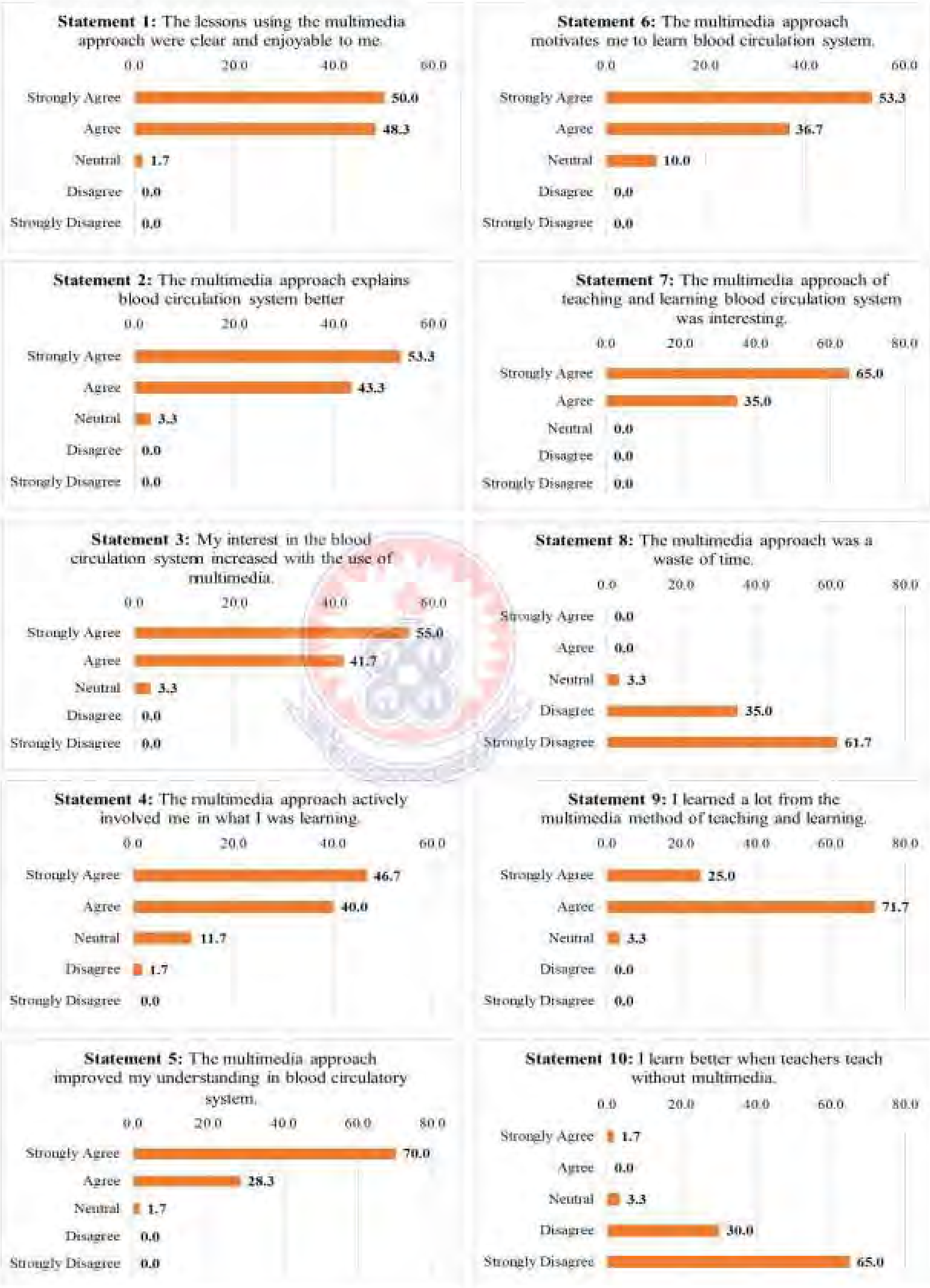
Further, the respondents were asked if "there was the clarity of test questions", the following responses were obtained: strongly agree (43.3 %), agree (55.0 %) and the remaining 1.7 % were neutral. Also, to the statement "the test covered all important aspects of the blood circulatory system in humans", 50.0 % indicated strongly agreed, 46.7 % stated agreed while the neutral responses were 3.3 %. Lastly, 88.4 % of respondents either strongly agreed (36.7 %) or agreed (51.7) with the statement "the assignments were helpful in understanding course material" while 10.0 % of the respondents were neutrals and 1.7 % of them were in total disagreement with the statement.

Table 8: Results of students' responses to Likert scale-statements

No.	Statements	Strongly Agree N (%)	Agree N (%)	Neutral N (%)	Disagree N (%)	Strongly Disagree N (%)
1	The lessons using the multimedia approach were clear and enjoyable to me.	30 (50.0)	29 (48.3)	1 (1.7)	0 (0.0)	0 (0.0)
2	The multimedia approach explains blood circulatory system in humans better	32 (53.3)	26 (43.3)	2 (3.3)	0 (0.0)	0 (0.0)
3	My interest in the blood circulatory system in humans increased with the use of multimedia	33 (55.0)	25 (41.7)	2 (3.3)	0 (0.0)	0 (0.0)
4	The multimedia approach actively involved me in what I was learning	28 (46.7)	24 (40.0)	7 (11.7)	1 (1.7)	0 (0.0)
5	The multimedia approach improved my understanding in blood circulatory system in humans	42 (70.0)	17 (28.3)	1 (1.7)	0 (0.0)	0 (0.0)
6	The multimedia approach motivates me to learn blood the system in humans	32 (53.3)	22 (36.7)	6 (10.0)	0 (0.0)	0 (0.0)
7	The multimedia approach of teaching and learning	39 (65.0)	21 (35.0)	0 (0.0)	0 (0.0)	0 (0.0)

	the blood circulatory system in humans was interesting.					
8	The multimedia approach was a waste of time.	0 (0.0)	0 (0.0)	2 (3.3)	21 (35.0)	37 (61.7)
9	I learned a lot from the multimedia method of teaching and learning.	15 (25.0)	43 (71.7)	2 (3.3)	0 (0.0)	0 (0.0)
10	I learn better when teachers teach without multimedia	1 (1.7)	0 (0.0)	2 (3.3)	18 (30.0)	39 (65.0)
11	The multimedia approach was helpful to me because I am a visual learner.	41 (68.3)	17 (28.3)	2 (3.3)	0 (0.0)	0 (0.0)
12	The use of multimedia reduces forgetfulness in examination	25 (41.7)	16 (26.7)	15 (25.0)	4 (6.7)	0 (0.0)
13	I would prefer the multimedia method again, if available for all integrated science lessons.	38 (63.3)	22 (36.7)	0 (0.0)	0 (0.0)	0 (0.0)
14	The multimedia instruction method was more useful compared to other ways of instruction	38 (63.3)	22 (36.7)	0 (0.0)	0 (0.0)	0 (0.0)
15	The instructor was able to make multimedia presentations clear and understandable	30 (50.0)	27 (45.0)	3 (5.0)	0 (0.0)	0 (0.0)
16	The instructor used examples or illustrations to clarify the topic	23 (38.3)	36 (60.0)	1 (1.7)	0 (0.0)	0 (0.0)
17	The instructor was willing to listen to students' questions and opinions	36 (60.0)	22 (36.7)	2 (3.3)	0 (0.0)	0 (0.0)
18	There was clarity of test questions	26 (43.3)	33 (55.0)	1 (1.7)	0 (0.0)	0 (0.0)
19	The test covered all important aspects of the blood circulatory system in humans	30 (50.0)	28 (46.7)	2 (3.3)	0 (0.0)	0 (0.0)
20	The assignments were helpful in understanding course material	22 (36.7)	31 (51.7)	6 (10.0)	1 (1.7)	0 (0.0)

Source: Field Data, 2021


Statement 1: The lessons using the multimedia approach were clear and enjoyable to me.
0.0 20.0 40.0 60.0
Strongly Agree 50.0
Agree 48.3
Neutral 1.7
Disagree 0.0
Strongly Disagree 0.0
Statement 6: The multimedia approach motivates me to learn blood circulation system.
0.0 20.0 40.0 60.0
Strongly Agree 53.3
Agree 36.7
Neutral 10.0
Disagree 0.0
Strongly Disagree 0.0
Statement 2: The multimedia approach explains blood circulation system better
0.0 20.0 40.0 60.0
Strongly Agree 53.3
Agree 43.3
Neutral 3.3
Disagree 0.0
Strongly Disagree 0.0
Statement 7: The multimedia approach of teaching and learning blood circulation system was interesting.
0.0 20.0 40.0 60.0 80.0
Strongly Agree 65.0
Agree 35.0
Neutral 0.0
Disagree 0.0
Strongly Disagree 0.0
Statement 3: My interest in the blood circulation system increased with the use of multimedia.
0.0 20.0 40.0 60.0
Strongly Agree 55.0
Agree 41.7
Neutral 3.3
Disagree 0.0
Strongly Disagree 0.0
Statement 8: The multimedia approach was a waste of time.
0.0 20.0 40.0 60.0 80.0
Strongly Agree 0.0
Agree 0.0
Neutral 3.3
Disagree 35.0
Strongly Disagree 61.7
Statement 4: The multimedia approach actively involved me in what I was learning.
0.0 20.0 40.0 60.0
Strongly Agree 46.7
Agree 40.0
Neutral 11.7
Disagree 1.7
Strongly Disagree 0.0
Statement 9: I learned a lot from the multimedia method of teaching and learning.
0.0 20.0 40.0 60.0 80.0
Strongly Agree 25.0
Agree 71.7
Neutral 3.3
Disagree 0.0
Strongly Disagree 0.0
Statement 5: The multimedia approach improved my understanding in blood circulatory system.
0.0 20.0 40.0 60.0 80.0
Strongly Agree 70.0
Agree 28.3
Neutral 1.7
Disagree 0.0
Strongly Disagree 0.0
Statement 10: I learn better when teachers teach without multimedia.
0.0 20.0 40.0 60.0 80.0
Strongly Agree 1.7
Agree 0.0
Neutral 3.3
Disagree 30.0
Strongly Disagree 65.0

