UNIVERSITY OF EDUCATION, WINNEBA

EFFECT OF COOPERATIVE LEARNING ON STUDENTS' PERFORMANCE IN CIRCULATORY SYSTEM: THE CASE OF A TVET INSTITUTION IN VOLTA REGION

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A thesis submitted to the school of graduate studies in partial fulfilment of the requirement for the award of the degree of Master of Philosophy
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DECLARATION

Student's Declaration

I, **Robert Agana,** hereby declare that, apart from references and quotations contained in published works which have been identified and dully acknowledged, this thesis 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 work was supervised in accordance with the guideline for supervision of thesis as laid down by the University of Education, Winneba.

Supervisor's Name: Dr. Charles Koomson

Signature:……………………………...…

Date:………………………………..…….

DEDICATION

I dedicate the whole work and its achievement to my father, Agana Asagbeya.

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TABLE OF CONTENTS

Content **Page**

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This study used Cooperative Learning to improve TVET students' academic performance in circulatory system at Have Technical Institute. The study adopted action research design. A sample of 40 students were purposively sampled for the study. The instruments that were used to collect data for the study are test (SDT, SAT and SKRT) and questionnaire. Expert review was used to determine the validity of the instruments. Test retest method was used to determine the reliability coefficient for the test and Cronbach's alpha was used to determine reliability coefficient of the questionnaire. For three weeks, a Cooperative Learning intervention consisting of Think-Pair-Share, Numbered Heads Together and Jigsaw was implemented. Both descriptive and inferential statistics were used to analyse data. The study's findings revealed that cooperative learning significantly improved the academic performance of students in circulatory system. Implementation of cooperative learning has also improved students' retention of knowledge in circulatory system. No significant difference was observed between male and female students' academic performance in circulatory system after the implementation of cooperative learning. The findings also showed that students have developed positive attitude towards cooperative learning. Based on these findings, it was recommended that Integrated Science teachers in Have Technical Institute should adopt cooperative learning strategy in their lesson delivery to enable student actively engage in the lesson.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter highlights the background to the study, statement of the problem, purpose, objectives of the study, research questions, significance of the study, limitations and delimitations. The chapter also explained abbreviations and defined terms used in the study.

1.1 Background to the Study

Science is the foundation upon which the bulk of present-day technological break-through is built (Onasanya & Omosewo, 2011). With the rapid advancements in science and technology, the educational system faces the challenge of preparing learners to thrive in a changing and demanding world. This necessitates a shift in the focus of education from solely acquiring knowledge to the development of attitudes, skills, and competencies that enable learners to effectively apply their learning in real-life situations (Mafuwane, 2011). The Ghanaian curriculum has embraced the principles of standard-based education, emphasizing the connection between classroom learning and real-life experiences. Core competences, such as critical thinking, problem solving, creativity, collaboration, and digital literacy, have been identified as essential kills necessary for students' success in the ever-evolving world (Mahama, 2022). Mahama further asserted that, to foster the mastery of these competences, teaching approaches that engage students, sustain their interest, and bridge the gap between school learning and the real world are required.

In Ghana, TVET institutions are mandated to develop practical skills and technical knowledge of students in various fields of study. It is, therefore, essential for the education system to adapt varied instructional strategies that will help in the effective teaching and learning of subjects that will enable students to meet the required standards in their respective fields of endeavor.

Student-centred teaching approaches have gained prominence in science education research since it ensures students' active participation in the learning process. This ensures that meaningful learning and knowledge retention are enhanced (Granger et al., 2012: Brown, 2008). Traditional teaching methods, where students passively receive information, fall short in this regard.

Bhengu and Mkhize (2013) advocate for a shift from "telling and listening" to a more student-centred approaches. In student-centred learning, the role of the teacher transforms into that of a facilitator and guide, while the student becomes the central focus of the educational process. In preparing students for future challenges, it is crucial to expose them to real-life problems and provide opportunities for finding appropriate solutions. Social constructivist learning theory provides a functional framework for achieving the goals of science education by integrating interdependence of social and individual process in the co-construction of knowledge (Barak, 2017).

