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Research Article

The impact of multimedia teaching strategies on students' academic performance in the human circulatory system concept

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The study investigated the impact of multimedia teaching strategy on students' academic performance in the concept of circulatory system in Humans. The study adopted action research design. The sample size comprised of 60 science 2A level 200 students from St. Vincent College of Education. The study made use of only one group. The group was taught using multimedia teaching method. Pre-intervention test was administered to students before the intervention. A post-intervention test was also administered to students after the students were taught using multimedia teaching method to determine the impact of the intervention. The mean gain between the pre-intervention and post-intervention test scores was found to be 6.62. Test results proved that there was statistically significant difference between the pre-intervention and post-intervention test scores of students. This proved that multimedia instructional method of teaching had a positive impact on students' academic performance in circulatory system in humans. The study therefore recommended that multimedia teaching strategy should be embraced by biology facilitators for teaching circulatory system in humans and other biological concepts especially abstract ones in order to improve students understanding, application and academic performance.

Keywords: Multimedia teaching strategy, blood circulatory system, academic performance

1. Introduction

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 concept. 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 et al., 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 in place of more interactive methods of teaching (Loveland, 2014). 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 et al., 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). 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 et al., 2016).

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 (1993) and 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 overemphasized. 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 to explore the impact of multimedia teaching strategy on students' academic performance in the concept of blood circulatory system in humans.

1.1. Current Study

It has been emphasised by various researchers that when blood circulatory system in humans like other scientific concepts are taught in abstract terms at the various levels of the educational ladder, it will force students to resort to rote-learning without understanding (Aleven et al., 2009). The most predominant teaching strategies used in presenting concepts in Biology to students include conventional method, brainstorming, demonstration, discussion and note-taking (Ayimbila & Akantagriwon, 2021). These methods do not help learners to develop critical thinking and inquiry skills. This has led to poor performance of students in biology at all levels of education and St. Vincent College of Education, Yendi is no exception. 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 from sister colleges, and local universities attribute the low achievement in biology not only to the use of inappropriate methods of teaching biology but mostly due to the inadequate classroom facilities that will aid practical and engaging grasp of the subject.

Most biology teachers including the researchers 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 the traditional or lecture method of teaching, inquiry method, and the collaborative method. These methods, even with the addition of charts and improvised teaching and learning materials are unable to properly explain concepts such as the process of photosynthesis, circulation of blood in mammals, digestion in mammals, transpiration in plants, fertilization process in plants, flight movement in birds and DNA replication and so on (Molnar & Gair, 2019).

To overcome some of the challenges to learning when these traditional methods of teaching are employed, Bolkan (2019) proposed the use of appropriate multimedia to enhance the presentation and to captivate and sustain students' attention and participation.

Therefore, the current study aims to investigate and determine the impact of multimedia teaching strategy on students' academic performance in the concept of blood circulatory system in humans. As a result, the study tested the following hypothesis:

H: There is statistically no significant difference in students' academic performance between the pre-intervention test and post-intervention test scores in blood circulation system in humans.

2. Literature Review

2.1. Multimedia Learning Theory

This study was guided by the cognitive theory of multimedia learning. This theory was proposed Mayer 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, 2005). Multimedia researchers generally defined multimedia as the combination of text and pictures; and suggested that multimedia learning occurs when we build mental representations from these words and pictures (Mayer, 2005). 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 enhance effective learning.

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 (2006), 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 et al., 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). 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.

2.2. Benefits of Using Multimedia Method in Teaching and Learning

The growth of Information, communication and Technology provides opportunity for integration of ICTs in teaching and learning. Multimedia is used to present abstract concept to learners. Multimedia is the integration of multiple media elements such as videos, audios, animation, diagrams into one synergetic and symbiotic whole that result in more benefit to the end user than one of the media elements can provide individually (Satyaprakasha & Behera, 2014).

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.

Multimedia instructions expose students to a variety of graphics, pictures and animation which draw students' attention more and involve more of their sense organs (John et al., 2018). It also facilitates the conceptual understanding of biological and other scientific concepts leading to greater achievement (Aggarwal & Dutt, 2014). Multimedia promotes interactivity between instructors and learners, encouraging and enhancing student's engagement in the learning process (Li & Kang, 2014). Multimedia helps students to develop positive attitude towards science subjects, thus improving the academic achievement of students (Kareem, 2018). It also boosts students' comprehension of difficult topics and raises their interest level. The benefits derived from the use of multimedia resources is not limited to the ease of the teacher's work alone specially to support constructive concept development, but help students in such a way that make them relate their knowledge in real life situations (Akinoso, 2018). Multimedia can improve learning and retention of material presented during teaching and learning (Kapri, 2017). The use of multimedia increases student success and motivation while positively affecting students' attitudes towards lessons (Ilhan & Oruç, 2016). It also helps students to develop positive attitude towards learning, thus improving the academic performance of students (Kareem, 2018)

3. Method

3.1. Research Design

Action research design was adopted for the study. The design made use of only one group where pre-intervention test was conducted before the intervention and post-intervention test was also conducted after the intervention to examine the effectiveness of the intervention or treatment.