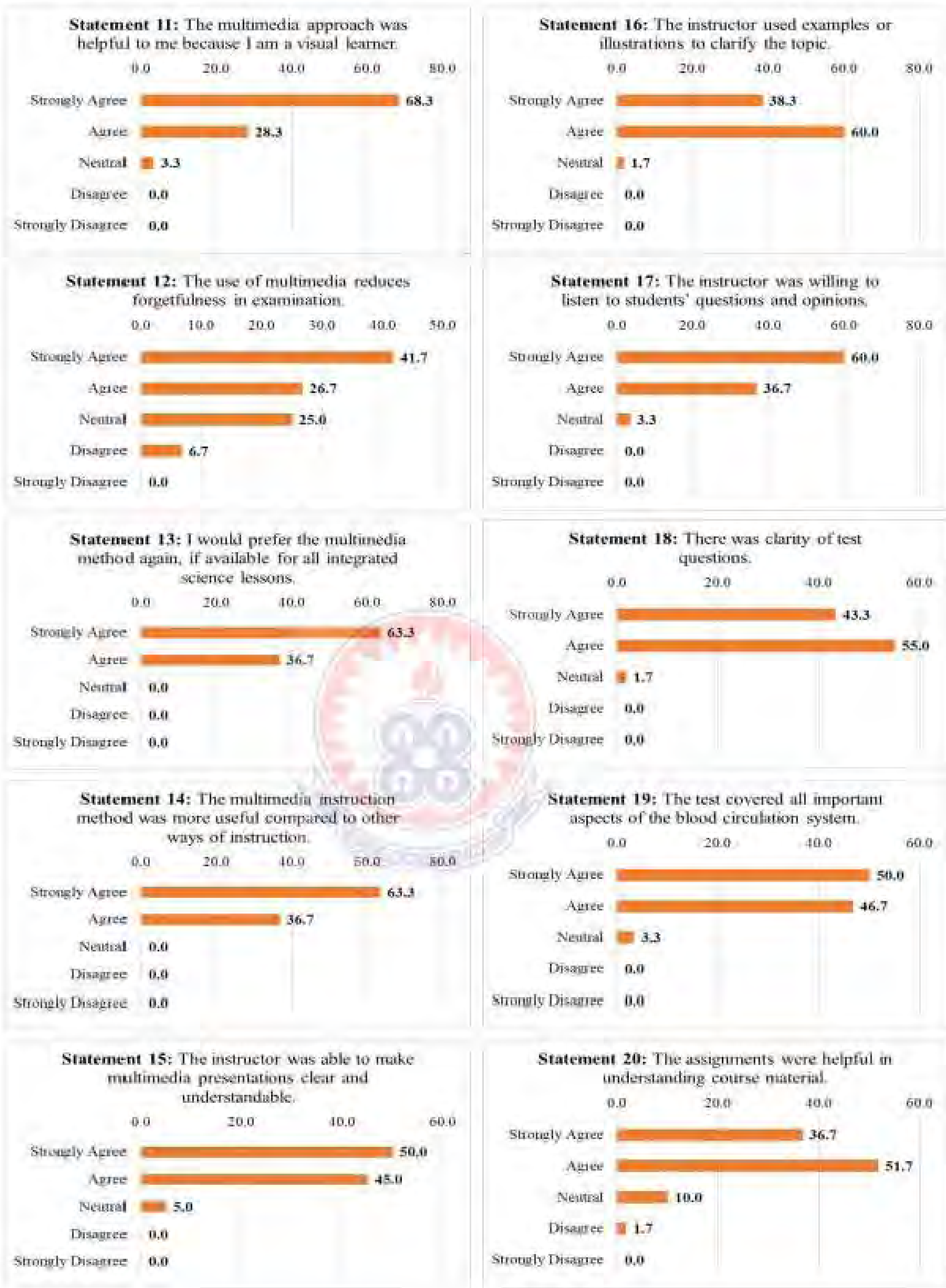


Figure 14: Results of students' responses to Likert -scale statements

4.6 Discussion of findings

The main purpose of the study was to assess the academic performance of students during the teaching and learning of blood circulatory system in humans using Multimedia Instructional Method (MMIM) at St. Vincent College of Education, Yendi.

Generally, at the onset of the intervention/treatment it was found that students' conceptual understanding of the structure, composition, functions, and disorders associated with the blood circulatory system in humans was limited. Most of the students had poor conceptual understanding of blood circulatory system in humans. Some of the misconceptions held by participating students were: "the heart is an organ actively responsible for blood formation", "the function of the heart is to convert impure blood into pure blood", "the heart is the centre where our emotions and feelings are stored", "all veins contain dirty blood", "all arteries contain clean blood".

Other misconceptions include: "the heart produces the necessary energy for the body", "arteries are closer to the heart in the body", "systemic circulation is much more important in function than pulmonary circulation", "the function of pulmonary circulation is to help systemic circulation", "clean blood circulates in the left side of the body while dirty blood circulates in the right side of the body", "heart disease is a man's disease". After the identification of the misconceptions of students about the blood circulatory system in humans, remediation steps were undertaken by the Researcher to address them. This was achieved by the employment of the Multimedia Instructional Method (MMIM) in teaching the topic.

The lessons were thus structured to be interactive and rich in visual graphics. The weekly lessons that included pre-test and post-test helped the students to understand the various concepts relating to blood circulatory system in humans. At the end of the weekly interventions, students' knowledge in the topic was assessed by comparing their scores of pre-tests and post-tests. This helped to ascertain the effectiveness of the remediation in overcoming the misconceptions earlier held by the students in relation to the blood circulatory system in humans prior to the use of the multimedia teaching approach.

The results of the study led to the conclusion that the Multimedia Instructional Method (MMIM) had a positive impact on students' academic performance of the blood circulatory system in humans. The findings revealed that there was a meaningful difference between the mean pre-test and post-test scores of the study participants. This is an indication that the Multimedia Instructional Method (MMIM) was effective in the teaching of the blood circulatory system in humans. The enhanced academic performance of the students after the intervention was an indication that the MMIM largely addressed the misconceptions of the students thus improving their conceptual understanding of the topic.

It is worth noting that the significant improvements in test scores from the pre-test to the post-test for the study participants are consistent with some previous studies that report the positive impact of multimedia on student learning. For instance, the findings are consistent with similar studies in other settings that have emphasised the effect of a multimedia approach in teaching different subjects like Mathematics (Akinoso, 2018; Ogochukwu, 2010), English (Sharma, 2013), Physical education (Antoniou, Gourgoulis, Trikas, Mavridis, & Bebetsos, 2003), Neurosurgery (Merajikhah, Imani, & Nowruzi, 2020), Social Psychology (Bartlett & Strough, 2003), Physics (Okwo & Asadu, 2002), and Economics (Malek, Hall, & Hodges, 2014).

Moreover, there is a study undertaken in Nigeria by Ogochukwu (2010) who reported that students' interest in Mathematics was enhanced when the multimedia presentation was employed. The multimedia approach is also reported to have contributed to the improvement in students' understanding, enthusiasm, class attendance, and satisfaction (Sharma, 2013).

Secondly, the research by Roschelle, Pea, Hoadley, Gordin, and Means (2000) has indicated that learning is most effective when characterised by active engagement; participation in groups; the provision of frequent interaction and feedback; and making connections to real-world contexts. The findings in this study buttress these concepts. According to the questionnaire responses of the study participants, and the Researcher's observations, students' interest, motivation, and participation in the lessons on the blood circulatory system in humans duly increased because of the use of the multimedia approach. This is also corroborated by Akın and Çeçen (2015) who observed that student motivation increased after the implementation of multimedia in the study. Motivation has always been an important element in educational programmes and it is closely associated with students' desire to participate in learning activities (Furió, Juan, Seguí, & Vivó, 2015).

Formal questionnaire responses indicated that most of the participants were visual learners. This study employed multimedia contents which had strong visual components and animations. These were more attention-catching, coupled to narrations that could be paused and replayed in a self-paced learning system.

Thus, students gained enough knowledge and understanding of the concept of blood circulatory system in humans.

The analyses of the results and the reported conceptions of students about MMIM-based teaching and learning led to the conclusion that Multimedia Instructional Method (MMIM)-based learning had a positive impact on students' conceptual understanding of the blood circulatory system in humans. This result is consistent with some previous studies that report the positive impact of MMIM on student learning in other contexts

(Aly, Elen, & Willems, 2004; Bockholt et al., 2003; Kapri, 2016; Kareem, 2018; Osei-Boateng, 2015; Satyaprakasha & Behera, 2014; A. R. Smith, Cavanaugh, & Moore, 2011; Yang, 2009). The MMIM teaching approach played a major role in bringing about these improvements in students' learning. Recent research on conceptual change suggests that the use of instructional strategies can stimulate a restructuring of students' understanding of scientific concepts. These include strategies aiming to increase students' metacognitive awareness (Beeth, 1998), fostering collaboration, and promoting dialogue among the students (Vosniadou, Ioannides, Dimitrakopoulou, & Papademetriou, 2001). It has been argued that such strategies result in higher levels of thinking, recognition of the gaps in one's knowledge, and articulation of the relationships between various variables associated with a particular science concept and thus increase the plausibility and intelligibility of scientifically correct ideas.

The analyses show that Multimedia Instructional Method (MMIM) made learning an enjoyable experience, increased students' active participation in learning, gave students a chance to repeat what they already knew about the topic of blood circulatory system in humans, MMIM gave the students the opportunity to ask clarifying questions to their peers, the opportunity to exchange ideas with their peers, and challenged them to support their claims with credible evidence and rational reasoning.

The participants also stated that learning about the about the topic of blood circulatory system in humans through MMIM increased their interest in the topic, learning through MMIM helped them to learn new things about the topic. Finally, participants stated that their ideas about the topic changed as a result of MMIM intervention.

Consequently, the improved results of the study participants can be linked to the higher student engagement that the multimedia strategy brought to bear. The evidence of student engagement with content and improved performance through the use of technology is well documented (Bonwell & Eison, 1991; Evans, Watson, & Willows, 1987; Gregorius, 2005a, 2005b; Gregorius, Santos, Dano, & Gutierrez, 2010a, 2010b).

This is further corroborated by literature findings which state that visual-graphical representations have the potential to deepen students' understanding of the connection between representations and concepts that require multilevel thinking (Johnstone, 1991; Wu, Krajcik, & Soloway, 2001). Visual-graphical representations are said to constitute an important feature in multimedia. The multisensory nature of multimedia makes it stimulate multiple senses of the audience at a time (Kareem, 2018).

Therefore, if multimedia is applied in teaching topics on the blood circulatory system in humans, it does stimulate students' senses in the classroom and allow an impactful interaction between the students and teachers. This thus, makes teaching of the blood circulatory system in humans more attractive and interesting to students. It also enhances students' motivation and understanding thereby making learning more meaningful.

Thomas (1996) concludes that the human vision system simultaneously performs the functions of perceiving and recognising form, colour, texture, motion, and spatial relationships and these are essential for any effective learning activity. Computer graphics technology has extended human visual systems to contexts and problem-solving situations beyond our normal vision and thus provides a powerful representation for communicating complex scientific ideas and processes (Tsui, 2003).

Most of the participants of the study were in favour of the multimedia teaching approach. Most of them stated that they enjoyed the multimedia experience more than their standard traditional class time. Furthermore, they indicated that they understood the concepts of blood circulatory system in humans much better and would prefer the method again if it were available for all other integrated science subjects and topics. The topics in blood circulatory system in humans have been animated and there is a demonstrable evidence that animation leads to more efficient knowledge acquisition (Vogel-Walcutt, Gebrim, & Nicholson, 2010). Students were observed to be more engaged with the content and the content delivery method and generally engaged enthusiastically with the learning experience. Students feel a sense of reality in what they learn, and this is well researched (Hoska, 2009; Onyegegbu, 2008).