Cooperative learning is a learner-centered approach to instruction where students are arranged in pairs or small groups to help each other learn assigned material (Ashman & Gillies, 2003). Cooperative learning not only enhances students' academic performance but also promotes knowledge retention because students are actively engaged in processing and explaining concepts to peers, which reinforces learning. Additionally, cooperative learning positively influences students' attitudes toward learning, as working in groups creates a more enjoyable and motivating learning environment (Ashman & Gillies, 2003). The approach encourages collaboration, sharing of ideas, peer support, and active participation, which collectively improve students' academic performance, knowledge retention and attitude towards learning (Tran, 2019; Alrayah, 2018). While cooperative learning has gained popularity in various disciplines, its application in TVET institutions remains understudied (Luengo-Aravena et al., 2024). This study aims to fill this research gap by using the cooperative learning approach to improve TVET students' academic performance in the circulatory system, enhance knowledge retention, and foster positive attitudes toward learning.

Gender has been identified as a factor affecting students' academic achievement in Science subjects (Bradly, 2013). Girls tend to perform worse than boys in these subjects, and this gap broadens as students move up the academic lather (Raheem, 2012). When it comes to cooperative learning, the dynamics of gender can also play a role in academic performance (Ghaith, 2003). When implemented appropriately, it has been proven to equally enhance the academic performance of both male and female. (Johnson & Johnson, 2009). It was therefore necessary to assess if gender has any influence on the academic performance of TVET students in the circulatory system when taught with cooperative learning.

1.2 Statement of the Problem

The circulatory system is an essential component of the human body responsible for transporting oxygen, nutrients, and other vital substances, including hormones, throughout the body. It plays a critical role in maintaining homeostasis and keeping our bodies functioning correctly (Sungur & Tekkaya, 2003). However, many students of Have Technical Institute struggle with understanding the complexity of this system.

The researcher through his classroom practice observed that most students of Have Technical Institute have difficulties in understanding the circulatory system, leading to lack of interest in the subject. A thorough review of their exercise books and examination scripts revealed widespread difficulties, including the incorrect identification of parts of the heart, challenges in stating functions of the various parts of the heart. Students also have difficulties understanding how blood flows through the heart. Additionally, students faced difficulties grasping the concept of blood pressure. These challenges result not only in poor academic performance but also in low knowledge retention and a lack of sustained understanding of the circulatory system over time.

Moreover, students' attitude toward learning the circulatory system is often negative; many find the topic confusing and frustrating, which affects their engagement and willingness to participate in learning activities (Akongu et al., 2020). Traditional teaching methods used by science teachers have not been able to adequately address these issues, leaving students with poor understanding, limited knowledge retention, and low motivation to learn (Azure, 2018; Sungur & Tekkaya, 2003).

In addition, gender differences may influence how students respond to learning strategies. While some studies suggest that boys and girls may perform differently in science subjects (Bradly, 2013; Raheem, 2012), it remains unclear whether cooperative learning can equalize performance across genders in TVET settings.

Given these challenges, there is a need to explore innovative teaching approaches that not only improve academic performance but also enhance knowledge retention, foster positive attitudes toward learning, and address gender-related differences in achievement. Research by Ali and Raza (2024) suggests that cooperative learning can address these gaps by actively engaging students and supporting peer learning. Therefore, this study used cooperative learning to improve TVET students' academic performance, knowledge retention, attitudes toward learning, and address gender-based differences in understanding the circulatory system.

1.3 Purpose of the Study

The purpose of the study was to use cooperative learning to improve TVET students' academic performance in the circulatory system at Have Technical Institute in the Volta Region of Ghana.

1.4 Objectives of the Study

The objectives of the study were to:

1. assess the effect of cooperative learning on TVET students' academic performance in circulatory system.
2. determine the influence of gender on students' academic performance in circulatory system when taught with cooperative learning.
3. determine the effect of cooperative learning on students' knowledge retention.
4. determine the attitude of students towards the use of cooperative learning during Integrated Science lessons.

1.5 Research Questions

The following research questions guided the study.

1. What is the effect of cooperative learning on TVET students' academic performance in circulatory system?
2. What is the influence of gender on students' academic performance in circulatory system when taught with cooperative learning?
3. What is the effect of cooperative learning on students' knowledge retention?

4. What is the attitude of students towards the use of cooperative learning during Integrated Science lessons?

1.6 Significance of the Study

The academic performance in integrated science, of students who participated in this study was improved.

Furthermore, the study's results can serve as a basis for Integrated Science teachers in Have Technical Institute to transition from traditional teacher-centred approaches to student-centred approaches. By incorporating cooperative learning strategies, teachers can enhance students critical thinking abilities, social cohesion and team spirit. This shift towards student-centred instruction can have positive impact on students' engagement and learning outcomes.