The study was conducted in St. Vincent College of Education in the Savanna Region of Ghana. The population of the study was made up of all level 200 students in St. Vincent College of Education. Science ''2A'' class was selected for the study using convenience sampling technique. The sample size of the study was made up of 60 students.

3.2. Research Instruments

The instruments used for data collection were pre-intervention test and post- intervention test. The data was collected by the researchers before and after the intervention for a period of four weeks. In the first week, a general pre-intervention test, Blood Circulation in Humans Concepts Test [BCHCT] was administered to students before the intervention. The concepts blood circulatory system in humans was taught using three weeks. TIA1, TIA2, and TIA3 represent the weekly pre-intervention tests. and TIB1, TIB2, and TIB3 also represent the weekly post-intervention tests.

TIA1 represents pre-intervention test on structure and functions of blood circulatory system in humans and TIB1 represents post-intervention test on structure and functions of blood circulatory

system in humans. TIA2 signifies pre-intervention test on composition and functions of blood circulatory system in humans and TIB2 represents post-intervention test on composition and functions of blood circulatory system in humans. TIA3 represents pre-intervention test on disorders associated with blood circulatory system in humans and TIB3 signifies post-intervention test on disorder associated with blood circulatory system in humans. Also, after the intervention general post-intervention test on Students Knowledge on Blood Circulation in Human Test [SKBCHT] was also administered in the fourth week.

BCHCT was made up of 20 multiple choice questions and SKBCHT was also made up of 20 multiple choice questions. TIA1, TIA2 and TIA3 were made up of 10 multiple choice questions each. TIB1 and TIB3 consisted of 3 theory questions each and TIB2 was also made up of 4 theory questions.

3.3. Reliability of the Research Instruments

The reliability of the test items used for data collection were determined using test and retest reliability coefficient. The reliability of the pre-intervention test and post-intervention test were found to be 0.73 and 0.78 respectively. This proved that the instruments were reliable.

3.4. Intervention Process

The intervention was carried out in four weeks using multimedia teaching strategy. During week one, the instructors tackled the structure and functions of the blood circulatory system in humans. During week two, the instructor took learners through the composition and functions of the blood circulatory system in humans. The disorders associated with blood circulatory system of humans was taught in the third week. In the fourth week, the facilitator review blood circulatory system in humans with emphasis on each of the three subtopics. The intervention was administered with the aid of diagrams, illustration and videos. The intervention process is presented in Appendix.

3.5. Data Analysis

The data collected from the students were analysed using inferential statistics (t-test) with the help of SPSS version 27. The student's pre-intervention test and post-intervention test scores were analysed using t-test to test the null hypothesis.

Examining test of normality of distribution is very important prior to carrying out analysis of pre-intervention test and post-intervention test. Therefore, Kolmogorov-Smirnov test of normality was run (see Table 1).

Table 1
Normality test results

	Kolmogorov-Smirnov[a]		
Variable	*Statistic*	*df*	*p*
Pre-intervention test	.096	60	.200.
Pre-intervention test	.108	60	.082*

According to Table 1, the *p*-values of the pre-intervention test and post-intervention test are 0.2 and 0.082 respectively. These values are higher than .05 and hence parametric test (*t*-test) was safe to use in comparing the two tests.

4. Results

The scores from the pre-intervention test and post-intervention test were subjected to statistical analysis using the Statistical Package for Social Sciences. The data was analysed using descriptive statistics of mean and Standard Deviation while hypothesis was also tested at .05 level of significance using *t*-test.

The Science ''2A'' class of 60 participants were administered pre-intervention test instruments (BCHCT, TIA1, TIA2, and TIA3) and post-intervention instruments (TIB1, TIB2, TIB3 and SKBCHT). These achievement tests were prepared to help examine the impact of multimedia

teaching strategy on students' performance on blood circulatory system in humans. The mean pre-intervention tests and post-intervention tests of participants in the study group were compared to understand students' progress between pre and post intervention tests.

Table 2 shows the comparison of the mean pre-intervention test and post-intervention test scores of the study participants (N = 60). The table gives the means, mean differences, the *t*-values, and the two-tailed significance at .05.