Additionally, the study is in line with Kareem (2018) who demonstrated that some concepts which appeared abstract to students may become clearer and better retained when the multimedia approach is used. This may have positive effects on students' academic achievement and attitude to learning the subject. Also, there is enough evidence which suggests that some teaching techniques employed by teachers to teach concepts and biological events that cannot be seen by the naked eyes make learning difficult. These abstract biological concepts leave the academically weak students to over-stretch their imagination and hardly grasp anything at all.

As a result, some students are forced to resort to rote-learning, memorisation of information because of a lack of understanding (Asi, 2017; Shuaibu & Ishak, 2020). Thus, this defective style of learning that some students are compelled to resort to would be discouraged when teaching of biological concepts is done using the MMIM.

Overall, the study suggests that the use of multimedia in teaching facilitates understanding of blood circulatory system in humans. This is because the strategy involves the use of visually explicit information and a pictorial diagram of the topic. Visual explicitness may result in increased availability of information dynamics.

Undoubtedly, there is an abundance of literature to support the findings of the study, as has been demonstrated. Finally, Ferdousi and Bari (2015) suggest that the detailed visualisation of a learning subject/concept also has an impact on students' long-term retention of knowledge. The better visualisation, compared to the other methods, probably led to a better understanding of how these organs function (Dunleavy, Dede, & Mitchell, 2009; Ferdousi & Bari, 2015; FitzGerald, Taylor, & Craven, 2013). In addition, the interactive texts and information had a positive impact on students' performance (Alyahya & Gall, 2012). According to Tsui (2003), it is better to present an explanation in words (verbal-textual modality) coupled with pictures (visual-graphical modality) than using solely words.

Finally, the study participants' ratings of the Multimedia Instructional Method (MMIM) and the instructors' presentation of the information were in the range of good to excellent, suggesting the effectiveness of the teaching strategy (MMIM) employed. This is consistent with other findings presented in Bartlett and Strough (2003). The findings of this study have demonstrated that students' attitudes, interests, motivation, understanding, and performance are significantly affected by the strategy of instruction that is employed by their teachers. For these reasons, it is worth noting that educationists are constantly and continuously advocating for new instructional strategies to achieve the desired instructional outcomes (Ahmed & Abimbola, 2011).

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS, RECOMMENDATIONS, AND SUGGESTIONS FOR FURTHER RESEARCH

5.0 Overview

This chapter summarises the study findings, draws conclusions, and makes recommendations on the findings of the study. Additionally, suggestions for further research based on this study are stated.

5.1 Summary of Findings

The main purpose of this study was to examine the effect of a specific teaching strategy, the use of the Multimedia Instructional Method (MMIM) in enhancing the academic performance of students at the St Vincent College of Education, Yendi in the learning of the blood circulatory system in humans. The study participants were composed of an intact Science 2A class of 60 Level 200 students at St Vincent College of Education, Yendi. The participants comprised 70.0 % males and 30.0 % females.

A total of ten (10) intervention instruments were developed and deployed by the Researcher for the study. The instruments were made up of one (1) Students' Conception Instrument, four (4) pre-test instruments (BCHCT, TIA1, TIA2, and TIA3), four (4) post-intervention instruments (SKBCHT, TIB1, TIB2, and TIB3), and a post-multimedia intervention questionnaire (see Appendices).

Students' conceptions of the structure, composition, functions, and disorders associated with the blood circulatory system in humans were assessed using the Students' Conceptions instrument. The instrument contained 13 statements; each was an incorrect statement about the blood circulatory system in humans. However, the study participants were asked deliberately to indicate which of the incorrect statements were correct.

An initial pre-test; Blood Circulation in Humans' Concept Test (BCHCT) and delayed post-test instruments; Students' Knowledge of Blood Circulation in Humans Test (SKBCHT) were administered at the beginning and the end of each of the weekly lessons of treatment/intervention to all 60 study participants to ascertain the learning and performance of students in respect of the lesson topics taught using the MMIM. The BCHCT and SKBCHT each had 20 multiple choice questions of comparable standard and validity. Also, three (3) weekly pre-test interventions (TIA1, TIA2, and TIA3) comprising of 10 multiple choice questions were administered to the students at the beginning of the first lesson of each week whereas three (3) weekly post-test interventions (TIB1, TIB2, and TIB3) that comprised of essay-type questions were administered at the end of each lesson.

A four-week (4-week) intervention programme was carried out where the participants were taught for three weeks, and the fourth week was used for revision before the delayed post-test was administered. Additionally, all the study participants were administered a questionnaire to evaluate the perceptions, experiences, and understanding of the blood circulatory system in humans when taught using the Multimedia Instructional Method (MMIM). Results from the pre-intervention test and post-intervention test were collected, marked, recorded, analysed, and discussed.

The major findings of this study are summarised as follows:

- It became evident that students held various erroneous ideas and misconceptions about the blood circulatory system in humans.
- The Multimedia Instructional Method (MMIM) of teaching and learning that involved the use of visual-graphical representation materials on the structure, composition, functions, and disorders associated with the blood circulatory system were found to be effective in rectifying students' misconceptions.

- The MMIM of teaching enhanced the students' learning and led to improved performance of study participants. For instance, there was a meaningful difference between the mean pre-test and post-test scores of the study participants – an indication that the MMIM approach was effective in the teaching of the blood circulatory system in humans.
- The use of multimedia content was student-centred with strong visual components and attention-catching animations, teacher demonstrations, coupled with voice narrations that could be paused and replayed and that allowed students to gain adequate knowledge and understanding of the concept of blood circulation in humans.
- The MMIM approach was more interactive, and students were encouraged to ask questions during lessons hence the students were more actively engaged in the class.
- The teaching of all abstract concepts related to blood circulation in humans using MMIM helped to demystify the complex concepts and enhance better understanding and retention among students. As a result, students did not resort to rote-learning and memorisation of information.
- Students' attitudes, interests, motivation, understanding, and performance were positively affected by the MMIM that was employed in this study.
- Students indicated that they would prefer the use of multimedia teaching strategies for all other integrated science subjects and topics.

5.2 Conclusion

The study in its final analyses revealed that the use of multimedia teaching strategies improved the learning outcomes of students. It is thus established that the multimedia instructional strategy was effective in the teaching and learning of the concept of blood circulation in humans during Integrated Science classes at St Vincent College of Education, Yendi.

The use of the interactive visual-graphical and verbal-textual information to explain unseen and abstract phenomena in the blood circulatory system in humans enhanced students' interest, increased enthusiasm, promoted satisfactory class attendance, active engagement, frequent interaction and feedback, and a better understanding of the topic. This culminated in better students' performance in the subject.

5.3 Recommendations

Based on the above findings and conclusions from the study, the following recommendations are made:

(i) First and foremost, the use of appropriate pre-tests and post-tests during the study of the blood circulatory system in humans can greatly help identify students' varied misconceptions of the structure, the functions and the diseases of blood circulation in humans. While the use of the appropriate multimedia instruction tools as intervention can eliminate most of students' misconceptions, as ascertained through the student responses to short essay-type post intervention questions.

(ii) Similarly, teachers should consider the misconceptions of students in relation to every topic they teach and design appropriate learning tools that will mediate the correction of the wrongly held ideas and concepts about the topic.

(iii) Teachers and all instructors of St Vincent College of Education, Yendi should be encouraged to incorporate the use of Multimedia Instruction Methods (MMIM) of teaching in all other Biology topics and Integrated Science subjects.

(iv) The use of the interactive visual-graphical and verbal-textual information to explain unseen and abstract phenomena should be prioritised in the teaching of complex biological topics to enhance effective grasp of the topic by students.

(v) The MMIM use of strong audio-visual components and attention-catching animations, coupled with teacher demonstrations appeared as an effective student-centred approach and this should thus, be encouraged in all science classes.

(vi) Any impactful teaching and learning activity must be interactive and motivate students to ask questions and seek feedback during the course of the lesson so that students gain knowledge and understanding of the topics being taught. The use of the Multimedia Instructional Method (MMIM) thus remains a key teaching strategy in achieving this.

(vii) Teachers of Science and other subjects should improve their multimedia instructional skills through professional development programmes, further training, seminars, and short courses.

(viii) Teachers should be encouraged to use MMIM to teach all topics whose concepts are abstract in nature.

(ix) Some Biology students are compelled to resort to rote-learning or memorisation of information because of a lack of understanding (Asi, 2017; Shuaibu & Ishak, 2020) and this can be eliminated completely if students are taught using the MMIM teaching strategy that engages students enthusiastically, motivates them and stimulates their interest in learning the subject and catches their attention and enhances their comprehension.

5.4 Suggestions for Further Research

The findings of this study have not exhausted all other possible studies related to the use of Multimedia Instructional Method (MMIM). Consequently, the following are proposed:

- More participants can be involved in further research by using larger samples of subjects and enlarging the field of investigation. In this study, the participants were a Science 2A class of 60 Level 200 students from St Vincent College of Education, Yendi. Involving Science students of other levels and more Colleges of Education will widen the research scope and findings that may contribute greatly to the teaching of science in the country.
- A longer period of treatment could be involved in further related research. In the current study, the period of MMIM instruction was ran for only four weeks (3 weeks of teaching and a week of revision) because of limited resources. In future studies, the period of the treatment can be increased further to enhance more reliability and triangulation of the findings.
- Further studies can be undertaken in the application of MMIM in the teaching of all other topics in science. The current study was limited to the concept of the blood circulatory system in humans. However, similar studies can be conducted in relation to other topics in science and possibly to other fields like Mathematics and ICT.
- Finally, more variables such as gender, socioeconomic and health status, and place of origin of each student participant may be included and assessed to broaden the scope of the study.

REFERENCES

Ahmed, M., & Abimbola, I. (2011). Influence of teaching experience and school location on biology teachers' ratings of the difficulty levels of nutrition concepts in Ilorin, Nigeria. *Journal of Science, Technology, Mathematics and Education, 7*(2), 52-61.

Akın, E., & Çeçen, M. A. (2015). Student opinions on multimedia-based Turkish teaching and multimedia tools.

Akinoso, O. (2018). Effect of the Use of Multimedia on Students' Performance in Secondary School Mathematics. *Global Media Journal, 16*(30), 1-8.

Aleven, V., Mclaren, B. M., Sewall, J., & Koedinger, K. R. (2009). A new paradigm for intelligent tutoring systems: Example-tracing tutors. *International Journal of Artificial Intelligence in Education, 19*(2), 105-154.

Ali, A., & Elfessi, A. (2004). Examining students' performance and attitudes towards the use of information technology in a virtual and conventional setting. *Journal of Interactive Online Learning, 2*(3), 1-9.

Aly, M., Elen, J., & Willems, G. (2004). Instructional multimedia program versus standard lecture: a comparison of two methods for teaching the undergraduate orthodontic curriculum. *European Journal of Dental Education, 8*(1), 43-46.

Alyahya, S., & Gall, J. E. (2012). *iPads in education: A qualitative study of students' attitudes and experiences.* Paper presented at the EdMedia+ Innovate Learning.