Also, the findings of this study may motivate other science teachers in Have Technical Institute to embrace cooperative learning method of teaching to improve the academic performance of their students.

The study offered insight in to how gender influenced students' academic performance when cooperative learning is used.

The study also provided insights into the attitudes of TVET students towards the use of cooperative learning in the teaching circulatory system. This will help facilitators to understand students' perception of cooperative learning as an instructional method and guide them in understanding how they can improve on the implementation of this learning method

Finally, the study may contribute to existing literature on the use of cooperative learning method in science education.

1.7 Limitations of the Study

One limitation of this study was the relatively small sample size of TVET students involved. Due to practical and financial constraints, it was not possible to include a large number of participants.

Again, the implementation of cooperative learning requires some substantial amount of time to design and facilitate meaningful cooperative activities. Time constraints limited the duration and the depth of the interventions due to packed TVET curriculum. This limitation affected the extent to which participants could fully participate in the intervention processes.

Finally, test anxiety on the part of students could possibly affect their scores on both the pre-intervention and post-intervention tests. To minimize this limitation, the researcher assured students that the tests were not meant for grading or punishment but were solely for learning purposes. Students were encouraged to see the tests as part of normal classroom activities. Sufficient time was provided, and a calm, familiar classroom environment was maintained during all assessments to help reduce anxiety and ensure that students performed to the best of their abilities

1.8 Delimitation of the study

The study was delimited to only final year Mechanical Engineering Technology (MET) students of Have Technical Institute. The findings and conclusions drawn from this research may not be directly applicable to students in other second cycle institutions with different educational systems or contexts. The scope of the study was narrowed down to final year students only because they have already covered circulatory system. Every student has his/her ways of grasping concepts but this study only focused on cooperative learning strategy which may not be favorable to all students.

Also, the study focused on cooperative learning as an intervention to improve TVET students' performance in circulatory system and may not be applicable to other science topics.

1.9 Organization of the Study

This thesis is organized into five chapters. Chapter one presents an introduction to the study, outlining the background, research aim, objectives, questions, and significance. The chapter further highlights the limitations and delimitations as well as the significance of the study. Chapter two presents a comprehensive review of the relevant literature on Cooperative Learning in science education. It also highlights on some theoretical frameworks supporting the use of Cooperative Learning. Additionally, the chapter presents a thorough review of studies conducted utilizing Cooperative Learning with their findings. This chapter end with a conceptual framework.

Chapter three describes the research methodology, including the research design, sample selection, data collection methods, and data analysis techniques. Chapter four presents the findings of the study and discusses the results in relation to the research questions. Finally, Chapter five provides a summary of the research, conclusions, implications, and recommendations for future research.

1.10 Operational Definitions

In this study the following operational definitions were used;

- **Cooperative learning:** A learner centered approach to instruction where students are arranged in pairs or small groups to help each other learn assigned subject matter
- **Academic Performance:** The level of achievement and success of TVET students in terms of their understanding and application of knowledge and skills related to circulatory system
- **TVET students:** Students enrolled on technical and vocational education programs, focusing on practical skills and competencies in their specific disciplines.
- **STEM Education:** It is an inter disciplinary approach to learning that integrates science, technology, engineering and mathematics

1.11 Abbreviations

- **GTVETS**: Ghana Technical Vocational Education and Training Service
- **NABPTEX**: National Board for Professional and Technical Examination
- **STEM**: Science, Technology, Engineering and Mathematics
- **TVET**: Technical Vocational Education and Training
- **UNESCO:** United Nations Educational, Scientific and Cultural Organizations

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter reviews existing literature on the use of cooperative learning as an instructional approach in science education, stressing on its significance and types. It also delves into the theoretical foundation that support the use of cooperative learning. It also presents empirical studies that adopted the use of cooperative learning. The chapter concludes with a conceptual framework.

2.1 Cooperative Learning

2.1.1 Background to Cooperative Learning

Cooperative learning (CL) is an instructional strategy in which students work together in small groups to achieve shared learning goals, where each member's success is linked to the success of others (Johnson & Johnson, 2002). It stresses collaboration, active participation, and the co-construction of knowledge through peer interaction. Johnson and Johnson (2002) emphasised interdependence in cooperative learning. To them, students can reach their learning goals if and only if the other students in the learning group also reach their goals. This implies that every learner has responsibility of his own understanding as well as the understanding of the whole team.