Table 2
Comparison of pre-intervention tests and post-intervention tests of all participants in the study

Test Intervention	*N*	*Mean*	*SD*	*t*	*df*	*p*
Pre-intervention test (TIA1)	60	5.62	1.68	25.92	59	<.001
Post-intervention test (TIB1)	60	7.73	1.48	40.40	59	<.001
Pre-intervention (TIA2)	60	5.05	1.82	21.53	59	<.001
Post-intervention test (TIB2)	60	7.08	1.76	31.19	59	<.001
Pre-intervention test (TIA3)	60	5.62	2.17	20.04	59	<.001
Post-intervention test (TIB3)	60	7.47	1.83	31.66	59	<.001
Pre-intervention test (BCHCT)	60	9.43	3.50	20.88	59	<.001
Post-intervention test (SKBCHT)	60	16.05	2.89	43.02	59	<.001

The pre-intervention test instruments were TIA1, TIA2, TIA3, and BCHCT whereas the post-intervention 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 (M = 7.73), TIB2 (M = 7.08), TIB3 (M =7.47), and SKBCHT (M =16.05) were found to be higher than the pre-intervention means test scores TIA1 (M =5.62), TIA2 (M = 5.05), TIA3 (M = 5.62), and BCHCT (M = 9.43), as shown in Table 2. 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 academic performance in the pre-intervention test and post-intervention test scores among participants, the actual t-test within the group of 60 participants was computed. Table 2 shows the calculated *t*-values for all pre-tests and post-tests TIA1 (*t*-value = 25.92, df = 59, *p*-value < .001), TIB1 (*t*-value = 40.40, df = 59, *p*-value < .001), TIA2 (*t*-value = 21.53, df = 59, *p*-value < .001), TIB2 (*t*-value = 31.19, df = 59, *p*-value < .001), TIA3 (*t*-value = 20.04, df = 59, *p*-value < .001), TIB3 (*t*-value = 31.66, df = 59, *p*-value < .001), BCHCT (*t*-value = 20.88, df = 59, *p*-value < .001), and SKBCHT (*t*-value = 43.02, df = 59, *p*-value < .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 .05 level of significance for this study. This means that meaningful differences were found between the pre-intervention test scores and post-intervention test scores among all 60 participants. Hence, the null hypothesis which stated that there is no significant difference in the mean pre-intervention tests and mean post-intervention tests performance among all participants in the lessons on the blood circulatory system in humans was rejected.

This shows that there was an enhanced students' performance after the interventions. Consequently, students' performance can be attributed to the impact 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-intervention tests and post-intervention tests of students' performances in the blood circulatory system in humans among the 60 participants were obtained by subtracting pre-intervention test scores from post-intervention test scores.

The data presented in Table 3 shows the mean difference between the pre-intervention scores and post-intervention scores**.** 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 teaching strategy in teaching blood circulatory system in humans improved the academic performance of students.

Table 3
Differences in pre-intervention test and post-intervention test scores of study participants

Test Difference	*N*	*Mean*	*SD*	*t*	*df*	*p*
Week 1 (TIB1 – TIA1)	60	2.12	2.23	7.34	59	<.001
Week 2 (TIB2 – TIA2)	60	2.03	2.34	6.72	59	<.001
Week 3 (TIB3 – TIA3)	60	1.85	2.25	6.36	59	<.001
Overall (SKBCHT – BCHCT)	60	6.62	4.78	10.71	59	<.001

According to Table 3, the *t*-value was calculated to be 7.34 which is greater than the *t*-value of 2.00 for 59 degrees of freedom at .05 level of significance for Week-1. Also, the p-value was less than .005 which is statistically significant at .05 level of significance, so there exists a significant difference between the week 1 pre-intervention test (TIA1) and post-intervention test (TIB1) scores of students' performances. For week 2, the mean gain between TIA2 and TIB2 was found to be 2.03 (*t*-value = 6.72, *p*-value < 0.001). The mean gain between week 3 pre-intervention test (TIA3) and post-intervention test (TIB3) was 1.85 (*t*-value = 6.36, *p*-value < .001). For the overall pre-intervention test and post-intervention test, the mean gain between BCHCT and SKBCHT was 6.62 (*t*-value = 10.71, *p*-value < .001).

In all instances, the *t*-values are greater than the tabulated *t*-value of 2.00 for 59 degrees of freedom at .05 level of significance. This proved that there was statistically significant difference between pre-intervention test and post-intervention test with respect to the performance of the students in tests. These results imply that the multimedia teaching strategy of teaching had a positive impact on students' performance in blood circulatory system in humans.

5. Discussion

The main purpose of the present study was to assess the academic performance of students during the teaching and learning of blood circulatory system in humans using multimedia teaching strategy. The results of the study led to the conclusion that the Multimedia Teaching Strategy had a positive impact on students' academic performance in the concept blood circulatory system in humans. This is in line with Akinbadewa (2020) who concluded that multimedia instructional package significantly enhanced students' academic performance in biology concepts. Igbibo and George (2019) also confirmed that multimedia instructional package significantly improved students' academic performance in Biology. The findings revealed that there was a meaningful difference between the mean pre-intervention test and post-intervention test scores of the study participants. This is an indication that multimedia teaching strategy was effective in the teaching of blood circulatory system in humans. The enhanced academic performance of the students after the intervention was an indication that the instructional strategy is very effective.