Anamuah-Mensah, J., Mereku, D., & Asabere-Ameyaw, A. (2003). Ghanaian junior secondary school students' achievement in mathematics and science. *Results from Ghanaian's participation in the.*

Andresen, B. B., & van den Brink, K. (2002). *Multimedia in education.* Paper presented at the Infarmation technologies at school: conference materials.

Angadi, G., & Ganihar, N. N. (2015). Development and validation of multimedia package in biology.

Antoniou, P., Gourgoulis, V., Trikas, G., Mavridis, T., & Bebetsos, E. (2003). Using Multimedia as an instructional tool in Physical Education. *Journal of Human Movement Studies, 44*(6), 433-446.

Armentano, R. L., Cabrera Fischer, E. I., & Cymberknop, L. J. (2019). *Biomechanical Modeling of the Cardiovascular System*. doi:10.1088/2053-2563/aafb0d

Asi, P. (2017). *Using computer assisted programme to improve performance of Senior High School Form One students in integrated science.* University of Education, Winneba,

Baddeley, A. D. (1986). Working memory. *Philosophical Transactions of the Royal Society of London. B, Biological Sciences, 302*(1110), 311-324.

Baddeley, A. D., & Hitch, G. J. (1994). Developments in the concept of working memory. *Neuropsychology, 8*(4), 485.

Baddeley, A. D., & Logie, R. H. (1999). Working memory: The multiple-component model.

Bangkok, U. (2004). Integrating ICT as an integral teaching and learning tool into pre-service teacher training courses. *Issues in educational research, 15*(1), 101-113.

Bartlett, R. M., & Strough, J. (2003). Multimedia versus traditional course instruction in introductory social psychology. *Teaching of Psychology, 30*(4), 335-338.

Becker, W. E., & Watts, M. (1996). Chalk and talk: A national survey on teaching undergraduate economics. *The American Economic Review, 86*(2), 448-453.

Beeth, M. E. (1998). Teaching for conceptual change: Using status as a metacognitive tool. *Science education, 82*(3), 343-356.

Bockholt, S. M., West, J. P., & Bollenbacher, W. E. (2003). Cancer cell biology: A student-centered instructional module exploring the use of multimedia to enrich interactive, constructivist learning of science. *Cell biology education, 2*(1), 35-50.

Bolkan, S. (2019). Facilitating student attention with multimedia presentations: examining the effects of segmented PowerPoint presentations on student learning. *Communication Education, 68*(1), 61-79.

Bonwell, C. C., & Eison, J. A. (1991). *Active Learning: Creating Excitement in the Classroom. 1991 ASHE-ERIC Higher Education Reports*: ERIC.

Bordens, K. S., & Abbott, B. B. (2002). *Research design and methods: A process approach*: McGraw-Hill.

Butzin, S. M. (2000). Project CHILD. *THE Journal (Technological Horizons In Education), 27*(11), 90.

Calhoun, E. F. (1994). *How to use action research in the self-renewing school*: ERIC.

Castillo, J. J. (2009). Convenience sampling. Experiment Resources. In.

Cawthera, A. (2003). Computers in secondary schools in developing countries. *Retrieved July, 25*, 2011.

Chandler, P., & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and instruction, 8*(4), 293-332.

Chi-Yan, T., & Treagust, D. F. (2004). Motivational aspects of learning genetics with interactive multimedia. *The American Biology Teacher, 66*(4), 277-285.

Clark, J. M., & Paivio, A. (1991). Dual coding theory and education. *Educational psychology review, 3*(3), 149-210.

Cline, A. H. (2007). Technology Enhances Classroom Learning http://www/desotoschools. com/cline% 2005_15_01. htm. *Accessed: Dec, 12*.

Collis, B., Oberg, A., & Shera, W. (1988). An evaluation of computer-based instruction in statistical techniques for education and social work students. *Journal of Educational Technology Systems, 17*(1), 59-71.

Compeau, D. R., & Higgins, C. A. (1995). Computer self-efficacy: Development of a measure and initial test. *MIS quarterly*, 189-211.

Conway, P., & Zhao, Y. (2003). From luddites to designers. *What should teachers know about technology: Perspectives and practices*, 15-30.

Cox, M. J., Cox, K., & Preston, C. (2000). What factors support or prevent teachers from using ICT in their classrooms?

Creswell, J. W. (2002). *Educational research: Planning, conducting, and evaluating quantitative*: Prentice Hall Upper Saddle River, NJ.

Daniel, J. I. (1999). Computer-aided instruction on the World Wide Web: The third generation. *The Journal of Economic Education, 30*(2), 163-174.

Das, P. (2014). MULTIMEDIA APPROACH IN EDUCATIONAL TECHNOLOGY.

David, J. L. (1991). Restructuring and technology: Partners in change. *Restructuring for learning with technology*, 73-87.

Dawson, D. C. (2002). *A practical research methods*: How to Books limited.

DeMarrais, K. B., & Lapan, S. D. (2003). *Foundations for research: Methods of inquiry in education and the social sciences*: Routledge.

Dunleavy, M., Dede, C., & Mitchell, R. (2009). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. *Journal of Science Education and Technology, 18*(1), 7-22.

Ebel, R. L., & Frisbie, D. A. (1991). Essentials of Educational Measurements (5th Edition). New York: Prentice Hall.

Eisinga, R., Te Grotenhuis, M., & Pelzer, B. (2013). The reliability of a two-item scale: Pearson, Cronbach, or Spearman-Brown? *International journal of public health, 58*(4), 637-642.

Entsua-Mensah, K., Doku, A., & Adzamli, I. (2012). The National Cardiothoracic Centre, Accra Ghana: proceedings of the second International Update Course in Cardiology - improving the coverage of cardiology services. *Pan Afr Med J, 11*, 8. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/22368751
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3283026/pdf/PAMJ-11-08.pdf

Erickson, J., & Lehrer, R. (2000). What's in a link? Student conception of the rhetoric association in hypermedia documents. *The Journal of Learning Sciences, 7*(3/4), 351-386.

Ertmer, P. (2003). Transforming teacher education: Visions and strategies. *Educational technology research and development, 51*(1), 124-128.

Evans, M. A., Watson, C., & Willows, D. M. (1987). A naturalistic inquiry into illustrations in instructional textbooks. In *The psychology of illustration* (pp. 86-115): Springer.

Fenrich, P. (2005). *Creating instructional multimedia solutions: Practical guidelines for the real world*: Informing Science.

Ferdousi, B., & Bari, J. (2015). Infusing mobile technology into undergraduate courses for effective learning. *Procedia-Social and Behavioral Sciences, 176*, 307-311.

Ferrance, E. (2000). *Action research*: LAB, Northeast and Island Regional Education Laboratory at Brown University.

Fiche, M., Bonvin, R., & Bosman, F. (2006). Microscopes and computers in small-group pathology learning. *Medical education, 40*(11), 1138-1139. Retrieved from https://onlinelibrary.wiley.com/doi/pdfdirect/10.1111/j.1365-2929.2006.02597.x?download=true

FitzGerald, E., Taylor, C., & Craven, M. (2013). To the Castle! A comparison of two audio guides to enable public discovery of historical events. *Personal and Ubiquitous Computing, 17*(4), 749-760.

Fleming, D. S. (2000). The AEL Guide to Action Research.

Furió, D., Juan, M. C., Seguí, I., & Vivó, R. (2015). Mobile learning vs. traditional classroom lessons: a comparative study. *Journal of Computer Assisted Learning, 31*(3), 189-201.

Gardner, H. (1996). Multiple intelligences:" myths and messages". *The International Schools Journal, 15*(2), 8.

Gill, J., & Johnson, P. (2002). *Research methods for managers*: Sage.

Goguen, J. (2005). *What Is a Concept?*, Berlin, Heidelberg.

Golafshani, N. (2003). Understanding reliability and validity in qualitative research. *The qualitative report, 8*(4), 597-607.

Grabe, M., & Christopherson, K. (2005). Evaluating the advantages and disadvantages of providing lecture notes: The role of internet technology as a delivery system and research tool. *The internet and higher education, 8*(4), 291-298.

Gravetter, F., & Forzano, L. (2006). Research methods for the behavioral sciences 2nd Ed. *Mason, OH: Thompson*.

Gregorius, R. M. (2005a). Various learning environments and their impact on student performance, Part I: Traditional versus PowerPoint and WebCT augmented classes. *Chemical Educator, 10*(2), 72-77.

Gregorius, R. M. (2005b). Various learning environments and their impact on student performance, Part II: PowerPoint versus Flash-based selfinstruction. *Chemical Educator, 10*(2), 78-81.

Gregorius, R. M., Santos, R., Dano, J. B., & Gutierrez, J. J. (2010a). Can animations effectively substitute for traditional teaching methods? Part I: preparation and testing of materials. *Chemistry Education Research and Practice, 11*(4), 253-261.

Gregorius, R. M., Santos, R., Dano, J. B., & Gutierrez, J. J. (2010b). Can animations effectively substitute for traditional teaching methods? Part II: Potential for differentiated learning. *Chemistry Education Research and Practice, 11*(4), 262-266.

Hani, M. (2010). Teaching with the Interactive Whiteboard: An Engaging Way to Provide Instruction. *Online Submission*.

Harrison, A. G., & Treagust, D. F. (2000). A typology of school science models. *International journal of science education, 22*(9), 1011-1026.

Heinich, R., Molenda, M., & Russell, J. (2000). Visual design. *Instructional media and the new technologies of instruction*.

Hennessy, S., Deaney, R., & Ruthven, K. (2006). Situated expertise in integrating use of multimedia simulation into secondary science teaching. *International journal of science education, 28*(7), 701-732.

Hoska, D. (2009). Motivating Learners through Synchronized Multimedia Techniques: Developing a Positive Learner. *Interactive Instruction and Feedback. California: Wadsworth Publishing Company Inc*.

ICSU. (2011). Report of the ICSU Ad-hoc Review Panel on Science Education. In: International Council for Science Paris.

Jenkins, R. (2004). *Virtual Unknown Microbiology. Journal of Biological Education* (Vol. 38).

Johnstone, A. H. (1991). Why is science difficult to learn? Things are seldom what they seem. *Journal of Computer Assisted Learning, 7*(2), 75-83.

Jones, S., & Scaife, M. (2000). *Animated diagrams: An investigation into the cognitive effects of using animation to illustrate dynamic processes.* Paper presented at the International Conference on Theory and Application of Diagrams.

Kapri, U. C. (2016). Impact of multimedia technology in teaching of biological science to the underachievers in science at secondary school level. *Researchpaedia, 3*(1), 29-38.

Kareem, A. A. (2018). The use of multimedia in teaching biology and Its Impact on students' learning outcomes. *The Eurasia Proceedings of Educational and Social Sciences, 9*, 157-165.

Ke, F. (2008). A case study of computer gaming for math: Engaged learning from gameplay? *Computers & education, 51*(4), 1609-1620.