They emphasised that reward should be a part of cooperative learning process so that each learner would maximise his efforts to understand as well as help the other team members to understand the concept for the success of the team. They believe that group work gives the individual a double task; the first one is to understand the materials and the second one is to make sure that the other group members understand the materials.

Johnson and Johnson (2002) also focused on the social skills which is one of the principles of cooperative learning. They stated that it is important for the students to believe that every individual is important for the group in order to make the learning groups cooperative in nature. They added that the students in each group should use the appropriate social skills needed for cooperative learning.

In this study, cooperative learning was relevant for teaching the circulatory system in integrated science because by engaging students in structured group activities, cooperative learning enhances academic performance, encourages knowledge retention, and fosters positive attitudes towards learning complex scientific concepts (Ahmed & Lawal, 2020; Firmasya & Dadang, 2022). It provides an interactive environment where learners can discuss, question, and clarify concepts collaboratively, thus improving both understanding and motivation (Yang, 2023).

Historically, cooperative learning evolved from the early work of the Gestalt psychologists, notably Kurt Koffka, and was later refined by Kurt Lewin, a social psychologist in the 20th century who emphasized interdependence in group dynamics (Choi et al., 2011; Johnson & Johnson, 2015). The formalization of cooperative learning strategies was developed in the 1960s and 1970s by David and Roger Johnson and Robert Slavin, who operationalized group-based learning models for classroom application (Mesley et al., 2013; Slavin, 2009). Today, cooperative learning is widely adopted in all levels of education cross the globe due to its positive effects on student learning outcomes, engagement, and social cohesion (Yassin et al., 2018).

2.1.2 Cooperative learning strategies

There are several cooperative learning strategies that are employed in various classrooms to improve students' academic performance and social cohesion (Pratt, 2003). Felder and Brent (2001) identified jigsaw, learning together, student teams-achievement divisions, think-pair-share, rally coach and round table as the commonly used cooperative learning strategies. Pratt (2003) emphasized that, though each of these strategies can be used alone, the outcome is maximized when multiple cooperative learning strategies are employed for a lesson.

Jigsaw: The Jigsaw method was developed by Elliot Aronson is 1978 (Hedeen, 2003). In the Jigsaw method, students are assigned to multi-member teams to work on academic material that has been divided into sections (Faizah, 2018). Each member of the group is assigned a section of study on which he or she becomes an expert. Experts are then assigned to expert groups in which the members of the group discuss the information and decide on the best way to present the material to members of their home teams. After the students have mastered the material, group members return to their home teams to teach the other members the material (Hedeen, 2003). Hedeen (2003) argues that the jigsaw technique offers students an innovative way to process and retain information more effectively by teaching others. This strategy is mostly used for a group project or class research. Sometimes it is used to read sections of a text or discuss sections of a topic.

Learning together: Learning together is a cooperative learning strategy that was developed in 1987 at the University of Minnesota by David W. Johnson and Roger T. Johnson. Learning together was originally designed to help train teachers how to use cooperative learning groups in the university (Ahmed & Lawal, 2020). It involves students working in four to five heterogeneous groups, sharing an opinion on a given material (Gaith, 2003). Leaning together model of cooperative learning promotes team building, and allow learners to work in groups and discuss how well they are getting along with each another. Team members assist, share, encourage and support one another's effort to succeed through promotive interaction within the group (Ahmed & Lawal, 2020). The learning together strategy was developed based on the principle of: face-to-face interaction, social skills, group processing, positive interdependence, and individual accountability (Ahmed & Lawal, 2020).

Rally Coach: This is a great structure used by students to solve problem mostly involving calculation. The Rally Coach cooperative learning model was introduced by Kagan and Kagan (Kagan, 2009). According to Kagan (2009), Rally coach model of cooperative learning is a learning which involves a pairing of student with different abilities to help each other in solving a problem. With this, students work in partners and one student will be the "coach" while the other student solves the problem and then they will switch. One student will solve a problem and the other student will tell him/her what to do or evaluate how he/she did it. Then, they will switch and the other student will coach while the other student completes the problem (Kagan 2009)

Round Table: Like Rally Coach, Round Table model of cooperative learning was introduced by Kagan and Kagan (Kagan, 2009). According to Kagan (2009) Round Table is a model of cooperative learning in which students provide ideas in their turn to solve a problem. Each student contributes to the assignment given to them and a group feedback is given in written. This strategy can be used for group writing or brainstorming. Students pass around a paper and everyone writes on it. Usually, time is given so that each student has the same amount of writing time (Suryani et al., 2021).