The study found that there was statistically significant difference between the pre-intervention test and post-intervention test scores of students taught using multimedia teaching strategy. This finding is consistent with some previous studies that reported the positive impact of multimedia on student learning. For instance, the finding is consistent with similar studies in other settings that have emphasised the effect of a multimedia approach in teaching different subjects like Mathematics (Akinoso, 2018) who found that students' academic performance improved significantly after being exposed to multimedia teaching strategy. The finding also agrees with the finding of Ayimbila et al. (2021) that students' experience significant academic improvement when taught using multiple modes.

The finding is also consistent with the finding of Aggarwal (2018) who investigated the effect of multimedia approach on students' academic performance in Biology and found that students' performance was enhanced after they were taught using multimedia. The finding also collaborates with the finding of Satyapraksha and Behera (2014) and Satyapraksha and Sudhanshu (2014) that multimedia significantly enhanced the academic achievement of students with respect to knowledge, understanding and application and total achievement in Biology. The multimedia approach is also reported to have contributed to the improvement in students' understanding,

enthusiasm, class attendance, and satisfaction (Sharma, 2013). The results further confirmed the finding of Dahal et al. (2021) who reported that taught using multimedia experience significant improvement in their academic performance. The finding of the study also supports the finding of Kassa et al. (2024) who revealed that multimedia significantly improved students' academic performance regardless of their learning preferences. The finding further confirmed the finding of Kaur et al. (2022) who reported that multimedia approach significantly improved students' academic performance in social sciences. The finding of the study is also in line with Sun et al. (2022) who revealed that multimedia approach had positive effect on students learning attitude and learning satisfaction.

6. Conclusion

From the results of the study, it was established that the use of multimedia teaching strategy 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 blood circulation system in humans.

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.

The study therefore recommended that multimedia teaching strategy should be embraced by biology facilitators for teaching circulatory system in humans and other biological concepts especially abstract ones in order to improve students understanding, application and academic achievement. It is also recommended that Ghana Education Service and Ministry of Education should provide schools with microscopes, projectors and other ICT learning materials to enable teachers incorporate technology in their lesson's delivery.

7. Limitation and Future Research

This study highlighted the impact of multimedia teaching strategy on students' academic performance in the concept of blood circulatory system in humans. This study was limited by the fact that it was conducted in only one College of Education and hence generalization of the findings should be done with caution. The study was also restricted to circulatory system of humans and hence limits its generalizability to other topics in Biology. Future studies should explore the impact of multimedia teaching strategy on other topics in Biology. Future research should also investigate the effect of multimedia teaching strategy in other courses or subjects. In addition, the current study focused on St. Vincent College of Education only. Future research should consider other Colleges of Education.

Author contributions: All authors have sufficiently contributed to the study, and agreed with the conclusions.

Data availability: The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declaration of interest: No conflict of interest is declared by author.

Ethics statement: All participants provided informed consent prior to their involvement in the study. They were informed about the study's purpose, procedures, and their right to withdraw at any time without consequence.

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Appendix 1. Intervention process

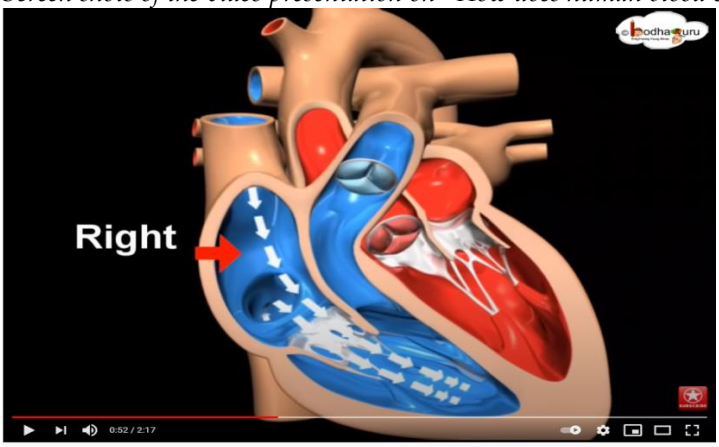
WEEK	INTERVENTION
Week One (1)	**Subtopic: The structure and functions of the blood circulatory system in humans** In the first week, a general pre-intervention test, Blood Circulation in Humans Concepts Test was administered to students before the intervention to determine the baseline performance of the students. The first subtopic, the structure and functions of the blood circulatory system in humans was taught in the first week using multimedia instructional method. The lesson began with the conduct of the weekly evaluation pre-intervention test A [TIA1] 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. Once the pre-intervention test was completed, the students' responses were collected, marked, and recorded. After the Week one pre-intervention test was executed, the instructor 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 instructor ensured that only plausible and intelligent responses of students were discussed and emphasized to aid memory and learning in a bid to resolve the misconceptions held by the students. After the short question and answer session on the topic, the instructor then engaged further the students using interactive learning media that demonstrates what constitutes the structure and functions of the blood circulatory system in humans. First, media presentation lesson was conducted using video clip titled "How does human blood circulatory system work – 3D animation". This is showed in figure1. The instructor explained the various parts of the heart with the use of an elaborate diagram of the human body. The first week intervention was done the aid of figure 1-7. These figures are found in the appendices. A post-intervention test B1 [TIB1] was conducted after the intervention.
Week Two (2)	**Sub-topic: The composition and functions of the blood circulatory system in humans** The composition and functions of blood circulatory system in humans was taught in the second week. The first day lesson on the second subtopic began with the administration of the pre-intervention test A [TIA2] on blood system in humans. The scripts were collected, marked and recorded. 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 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 instructor stated clearly and briefly explained the topic of the lesson, which was the composition and functions of the blood circulatory system in humans. The video clip which explains the composition, and the functions of the blood circulatory system in humans was then viewed. Upon viewing the above video clip, the students were divided into six group and each group discussed and noted five vital things they have learnt from the video clip on the heart and the blood circulatory system and shared with their neighbouring group. Further, each of the six groups was given a microscope to view a blood specimen and to note whatever their eyes