Kemp, J. E., & Dayton, D. K. (1985). *Planning and producing instructional media*: Harper & Row.

Khoiriah, K., Jalmo, T., & Abdurrahman, A. (2016). The Effect of Multimedia-based Teaching Materials in Science Toward Students' Cognitive Improvement. *Jurnal Pendidikan IPA Indonesia, 5*(1), 75-82.

Klein, J., & Koroghlanian, C. (2004). The effect of audio and animation in multimedia instruction. *Journal of educational multimedia and hypermedia, 13*(1), 23-46.

Kubasko, D., Jones, M. G., Tretter, T., & Andre, T. (2008). Is it live or is it Memorex? Students' synchronous and asynchronous communication with scientists. *International journal of science education, 30*(4), 495-514.

Kubiatko, M., & Haláková, Z. (2009). Slovak high school students' attitudes to ICT using in biology lesson. *Computers in Human Behavior, 25*(3), 743-748.

Kuhlemeier, H., & Hemker, B. (2007). The impact of computer use at home on students' Internet skills. *Computers & education, 49*(2), 460-480.

Loveland, J. L. (2014). Traditional lecture versus an activity approach for teaching statistics: A comparison of outcomes.

Ludwig, T. E., Daniel, D. B., Froman, R., & Mathie, V. A. (2004). Using multimedia in classroom presentations: Best principles. *Society for the Teaching Psychology Pedagogical Innovations Task Force*, 1-32.

Malek, N. P., Hall, J. C., & Hodges, C. (2014). *A review and analysis of the effectiveness of alternative teaching methods on student learning in economics*: West Virginia Univ., Department of Economics.

Maor, D., & Fraser, B. J. (1996). Use of classroom environment perceptions in evaluating inquiry-based computer-assisted learning. *International journal of science education, 18*(4), 401-421.

Mathis, W. (2012). Based Options for Education Policymaking: Common Core State Standards. *National Education Policy Center*.

Mayer, R. E. (1999). based principles for the design of instructional messages: The case of multimedia explanations. *Document design, 1*(1), 7-19.

Mayer, R. E. (2003). The promise of multimedia learning: using the same instructional design methods across different media. *Learning and instruction, 13*(2), 125-139.

Mayer, R. E. (2005a). Cognitive theory of multimedia learning. *The Cambridge handbook of multimedia learning, 41*, 31-48.

Mayer, R. E. (2005b). Introduction to multimedia learning. *The Cambridge handbook of multimedia learning, 2*, 1-24.

Mayer, R. E. (2005c). Principles of multimedia learning based on social cues: Personalization, voice, and image principles.

Mayer, R. E., & Moreno, R. (1998). A cognitive theory of multimedia learning: Implications for design principles. *Journal of educational psychology, 91*(2), 358-368.

McFarlane, A., & Sakellariou, S. (2002). The role of ICT in science education. *Cambridge Journal of Education, 32*(2), 219-232.

McLean, M. (2000). Introducing computer-aided instruction into a traditional histology course: student evaluation of the educational value. *Journal of Audiovisual Media in Medicine, 23*(4), 153-160.

Merajikhah, A. M., Imani, B., & Nowruzi, N. (2020). The Comparison of the Effects of Multimedia Tools and Traditional Methods on Neurosurgery Learning. *Educ Res Med Sci, 9*(1), e100355. doi:10.5812/erms.100355

Meyers, C., & Jones, T. B. (1993). *Promoting Active Learning. Strategies for the College Classroom*: ERIC.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*: sage.

Molnar, C., & Gair, J. (2019). Adaptive Immune Response-Concepts of Biology. *British Columbia Ministry of Advanced Education*.

Moore, D. M. M., Burton, J. K., & Myers, R. J. (2004). Multiple-Channel Communication: The Theoretical and Research Foundations of Multimedia.

Moreno, R., & Mayer, R. E. (2000). A coherence effect in multimedia learning: The case for minimizing irrelevant sounds in the design of multimedia instructional messages. *Journal of educational psychology, 92*(1), 117.

Mugenda, O. M., & Mugenda, A. (1999). Research methods: Quantitative and. Qualitative Approaches. *Africa Centre for Technology Studies (ACTS), Nairobi*.

my.clevelandclinic.org. (2022). Circulatory System: Anatomy and Function. Retrieved from https://my.clevelandclinic.org/health/body/21775-circulatory-system

Nitko, A. J. (2001). Conceptual frameworks to accommodate the validation of rapidly changing requirements for assessments. *Curriculum and assessment, 1*, 143-163.

Nuanmeesri, S. (2018). The Augmented Reality for Teaching Thai Students about the Human Heart. *International Journal of Emerging Technologies in Learning, 13*(6).

Nusir, S., Alsmadi, I., Al-Kabi, M., & Sharadgah, F. (2013). Studying the impact of using multimedia interactive programs on children's ability to learn basic math skills. *E-learning and Digital Media, 10*(3), 305-319.

O'Byrne, P. J., Patry, A., & Carnegie, J. A. (2008). The development of interactive online learning tools for the study of anatomy. *Medical Teacher, 30*(8), e260-e271.

Ogochukwu, N. V. (2010). Enhancing students interest in mathematics via multimedia presentation. *African Journal of Mathematics and Computer Science Research, 3*(7), 107-113.

Okello, V., & Kagoire, M. (1996). Makerere university curriculum module. *Kampala: Bezatel Design Studies*.

Okwo, F., & Asadu, C. (2002). Comparative effect of three modes of mediated instruction on secondary school students' achievement in physics. *International Journal of Arts and Technology Education, 2*(1), 137-144.

Oliver, M., Francis, J., Stanley, W., & Entman, M. L. (2022). Human cardiovascular system | Description, Anatomy, & Function. Retrieved from https://www.britannica.com/science/human-cardiovascular-system

Onyegegbu, N. (2008). Using new technologies in creating excitement in biology laboratory activities. *Educational Research and Reviews, 3*(1), 010-013.

Osei-Boateng, D. (2015). *Using the multimedia approach to enhance teaching of biology at Techiman Senior High School.* University of Education, Winneba,

OTA. (1995). Teachers and technology: Making the connection. *Washington, DC: US Government Printing Office*.

Paivio, A. (1986). *Dual coding theory and education.* Paper presented at the Draft chapter presented at the conference on Pathways to Literacy Achievement for High Poverty Children at The University of Michigan School of Education.

Paivio, A. (1990). *Mental representations: A dual coding approach*: Oxford University Press.

Paris, P. G. (2004). E-Learning: A Study on Secondary Students' Attitudes towards Online Web Assisted Learning. *International Education Journal, 5*(1), 98-112.

Patton, M. Q. (2018, June). Evaluation science. *American Journal of Evaluation,* 183-200.

Pelaez, N. J., Boyd, D. D., Rojas, J. B., & Hoover, M. A. (2005). Prevalence of blood circulation misconceptions among prospective elementary teachers. *Advances in Physiology Education, 29*(3), 172-181. Retrieved from https://journals.physiology.org/doi/pdf/10.1152/advan.00022.2004

Philips, R. (1997). The Developer's Handbook to Interactive Multimedia (A Practical Guide for Educational Applications). *New York: Kogan Page, Ltd. https://doi. org/10.1, 1*, 7898.

Pintrich, P. R., Marx, R. W., & Boyle, R. A. (1993). Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change. *Review of Educational research, 63*(2), 167-199.

Ramasundaram, V., Grunwald, S., Mangeot, A., Comerford, N. B., & Bliss, C. (2005). Development of an environmental virtual field laboratory. *Computers & education, 45*(1), 21-34.

Roschelle, J. M., Pea, R. D., Hoadley, C. M., Gordin, D. N., & Means, B. M. (2000). Changing how and what children learn in school with computer-based technologies. *The future of children*, 76-101.
Sagor, R. (2000). *Guiding school improvement with action research*: Ascd.
Sanders, M., Lewis, P., & Thornhill, A. (2009). Research Methods for business students 5th ed. *Harlow: Prentice Hall*.
Sangodoyin, A. (2010). Computer animation and the academic achievement of Nigerian senior secondary school students in biology. *Journal of the Research Center for Educational Technology, 6*(2), 148-161.
Sarantakos, S. (1998). Sampling procedures. In *Social Research* (pp. 139-164): Springer.
Satyaprakasha, C., & Behera, S. (2014). Effectiveness of multimedia teaching on achievement of VIII standard students in biology. *International Journal of Informative & Futuristic Research, 1*(8), 59-69.
Sharma, P. (2013). Role of interactive multimedia for enhancing students' achievement and retention. *International Women Online Journal of Distance Education, 2*(3), 12-22.
Shuaibu, A., & Ishak, N. A. (2020). EFFECT OF THE 7E INSTRUCTIONAL STRATEGY ON THE OVERALL ATTITUDE OF STUDENTS IN BIOLOGY IN PUBLIC SECONDARY SCHOOLS IN ADAMAWA STATE, NIGERIA. *Asia Pacific Journal of Educators and Education, 35*(2), 171-186.
Siegfried, J. J., Saunders, P., Stinar, E., & Zhang, H. (1996). Teaching tools: How is introductory economics taught in America? *Economic Inquiry, 34*(1), 182-192.
Sivin-Kachala, J., & Bialo, E. (2000). Research report on the effectiveness of technology in schools. *Executive summary*.
Slack, R. (1999). *PEDACTICE: The Use of Multimedia in Schools* (Vol. 17): Centre for Educational Sociology.
Smith, A. R., Cavanaugh, C., & Moore, W. A. (2011). Instructional multimedia: An investigation of student and instructor attitudes and student study behavior. *BMC medical education, 11*(1), 1-13.
Smith, T. W. (1995). *Little things matter: A sampler of how differences in questionnaire format can affect survey responses.* Paper presented at the Proceedings of the American Statistical Association, Survey Research Methods Section.
Sorden, S. D. (2005). A cognitive approach to instructional design for multimedia learning. *Informing Science, 8*.
Stillings, N. A., Chase, C. H., Weisler, S. E., Feinstein, M. H., Garfield, J. L., & Rissland, E. L. (1995). *Cognitive science: An introduction*: MIT press.
Stuckey-Mickell, T. A., & Stuckey-Danner, B. D. (2007). Virtual labs in the online biology course: Student perceptions of effectiveness and usability. *MERLOT journal of online learning and teaching, 3*(2), 105-111.
Susanne, M. B., West, J. P., & Bollenbacher, W. E. (2003). Cancer cell biology: A student-centered instructional module exploring the use of multimedia to enrich interactive, constructivist learning of science. *Cell biology education, 2*(1), 35-50.
Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and instruction, 4*(4), 295-312.
Taylor, R. P. (2003). Reflections on the computer in the school. *Contemporary Issues in Technology and Teacher Education, 3*(2), 253-274.
Thomas, D. A. (1996). Integrated Mathematics, Science, and Technology: An Introduction to Scientific Visualization. *Journal of Computers in Mathematics and Science Teaching, 15*(3), 267-294.