Student Teams-Achievement Divisions (STAD): it is a cooperative learning strategy in which small groups of learners with different levels of ability work together to accomplish a shared learning goal. It was devised by Robert Slavin and his associates at Johns Hopkins University (Slavin, 2006).

STAD is considered as one of the most researched, simplest, and most straightforward of all cooperative learning (Slavin, 2006). It was established based on the fulfillment of instructional pedagogy and is used in meeting well-defined instructional objectives (Slavin, 2006). It's consists of a small group of learners with different levels of abilities, where they all come together to accomplish a shared learning goal (Slavin, 2015). In STAD students are assigned to a four-member learning teams that are mixed in performance level, ethnicity and gender. The teacher presents a lesson, and students work within their teams to make sure that all team members have mastered the lesson. Students take individual examinations on the content. Students' exam scores are compared to their past averages, and points are awarded on the basis of the extent to which students meet or surpass their own previous performance. These points are then summed to form team scores, and teams that meet certain criteria are rewarded (Kagan & Kagan, 2009).

Think-Pair-Share (TPS): It is a cooperative learning activity that can work in varied size classrooms and in any subject (Sharma & Saarsar, 2018). This strategy requires students to think individually about a topic and share ideas with classmates. This strategy was developed by Frank Lyman and his colleagues in Maryland (Sharma & Saarsar, 2018). They further stated that this model got its name from the three stages of student action, with emphasis on what students are to do at each of those stages. Singh et al. (2020) identified three stages of this strategy of CL. These are: 1) **Think**. The teacher provokes students' thought with a question, and instructs students to take few moments just to think about the question.

2) **Pair**. Using designated partners, students pair up to talk about the answer each came up with. They compare their answers and identify the answers they think are most convincing.

3) **Share**. After students talk in pairs for a few moments, the teacher calls each pairs to share their answers with the rest of the class.

Three of these cooperative learning strategies were used for the study. These include Think-Pair-Share, Numbered Heads Together and Jigsaw cooperative learning. The choice of these cooperative learning strategies for the study was informed by their suitability for achieving the research purpose. These strategies promoted active participation, peer teaching, and collaborative problem-solving, which are essential for enhancing academic performance, knowledge retention, and positive attitudes toward science learning. Jigsaw, in particular, was selected because it allows for structured group interdependence, ensure individual accountability, and provide opportunities for all students irrespective of their gender to contribute and learn from each other. Think-Pair-Share and Numbered Heads Together were included to encourage discussion, reflection, and immediate feedback, facilitating deeper understanding and reinforcing students' mastery of complex scientific concepts.

2.1.3 Types of cooperative learning groups

Ternenge and Ember (2021) identified three main types of cooperative learning groups. These include formal, informal and base group.

2.1.3.1 Formal cooperative learning group

Dyson and Casey (2016) defined formal cooperative learning as students working together, for one class period to several weeks, to achieve mutual learning goals and complete jointly specific tasks and assignments. The formal cooperative learning group is the most widely used type among the three (Jollife, 2007). These groups provide the foundation for all other cooperative learning procedures. Facilitators can build any course requisite in any subject area for any age of student cooperatively (Stevens, 2008).

Johnson and Johnson (2009) assert that in order to ensure that all students have individual accountability and are vigorously involved in the groups, it is advisable for facilitators to assign a specific task for each group member. Teachers may assign task to students according to their abilities, or allow students to choose their own task once they have gained a certain level of confidence and autonomy (Gillies, 2004). Although assigning roles to group members is very crucial, Gillies (2004) opined that as matured students become familiar with doing group work, it is not necessary for teachers to define the exact roles for each student within the group. Students at this stage are able to organize themselves and share the roles according to their own ability

2.1.3.2 Informal cooperative learning group

An informal cooperative learning group is one in which students work together temporary in an ad hoc group that last for only one discussion or period to achieve shared learning goals (Slavin, 2006). According to Gillies (2004), informal cooperative learning groups are used to psyche students and focus their attention on the content to be learned, ensure students cognitively process the material being taught, and provide closure to an instructional session. Informal cooperative group is suitable for laboratory work in science lessons since it is not always possible to provide material for individual manipulation (Slavin, 2006).