Appendix continued

	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 instructor at the close of the lessons. As, most of the responses given were correct the instructor summarised the lesson by asking in turns one student at a time 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. The second intervention was carried out with the help of figure 8. **Once again, at the end of the teaching of the second subtopic using multimedia teaching strategy the post-intervention test B [TIB2] was administered, the responses were collected, marked and recorded.**
Week Three (3)	**Subtopic: 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. At the commencement of the lesson, the researchers conducted Pre-intervention test A [TIA3]. The scripts were collected, marked and recorded. The instructor continued the lesson by briefly presenting the subtopic of the day and then asked the students to mention at random any disorders or illnesses they could associate with the blood in humans' system. Most of the students mentioned hypertension or high blood pressure, though they could only state one of the causes of this unhealthy heart condition. The instructor distributed to the class diagrams that indicated different unhealthy conditions of the heart, especially the unsound blood vessels and what disorders or illnesses they could cause. 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 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. The intervention in the third week was done with the aid of figure 9-11. These figures are found in the appendices. After the intervention in week three, post-intervention test B [TIB3] was conducted and the students' responses were collected, marked and recorded.
Week Four	**Using MMTS to review the blood circulatory system in humans, with emphasis on each of the three subtopics.** The last week was used for revision and the final general post-intervention test, Students' Knowledge of Blood Circulation in Humans Test [SKBCHT] was conducted. Students' responses were taken, marked and recorded.

Figure 1

Screen shots of the video presentation on "How does human blood circulatory system work – 3D animation



Note. Adopted from https://www.youtube.com/watch?v=SwHjwO7BnsI

Figure 2

Diagram of the heart and the blood circulatory system in humans

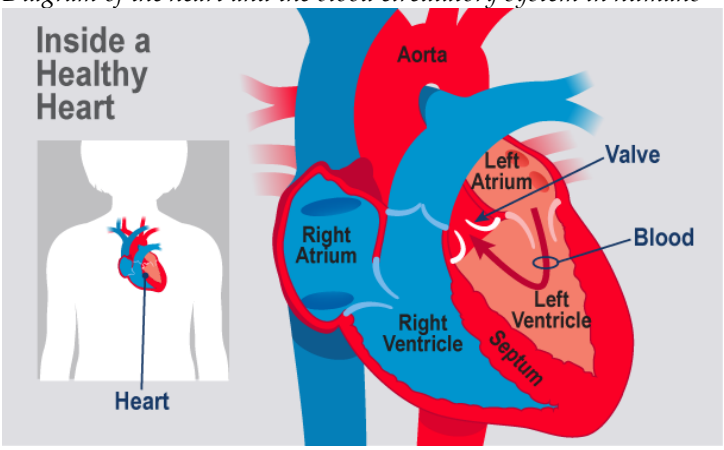


Figure 3

Diagram of the blood Circulatory System in Humans (Infographic) By Ross Toro - Infographics Artist (LiveScience contributor)