Travers, K. J. (1977). *Mathematics teaching*: HarperCollins Publishers.
Tsui, C.-Y. (2003). *Teaching and learning genetics with multiple representations.* Curtin University,
Van Merriënboer, J. J. (1997). *Training complex cognitive skills: A four-component instructional design model for technical training*: Educational Technology.
Veen, W. (1993). The role of beliefs in the use of information technology: implications for teacher education, or teaching the right thing at the right time. *Journal of Information Technology for teacher education, 2*(2), 139-153.
Vogel-Walcutt, J. J., Gebrim, J. B., & Nicholson, D. (2010). Animated versus static images of team processes to affect knowledge acquisition and learning efficiency. *Journal of Online Learning and Teaching, 6*(1), 1.
Von Glasersfeld, E. (1993). Learning and adaptation in the theory of constructivism. *Communication and Cognition, 26*(3), 393.
Vosniadou, S., Ioannides, C., Dimitrakopoulou, A., & Papademetriou, E. (2001). Designing learning environments to promote conceptual change in science. *Learning and instruction, 11*(4-5), 381-419.
WebM.D. (2016). Anatomy and the circulation of the heart, (Online library) Accessed: January 2020 (https://www.webmd.com/heart-disease/high-cholesterol-healthy-heart). *International Journal of Informative & Futuristic Research, 1*(8), 59-69.
Webster, M. (1985). Webster's Ninth New Collegiate Dictionary. *Dictionaries: Journal of the Dictionary Society of North America, 6*(1), 200-235.
Wild, C. (1995). Continuous improvement of teaching: A case study in a large statistics course. *International Statistical Review/Revue Internationale de Statistique*, 49-68.
William, C., Michael, P., & Gartner, G. (2007). Multimedia Carto graphy. In: New York: Springer.
Wiseman, D. C. (1999). *Research strategies for education*: Wadsworth Pub.
Wittrock, M. C. (1989). Generative processes of comprehension. *Educational psychologist, 24*(4), 345-376.
Wong, L. H. (2012). A learner-centric view of mobile seamless learning. *British Journal of Educational Technology, 43*(1), E19-E23.
Woolfolk Hoy, A., Davis, H. A., & Anderman, E. M. (2013). Theories of learning and teaching in TIP. *Theory into practice, 52*(sup1), 9-21.
Wu, H. K., Krajcik, J. S., & Soloway, E. (2001). Promoting understanding of chemical representations: Students' use of a visualization tool in the classroom. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, 38*(7), 821-842.
Yang, Y.-p. (2009). Integrating Internet Multimedia Materials into an English Remedial Instruction Program for Elementary School EFL Learners: An Action Research. *Unpublished master" s thesis). Southern Taiwan University of Science and Technology, Tainan, Taiwan*.
Yaspal Sudhanshu, Y. (2014). Effect of multi media teaching on achievement in Biology. *International Journal of Education and Psychological Research (IJEPR), 3*(1), 43-45.
Yeboah, O. S. (2010). The effect of computer simulation on the teaching and of photosynthesis at the senior high school level in the Accra Metropolis. Unpublished thesis University of Education, Winneba. *Communication and Cognition, 26*(3), 393.

Yu-Hsin, C., Ju-Tzu, C., & Deng-Jyi, C. (2012). The effect of multimedia computer assisted instruction and learning style on learning achievement. *WSEAS Transactions On Information Science And Applications Vol, 9*(1).

Yuen, A. H., & Ma, W. W. (2002). Gender differences in teacher computer acceptance. *Journal of technology and Teacher Education, 10*(3), 365-382.

Zimmermann, K. A. (2019). Circulatory System: Facts, Function & Diseases. Retrieved from https://www.livescience.com/22486-circulatory-system.html

Zumbach, J., Schmitt, S., Reimann, P., & Starkloff, P. (2006). Learning life sciences: Design and development of a virtual molecular biology learning lab. *Journal of Computers in Mathematics and Science Teaching, 25*(3), 281-300.

APPENDICES

Appendix A: CONCEPTION INSTRUMENT

UNIVERSITY OF EDUCATION, WINNEBA

SCIENCE EDUCATION DEPARTMENT

Student ID: ………………………………………………………………………

Gender: **Male** [ ] **Female** [ ]

Dear Student,

I am currently undertaking a study on the topic ***"Enhancing the conceptual understanding and performance of students during the teaching and learning of circulation of blood in humans using multimedia."*** This instrument assesses your conception of the structure, composition, functions, and disorders associated with the blood circulatory system in humans. This study is for academic purpose and your answers will be treated **confidentially** and will only be used for the purpose of the study. Please take time to go through the instructions carefully and answer each of the questions as **honestly** as you can. Kindly **Answer All Questions. Do Not Write Your Name anywhere on this Questionnaire.** Kindly return your Conception Instrument to the Researcher once you are through with answering the questions.

Thank you very much for your cooperation.

INSTRUCTIONS: This instrument contains **thirteen (13)** statements about structure, composition, functions, and disorders associated with the blood circulatory system in humans.

For each of the following statements, please indicate whether they are 'Correct' or 'Not Correct' by ticking **[√]** in the box to the right of the statement.

	Statements	**Correct**	**Not Correct**
1	The heart is an organ actively responsible for blood formation.		
2	The function of the heart is to clean blood (convert impure blood into pure blood).		
3	The heart is the centre where our emotions and feelings are stored.		
4	All veins contain dirty blood.		
5	All arteries contain clean blood.		
6	The heart produces the necessary energy for the body.		
7	Arteries are closer to the heart in the body.		
8	Systemic circulation is much more important in function than pulmonary circulation.		
9	Systemic and pulmonary circulations are independent from each other, and they take place in different parts of the body.		
10	The function of pulmonary circulation is to help systemic circulation.		
11	Pulmonary circulation takes place in the upper part		

	of the body while systemic circulation takes place in the lower part of the body.		
12	Clean blood circulates in the left side of the body while dirty blood circulates in the right side of the body.		
13	Heart disease is a man's disease		

Appendix B: GENERAL PRE-TEST DATA COLLECTING INSTRUMENT – BLOOD CIRCULATION IN HUMANS' CONCEPT TEST" (BCHCT)

UNIVERSITY OF EDUCATION, WINNEBA

SCIENCE EDUCATION DEPARTMENT

Student ID:

……………………………………………………………………………

Gender: **Male** **[ ]** **Female** **[ ]**

MULTIPLE CHOICE QUESTIONS

INSTRUCTIONS: This test contains **twenty (20)** Multiple Choice Questions (MCQs). Please answer ALL the questions in the test. Each question is followed by four (4) options lettered A to D. Find out the correct option and circle A, B, C or D to indicate your answer.

GENERAL PRE-TEST (BCHCT) QUESTIONS - 30 MINUTES

1. All of the following are functions of the blood circulatory system EXCEPT?
   (A) Thermoregulation
   (B) Transport of oxygen, carbon dioxide, nutrients, and waste products
   (C) Hematopoiesis
   (D) Transport of hormones and antibodies
2. What is the function of the blood vessels and capillaries?
   (A) They pump blood to the heart
   (B) They filter impurities from the blood

(C) They carry blood to all parts of the body

(D) They carry messages from the brain to the muscles.

3. The function of an artery is to

(A) transport blood toward the heart.

(B) transport blood away from the heart.

(C) connect the right and left atria directly.

(D) carry carbon dioxide to the tissue cells.

4. The major component of human blood is …….

(A) plasma.

(B) platelets.

(C) red cells.

(D) white cells.

5. An important function of white blood cells is to

(A) buffer blood.

(B) carry oxygen.

(C) fight infection.

(D) carry carbon dioxide

6. What is the organ that pumps blood all throughout the human body?

(A) The lungs

(B) The heart

(C) The kidneys

(D) The blood vessels and capillaries

7. Which of the following is a function of red blood cells?

(A) clot blood

(B) carry oxygen

(C) fight infection

(D) regulate osmotic pressure

8. Blood pressure will be at its highest when

(A) atria relax.

(B) atria contracts.

(C) ventricles relax.

(D) ventricles contract.

9. The blood vessel that carries blood from the lungs to the heart is the

(A) coronary vein.

(B) coronary artery.

(C) pulmonary vein.

(D) pulmonary artery

10. The **main** function of the valves in the heart is to

(A) prevent back-flow of blood.

(B) divide the heart into four chambers.

(C) control the volume of blood leaving the heart.

(D) control the volume of blood entering the heart.

11. A blood vessel that transports blood out of a capillary bed is a(n)

(A) vein.

(B) artery.

(C) venule.

(D) arteriole.

12. The most muscular chamber of the heart is the

(A) left atrium.

(B) right atrium.

(C) left ventricle.

(D) right ventricle.

13. Blood vessels that allow diffusion of gases through their thin walls are the

(A) arteries.

(B) venules.

(C) arterioles.

(D) capillaries

14. The watery part of the blood is called……….

(A) veins

(B) platelets

(C) plasma

(D) capillaries

15. Chambers of the heart

(A) Atria or auricles and ventricles

(B) Veins and arteries

(C) Adenoids and tonsils

(D) Tarsal and carpals

16. These blood vessels take deoxygenated blood to the heart and oxygenated blood from lungs.

(A) Veins

(B) Capillaries

(C) Arteries

(D) Lymph

17. Hypertension would be indicated by a blood pressure reading of

(A) 100 / 80

(B) 120 / 50

(C) 120 / 80

(D) 150 / 110

18. Which of the following would describe the path of the blood in the pulmonary circuit?

(A) Right ventricle → pulmonary trunk → pulmonary vein → left atrium.

(B) Left ventricle → pulmonary vein → pulmonary trunk → right atrium.

(C) Right ventricle → pulmonary vein → pulmonary artery →left atrium.

(D) Right atrium→ pulmonary trunk → aorta →vena cava → right atrium.

19. Which of the following correctly matches structure with function?

(A) platelets — provide immunity

(B) plasma proteins — carry oxygen

(C) red blood cells — carry carbon dioxide

(D) white blood cells — initiate blood clotting

20. All of the following are components of plasma **except**

(A) salts.

(B) water.

(C) proteins.

(D) platelets.

Appendix C: GENERAL POST-TEST DATA COLLECTING INSTRUMENT - STUDENTS' KNOWLEDGE OF BLOOD CIRCULATION IN HUMANS TEST (SKBCHT)

UNIVERSITY OF EDUCATION, WINNEBA

SCIENCE EDUCATION DEPARTMENT

Student ID:

……………………………………………………………………………

Gender: **Male** **[ ]** **Female** **[ ]**

MULTIPLE CHOICE QUESTIONS

INSTRUCTIONS: This test contains **twenty (20)** Multiple Choice Questions (MCQs). Please answer ALL the questions in the test. Each question is followed by four (4) options lettered A to D. Find out the correct option and circle A, B, C or D to indicate your answer.

GENERAL POST-TEST (SKBCHT) QUESTIONS - 30 MINUTES

1. What is the blood circulatory system in humans?
   (A) The body's breathing system
   (B) The body's system of nerves
   (C) The body's food-processing system
   (D) The body's blood-transporting system
2. The organ that pumps oxygenated blood to the body and deoxygenated blood to the lungs.

(A) brain

(B) liver

(C) heart

(D) kidney

3. The major component of human blood is …….

(A) plasma.

(B) platelets.

(C) red cells.

(D) white cells.

4. An important function of white blood cells is to

(A) buffer blood.

(B) carry oxygen.

(C) fight infection.

(D) carry carbon dioxide

5. Where is Red blood cells produced?

(A) bone marrow

(B) liver

(C) pancreas

(D) spleen

6. Blood pressure will be at its highest when

(A) atria relax.

(B) atria contracts.

(C) ventricles relax.

(D) ventricles contract.

7. The blood vessel that carries oxygenated blood from the lungs to the heart is the

(A) coronary vein.

(B) coronary artery.

(C) pulmonary vein.

(D) pulmonary artery

8. The **main** function of the valves in the heart is to

(A) prevent back-flow of blood.

(B) divide the heart into four chambers.

(C) control the volume of blood leaving the heart.

(D) control the volume of blood entering the heart.

9. The function of an artery is to

(A) transport blood toward the heart.

(B) transport blood away from the heart.

(C) connect the right and left atria directly.

(D) carry carbon dioxide to the tissue cells.

10. A blood vessel that transports blood out of a capillary bed is a(n)

(A) vein.

(B) artery.

(C) venule.

(D) arteriole.

11. The most muscular chamber of the heart is the

(A) left atrium.

(B) right atrium.

(C) left ventricle.

(D) right ventricle.

12. Blood vessels that allow diffusion of gases through their thin walls are the

(A) arteries.

(B) venules.

(C) arterioles.

(D) capillaries

13. Which type of blood vessel has thick walls in order to withstand high pressure?

(A) vein

(B) artery

(C) arteriole

(D) capillary

14. Chambers of the heart

(A) atria and ventricles

(B) veins and arteries

(C) adenoids and tonsils

(D) tarsal and carpals

15. These blood vessels take deoxygenated blood to the heart and oxygenated blood from lungs.

(A) veins

(B) capillaries

(C) arteries

(D) lymph

16. Hypertension would be indicated by a blood pressure reading of

(A) 100 / 80

(B) 120 / 50

(C) 120 / 80

(D) 150 / 110

17. Which of the following would describe the path of the blood in the pulmonary circuit?

    (A) right ventricle → pulmonary trunk → pulmonary vein → left atrium.

    (B) left ventricle → pulmonary vein → pulmonary trunk → right atrium.

    (C) right ventricle → pulmonary vein → pulmonary artery →left atrium.

    (D) right atrium→ pulmonary trunk → aorta →vena cava → right atrium.

18. Which of the following **best** describes a vein?

    (A) Thin-walled, elastic, and equipped with valves.

    (B) Thick-walled, elastic, and equipped with valves.

    (C) Thin walled, muscular, and supplied with nerves.

    (D) Thick-walled, muscular, and supplied with nerves.

19. Plasma is composed mostly of

    (A) salt.

    (B) water.

    (C) protein.

    (D) hormones.

20. These tiny blood cells clot the blood when a person gets cut.

    (A) red

    (B) white

    (C) platelets

    (D) lymph

Appendix D: WEEK 1 PRE-TEST DATA COLLECTING INSTRUMENT – (TIA1)

UNIVERSITY OF EDUCATION, WINNEBA

SCIENCE EDUCATION DEPARTMENT

Student ID:

……………………………………………………………………………

Gender: **Male** **[ ]** **Female** **[ ]**

MULTIPLE CHOICE QUESTIONS

INSTRUCTIONS: This test contains **ten (10)** Multiple Choice Questions (MCQs). Please answer **ALL** the questions in the test. Each question is followed by four (4) options lettered A to D. Find out the correct option and circle A, B, C or D to indicate your answer.

WEEK 1 PRE-TEST (TIA1) QUESTIONS

1. All of the following are functions of the blood circulatory system in humans EXCEPT?

   (A) Thermoregulation

   (B) Transport of oxygen, carbon dioxide, nutrients, and waste products

   (C) Hematopoiesis

   (D) Transport of hormones and antibodies

2. The chamber of the heart responsible for receiving blood as it returns from the lungs after it has been reoxygenated.

(A) Right Atrium

(B) Right Ventricle

(C) Left Atrium

(D) Left Ventricle

3. This is the only artery that carries unoxygenated blood away from the heart.

(A) Aorta

(B) Pulmonary Trunk

(C) Superior Vena Cava

(D) Inferior Vena Cava

4. The bicuspid valve is also known as the:

(A) Right atrioventricular valve

(B) Aortic semilunar valve

(C) Pulmonary semilunar valve

(D) Mitral valve

5. The correct sequence of heart chambers a red blood cell would pass through as it travels through the heart.

(A) Right Atrium – Left Ventricle – Left Atrium – Right Ventricle

(B) Right Atrium – Right Ventricle – Left Atrium – Left Ventricle

(C) Left Atrium – Left Ventricle – Right Atrium – Right Ventricle

(D) Left Atrium – Right Atrium – Left Ventricle – Right Ventricle

6. The vessels in the blood circulatory system in humans where the exchange of gas takes place are the…………?

(A) Veins

(B) Aorta

(C) Arteries

(D) Capillaries

7. Which of the following is NOT a formed element of blood?

(A) Red Blood Cells

(B) White Blood Cells

(C) Plasma

(D) Platelets

8. The type of blood vessels that have one-way valves preventing back flow of blood.

(A) Capillaries

(B) Arteries

(C) Veins

(D) Arterioles

9. Which of the following is NOT a layer of the heart?

(A) Endocardium

(B) Myocardium

(C) Endomyosin

(D) Pericardium

10. This is the only artery that carries unoxygenated blood away from the heart.

(A) Aorta

(B) Pulmonary Trunk

(C) Superior Vena Cava

(D) Inferior Vena Cava

Appendix E: WEEK 2 PRE-TEST DATA COLLECTING INSTRUMENT – (TIA2)

UNIVERSITY OF EDUCATION, WINNEBA

SCIENCE EDUCATION DEPARTMENT

Student ID:

…………………………………………………………………………

Gender: **Male** [ ] **Female** [ ]

MULTIPLE CHOICE QUESTIONS

INSTRUCTIONS: This test contains **ten (10)** Multiple Choice Questions (MCQs). Please answer ALL the questions in the test. Each question is followed by four (4) options lettered A to D. Find out the correct option and circle A, B, C or D to indicate your answer.

WEEK 2 PRE-TEST (TIA2) QUESTIONS

1. Blood plasma does NOT transport
   (A) Alveoli
   (B) Urea
   (C) Hormones
   (D) digested food
2. What type of blood flows in capillaries?
   (A) Deoxygenated blood only
   (B) Both oxygenated and deoxygenated blood

(C) Oxygenated blood only

(D) Detoxicated blood

3. Which one of the following statements is NOT true for white blood cells?

(A) They have no definite shape.

(B) They are capable of fighting infection.

(C) They are produced in bone marrow.

(D) They are smaller than red blood cells.

4. What substance gives red blood cells their colour?

(A) Platelets

(B) Haemoglobin

(C) Glucose

(D) Plasma

5. Why is blood that flows from the lungs to the heart more bright red than blood flowing from the rest of the body to the heart?

(A) Hormones in the blood make it a bright red.

(B) The lungs add a dye to the blood as it flows through.

(C) The oxygen in the blood makes it a brighter red.

(D) The carbon dioxide in the blood makes it a brighter red.

6. Which of the following is a function of blood?

(A) To produce bile

(B) To maintain body temperature

(C) To support the body

(D) To transport food to the stomach

7. If you cut yourself, you will bleed for a short time. Then the blood thickens and hardens. It forms a clot. What causes this clot?

(A) Antibodies from white blood cells.

(B) Haemoglobin leaves red blood cells to form the clot.

(C) Your body is running out of blood.

(D) Platelets form this clot.

8. The main function of platelets cells is to

(A) Carry oxygen around the body.

(B) Fight disease.

(C) Form clots.

(D) To give blood its reddish colour

9. The main function of red blood cells is to

(A) Carry carbon dioxide to the body's cells.

(B) Fight disease.

(C) Clot blood.

(D) Carry oxygen to the body's cells.

10. The pale-yellow liquid in blood is called

(A) Glucose

(B) Platelets

(C) Lumen

(D) plasma

Appendix F: WEEK 3 PRE-TEST DATA COLLECTING INSTRUMENT – (TIA3)

UNIVERSITY OF EDUCATION, WINNEBA

SCIENCE EDUCATION DEPARTMENT

Student ID: ……………………………………………………………………………

Gender: **Male** [ ] **Female** [ ]

MULTIPLE CHOICE QUESTIONS

INSTRUCTIONS: This test contains ten (10) Multiple Choice Questions (MCQs). Please answer ALL the questions in the test. Each question is followed by four (4) options lettered A to D. Find out the correct option and circle A, B, C or D to indicate your answer.

WEEK 3 PRE-TEST (TIA3) QUESTIONS

1. Deposit of plaque on the walls of a coronary artery is called?

   (A) Hypertension

   (B) Myocardial Infarction

   (C) Stroke

   (D) Atherosclerosis

2. A myocardial infarction is a/an?

   (A) Blood clot

   (B) Narrow blood vessel

   (C) Incomplete valve closure

(D) Heart attack

3. What is anaemia?

(A) Deficiency in the production of normal haemoglobin

(B) A disease in new-borns

(C) An inability to clot blood

(D) Cancer of the blood

4. What is another name for high blood pressure?

(A) Myocardial infarction

(B) Hypertension

(C) Angina

(D) Pneumonia

5. What is the diastolic blood pressure?

(A) 120 mm Hg

(B) 140 mm Hg

(C) 90 mm Hg

(D) 80 mm Hg

6. What is the minimum blood pressure for hypertension?

(A) 170/90 mm Hg

(B) 130/70 mm Hg

(C) 140/90 mm Hg

(D) 120/80 mm Hg

7. Which of these diseases make the lumen of arteries narrower?

(A) Atherosclerosis

(B) Hypertension

(C) Angina

(D) Heart failure

8. Which of these are not deposited in the lumen of coronary arteries in CAD?

(A) Calcium

(B) Phosphorus

(C) Fats

(D) Fibrous tissue

9. What is acute chest pain known as?

(A) Atherosclerosis

(B) Hypertension

(C) Angina pectoris

(D) Heart failure

10. Which of these is not a heart disease?

(A) Hypertension

(B) Angina pectoris

(C) Celiac disease

(D) Atherosclerosis

Appendix G: WEEK 1 POST-TEST DATA COLLECTING INSTRUMENT – (TIB1)

UNIVERSITY OF EDUCATION, WINNEBA

SCIENCE EDUCATION DEPARTMENT

Student ID:

……………………………………………………………………………

Gender: **Male** [ ] **Female** [ ]

ESSAY QUESTIONS

INSTRUCTIONS: Answer **ALL** questions in the test.