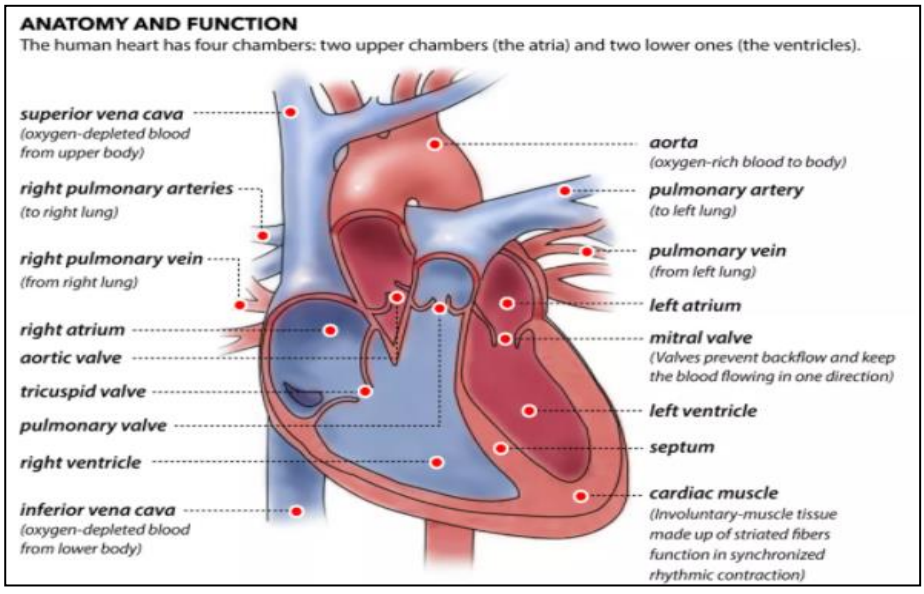
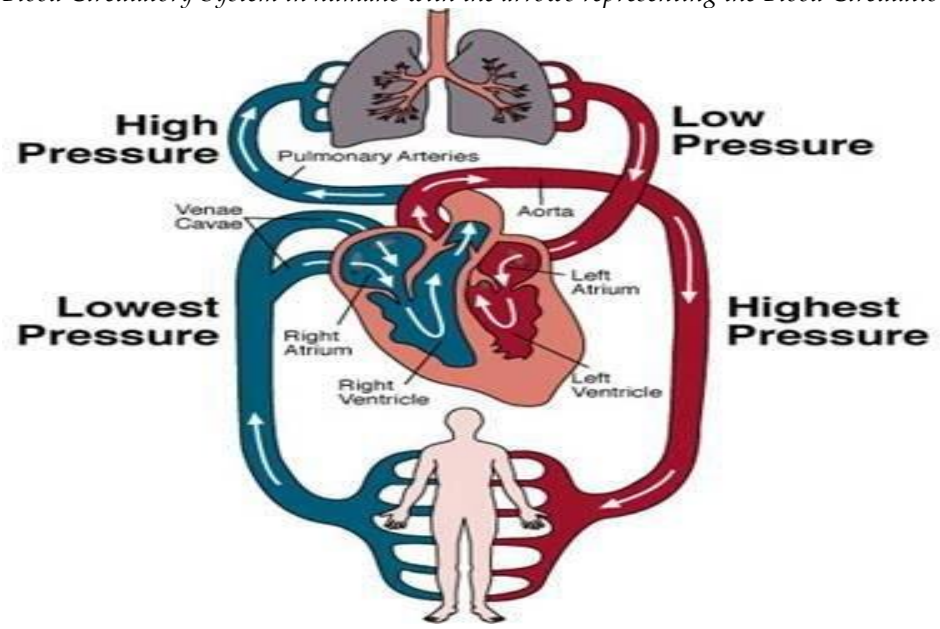
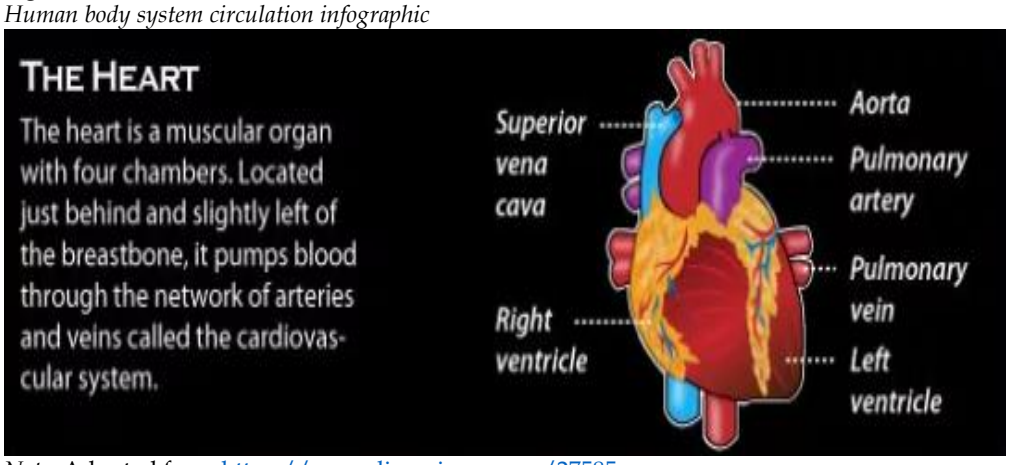