WEEK 1 POST-TEST (TIB1) QUESTIONS

1. The blood system in humans is divided into three (3) components name them?

   (3marks)

2. What is the function of the heart and where is it located?

   (3marks)

3. a) How many chambers has the heart.

   b) Name them.

   (4marks)

Total

(10marks)

MARKING SCHEME

1. i) Heart *(1mark)*

   ii) Blood vessel *(1mark)*

   iii) Blood *(1mark)*

2. The function of the heart is to pump blood around the body. It is located in between the two lungs. It lies left of the middle of the chest. ***(3marks)***

3. a) two (2)

   b) (i) The right atrium ***(1mark)***

   (ii) The right ventricle ***(1mark)***

   (iii) The left atrium ***(1mark)***

   (iv) The left ventricle ***(1mark)***

Total ***10marks***

Appendix H: WEEK 2 POST-TEST DATA COLLECTING INSTRUMENT – (TIB2)

UNIVERSITY OF EDUCATION, WINNEBA

SCIENCE EDUCATION DEPARTMENT

Student ID:

………………………………………………………………………………

Gender: **Male** [ ] **Female** [ ]

ESSAY QUESTIONS

INSTRUCTIONS: Answer **ALL** questions in the test.

WEEK 2 POST-TEST (TIB3) QUESTIONS

1. a) How many major functions of blood do we have? *(1mark)*

   b) Name them. *(3marks)*

2. Blood consists of two main components, name them. *(2marks)*

3. Define haemopoiesis. *(2mark)*

4. Give one function of the red blood cells. *(2marks)*

Total *(10marks)*

MARKING SCHEME

1. a) three (3) *(1mark)*

   b) i) Transport *(1mark)*

ii) Protection *(1mark)*

iii) Regulation *(1mark)*

2. a) Plasma *(1mark)*

   b) Formed elements *(1mark)*

3. It refers to the production of the formed elements of blood. *(2mark)*

4. a) To pick up oxygen from the lungs and deliver it to tissues *(1mark)*

   b) To pick up carbon dioxide from other tissues and upload it to the lungs *(1mark)*

Total *(10marks)*

Appendix I: WEEK 3 POST-TEST DATA COLLECTING INSTRUMENT – (TIB3)

UNIVERSITY OF EDUCATION, WINNEBA

SCIENCE EDUCATION DEPARTMENT

Student ID: ………………………………………………………………………….

Gender: **Male** [ ] **Female** [ ]

ESSAY QUESTIONS

INSTRUCTIONS: Answer **ALL** questions in the test.

WEEK 3 POST-TEST (TIB3) QUESTIONS

1. Mention 2 diseases that can affect the blood circulatory system in humans and explain them. ***(5marks)***
2. State three risk factors that can be caused by heart failure. ***(3marks)***
3. Explain what is meant by disorders of the blood circulatory system in humans. ***(2marks)***

Total ***(10marks)***

MARKING SCHEME

1. a) Atherosclerosis: it is caused by the hardening of the arteries. It is caused by a diet high in fat which leaves fatty deposits on the lining of the blood vessels. ***(2marks)***

b) Heart attack: this occurs when the blood supply is cut off from the heart often caused by a blood clot. ***(3marks)***

2. a) smoking ***(1mark)***

   b) obesity ***(1mark)***

   c) intake of fat-rich food. ***(1mark)***

3. Disorders of the blood circulatory system in humans is defined as any aliment which affects the heart, blood vessels, and blood cells. This disorder leads to insufficient or reduced transportation of blood, oxygen, hormones and nutrients to the tissue and cells. ***(2marks)***

Total ***(10marks)***

Appendix J: MARKING SCHEME FOR PRE-TEST (BCHCT) AND POST-TEST (SKBCHT)

PRE-TEST (BCHCT)		POST-TEST (SKBCHT)	
Question	**Answer**	**Question**	**Answer**
1	A	1	D
2	D	2	C
3	B	3	A
4	A	4	C
5	C	5	A
6	D	6	D
7	B	7	C
8	D	8	A
9	D	9	B
10	A	10	C
11	D	11	C
12	C	12	D
13	D	13	B
14	C	14	A
15	A	15	A
16	C	16	D
17	C	17	A
18	A	18	A
19	A	19	B
20	D	20	C

Appendix K: MARKING SCHEME FOR WEEKLY PRE-TESTS (TIA1, TIA2 AND TIA3)

TIA1		TIA2		TIA3	
Question	**Answer**	**Question**	**Answer**	**Question**	**Answer**
1	C	1	A	1	A
2	C	2	B	2	D
3	B	3	D	3	A
4	B	4	B	4	B
5	B	5	C	5	D
6	D	6	B	6	C
7	C	7	D	7	A
8	C	8	C	8	B
9	C	9	D	9	C
10	B	10	D	10	C

Appendix L: MULTIMEDIA INSTRUCTIONAL METHOD (MMIM)-BASED RESEARCH QUESTIONNAIRE

UNIVERSITY OF EDUCATION, WINNEBA

SCIENCE EDUCATION DEPARTMENT

Dear Student,

I am currently undertaking a study on the topic ***"Enhancing the conceptual understanding and performance of students during the teaching and learning of circulation of blood in humans using multimedia."*** This questionnaire seeks information about the effectiveness of Multimedia Instructional Method (MMIM) in understanding blood circulatory system in humans. This study is for academic purpose and your answers will be treated **confidentially** and will only be used for the purpose of the study. Please take time to go through the instructions carefully and answer each of the questions as **honestly** as you can. Kindly **Answer All Questions. Do Not Write Your Name anywhere on this Questionnaire.** Kindly return your questionnaire to the Researcher once you are through with answering the questions.

Thank you very much for your cooperation.

SECTION A: BIO-DATA OF PARTICIPATING STUDENTS

Please indicate the following details by either ticking **[√]** inside the brackets.

1. Gender: [ ] Male [ ] Female
2. Age group: [ ] 14 – 15 [ ] 16 – 17 [ ] 18 – 19 [ ] 20 + years

SECTION B: EVALUATION OF EFFECTIVENESS OF MULTIMEDIA INSTRUCTIONAL METHOD (MMIM) IN UNDERSTANDING BLOOD CIRCULATORY SYSTEM

For each of the following statements, please indicate to what degree Multimedia Instructional Method (MMIM) influences your understanding of blood circulatory system in humans by ***circling a number*** to the right of the statement. Where:

1 = Strongly Agree

2 = Agree

3 = Neutral

4 = Disagree

5 = Strongly Disagree

	Statements	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
1	The lessons using the multimedia approach were clear and enjoyable to me.	**1**	**2**	**3**	**4**	**5**
2	The multimedia approach explains blood circulatory system better	**1**	**2**	**3**	**4**	**5**
3	My interest in the blood circulatory system increased with the use of multimedia	**1**	**2**	**3**	**4**	**5**
4	The multimedia approach	**1**	**2**	**3**	**4**	**5**

	actively involved me in what I was learning					
5	The multimedia approach improved my understanding in blood circulatory system in humans	**1**	**2**	**3**	**4**	**5**
6	The multimedia approach motivates me to learn blood circulatory system	**1**	**2**	**3**	**4**	**5**
7	The multimedia approach of teaching and learning blood circulatory system was interesting.	**1**	**2**	**3**	**4**	**5**
8	The multimedia approach was a waste of time.	**1**	**2**	**3**	**4**	**5**
9	I learned a lot from the multimedia method of teaching and learning.	**1**	**2**	**3**	**4**	**5**
10	I learn better when teachers teach without multimedia	**1**	**2**	**3**	**4**	**5**
11	The multimedia approach was helpful to me because I am a visual learner.	**1**	**2**	**3**	**4**	**5**

12	The use of multimedia reduces forgetfulness in examination	**1**	**2**	**3**	**4**	**5**
13	I would prefer the multimedia method again, if available for all integrated science lessons.	**1**	**2**	**3**	**4**	**5**
14	The multimedia instruction method was more useful compared to other ways of instruction	**1**	**2**	**3**	**4**	**5**
15	The instructor was able to make multimedia presentations clear and understandable	**1**	**2**	**3**	**4**	**5**
16	The instructor used examples or illustrations to clarify the topic	**1**	**2**	**3**	**4**	**5**
17	The instructor was willing to listen to students' questions and opinions	**1**	**2**	**3**	**4**	**5**
18	There was clarity of test questions	**1**	**2**	**3**	**4**	**5**
19	The test covered all important aspects of the	**1**	**2**	**3**	**4**	**5**

	blood circulatory system					
20	The assignments were helpful in understanding course material	**1**	**2**	**3**	**4**	**5**

Appendix M. POST-MMIM INTERVENTION SHORT ESSAY-TYPE QUESTIONS FOR STUDENTS, AS A TOOL TO ASCERTAIN WHETHER OR NOT SOME OF THEIR MISCONCEPTIONS ABOUT THE BLOOD CIRCULATORY SYSTEM IN HUMANS HAVE CHANGED APPROPRIATELY

No.	Statements of students' initial misconceptions in blood circulatory system in humans before intervention	Short essay-type questions for students to ascertain whether or not some of their earlier misconceptions about the blood circulatory system in humans have changed appropriately after the Multimedia Instructional Method intervention.
1	The heart is an organ actively responsible for blood formation.	What is the key role/function of the heart as an organ?
2	The function of the heart is to clean blood (convert impure blood into pure blood).	Use the correct/appropriate terms to describe the cleaning function of the heart.
3	The heart is the centre where our emotions and feelings are stored.	Is the heart truly the centre of emotions? Upon studying blood circulation in humans, describe the place occupied by the heart within the blood circulatory system in humans.
4	All veins contain dirty blood.	Why do you think all veins do not contain ONLY deoxygenated blood ('dirty blood')? Explain your response with

		details.
5	All arteries contain clean blood.	**All arteries** may not contain ONLY oxygenated blood (pure/clean blood). Explain why and name the particular artery responsible…
6	The heart produces the necessary energy for the body.	**What in the human system really produces the energy for the body?**
7	Arteries are closer to the heart in the body.	Which particular type of arteries are close to the heart? Name them…
8	Systemic circulation is much more important in function than pulmonary circulation.	Explain why both systemic circulation and pulmonary circulation are equally important.
9	Systemic and pulmonary circulations are independent from each other, and they take place in different parts of the body.	Your earlier belief that both systemic and pulmonary circulations are independent of each other might have changed… Give reasons...
10	The function of pulmonary circulation is to help systemic circulation.	Do you still hold the belief that the pulmonary circulation is there to support ONLY the systemic circulation? Explain
11	Pulmonary circulation takes place in the upper part of the body while systemic circulation takes place in the lower part of the body.	Someone rejects the belief that pulmonary circulation takes place in the upper part of the body. Why do you think the person is right?
12	Clean blood circulates in the left side	Explain briefly why you think the

	of the body while dirty blood circulates in the right side of the body.	assertion that clean blood circulates in the left side of the body, etc. is false.
13	Heart disease is a man's disease	In a few words, educate a colleague of yours on what can cause a heart disease, and why the function of the heart is the same in all mammals, including humans