Figure 4
Blood Circulatory System in humans with the arrows representing the Blood Circulation into the Body



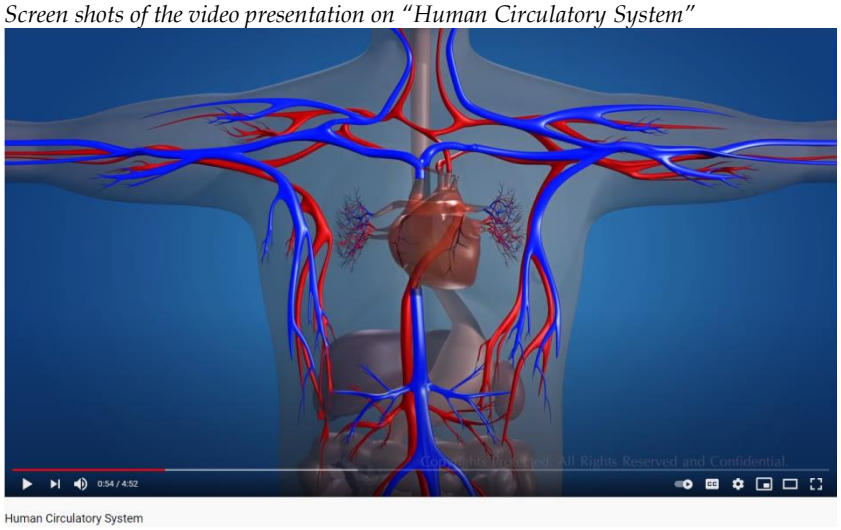
Note. Adopted from http://www.revisionworld.com/country.php

Figure 5
Human body system circulation infographic



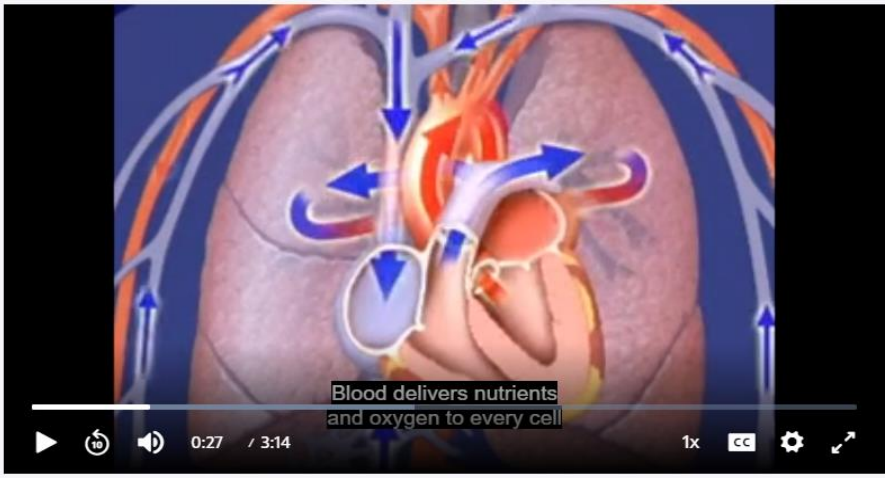
Note. Adopted from https://www.livescience.com/27585

Figure 2
Screen shots of the video presentation on "Human Circulatory System"



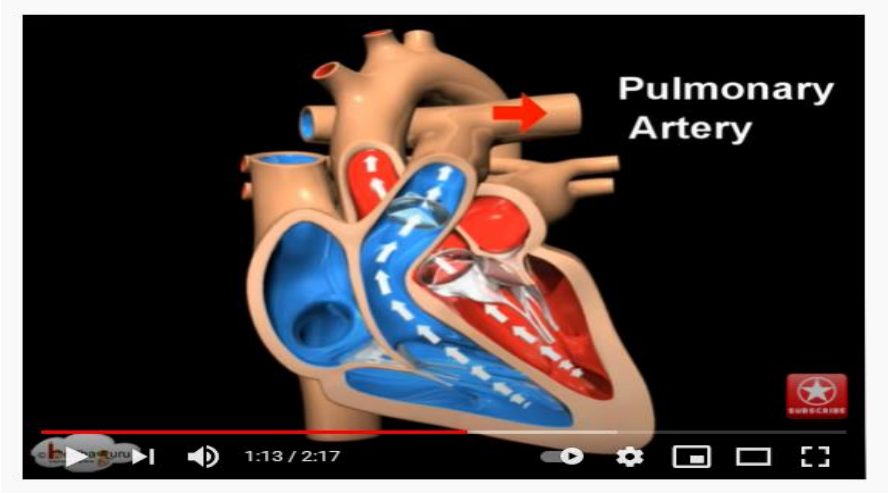
Note. Adopted from https://www.youtube.com/watch?v=_qmNCJxpsr0

Figure 3
Blood circulatory systems



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

Figure 4
How does human circulatory system work – 3D animation



Note. Adopted from https://www.youtube.com/watch?v=SwHjwO7BnsI

Figure 9
Types of Heart Diseases

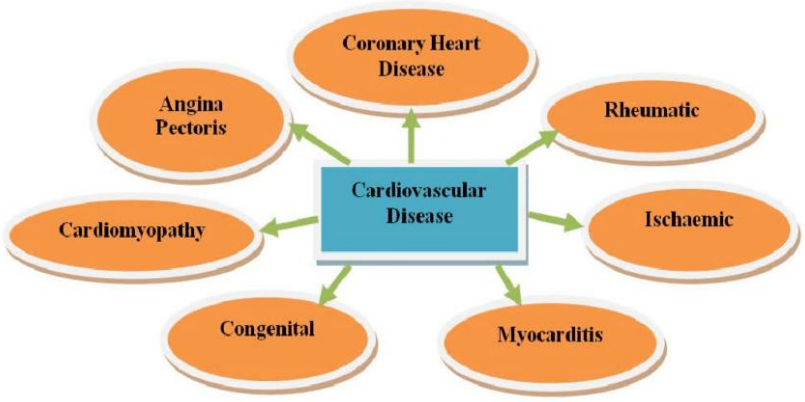
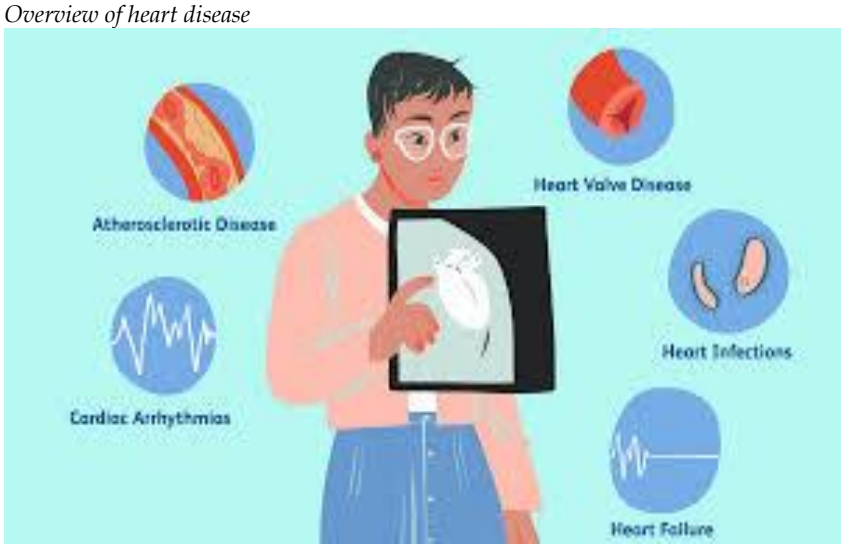
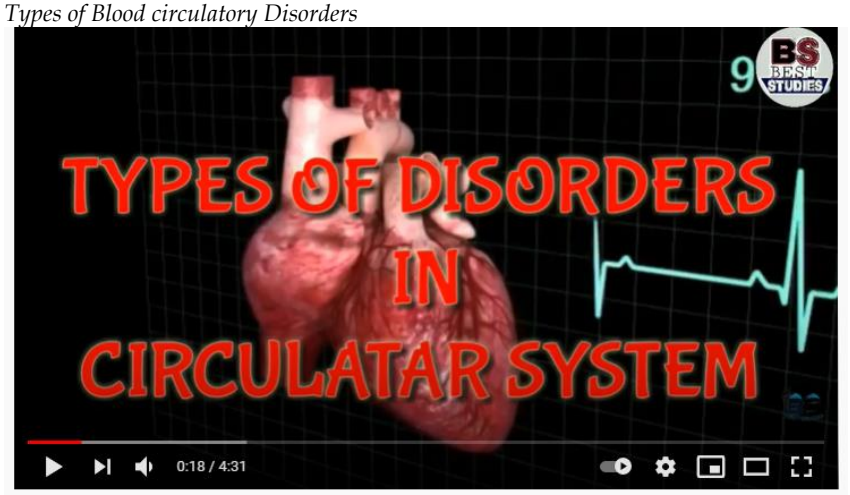


Figure 10
Overview of heart disease



Note. Adopted from https://www.verywellhealth.com/overview-of-heart-disease-4160961

Figure 5
Types of Blood circulatory Disorders



Note. Adopted from https://www.youtube.com/watch?v=6QaGyW-jkLY