2.1.3.3 Cooperative base groups

Cooperative base groups are long-term, heterogeneous cooperative learning groups with a fixed membership, whose main obligation is to give each member the needed support and encouragement to progress academically and develop cognitively and socially (Lubbe, 2020). Base groups have permanent membership and provide the long-term caring peer relationships necessary to help students develop cognitively and socially and also influence members to work harder in striving to achieve (Lubbe, 2020).

Webb (2008) believes that is important to have base groups in large classes because it improves attendance, personalizes the work required and improves the quality and quantity of learning. Dyson and Casey (2016) pointed out that base groups formally meet once a while to provide help and assistance to each other, confirm that each member is completing assignments and progressing satisfactory through the academic program, and discuss the academic progress of each member.

2.1.4 Elements of cooperative learning

Jocobs and Renandya (2019) stated that cooperative learning is more than just working in groups, and should include the following five basic elements: positive interdependence, individual accountability, promotive interaction, social skills, and group processing.

Positive interdependence is where team members rely on one another to achieve a common goal, and the entire group suffers the consequences if one member fails to do his or her work (Jocobs & Renandya, 2019). Positive interdependence exists when individuals perceive that they can reach their goals if and only if the other people with whom they are cooperatively related also reach their goals and, therefore, promote each other's efforts to achieve the goals (Nam & Zellner, 2011). Nam and Zellner perceived positive interdependence as the focal point of cooperative efforts. Slavin (2006) suggests that for a cooperative learning group to be successful, students must accept that they are linked with groupmates in a way that they cannot succeed unless their groupmates succeed. Positive interdependence among students according to Johnson and Johnson (2008), must be structured into the lesson for it to be cooperative. According to Nam and Zellner (2011), group dynamics play an important role in effective cooperation, and positive interdependence is key to a group's ability to accomplish a common goal.

Individual accountability is the aspect where each member of the group is held accountable for doing his or her share of the work (Jocobs & Renandya, 2019). Each group member is individually accountable to contribute his or her share of the group's work. Individual accountability exists when the performance of each individual student is assessed and the results are given back as feedback to the group and the individual (Nam & Zellner, 2011). Individual accountability includes completing one's share of the work and assisting the work of other group members. Individual accountability, according to Jocobs and Renandya (2019) can be structured by observing students as they work together and documenting the contributions of each member.

Promotive interaction is where most of the tasks are performed through an interactive process in which each group member provides feedback, challenges one another, teaches and encourages his or her team mates (Jocobs & Renandya, 2019). With promotive interaction, students promote each other's success by helping, assisting, praising, encouraging, and supporting each other's efforts to learn (Baines et al. 2008). Promotive interaction, according Jocobs and Renandya (2019), results in cognitive processes such as discussing the nature of the concepts being learned, orally explaining to others how to solve problems, teaching one's knowledge to team mates, challenging each other's reasoning, and connecting present with past learning. Interpersonal processes such as supporting and encouraging efforts to learn, jointly celebrating the group's success, and modeling appropriate use of social skills, according to Baines et al., (2008) are also promotive interactions.

Social skills involve appropriate use of collaborative skills where students are provided with the opportunity to develop and implement trust-building, leadership, decision-making, communication, and conflict management skills (Jocobs & Renandya, 2019). The success of every cooperative effort needs interpersonal and small group skills (Gillies, 2006). According to Jocobs and Renandya (2019), cooperative learning through its social skills component has been used to precisely teach skills such as leadership, trust-building, communication, decision-making, and conflict-management just like academic skills.

Group processing is defined by Stiles (2005) as the examination of the effectiveness of the process members use to maximize their own and each other's learning, so that ways to improve the process may be identified. In group processing, team members establish group goals, they occasionally assess their performance as a team and often identify changes that need to be made in order for the group to function more effectively (Dyson & Casey 2016).

2.2 Theoretical Framework

2.2.1 Social Constructivist Learning Theory (Vygotsky)

This study was grounded in social constructivism; a learning theory propound by Lev Vygotsky in the early 1920s. The theory posits that knowledge is constructed through social interaction, collaboration, and the mediation of more knowledgeable others (Amineh & Asl, 2015; Kim, 2001). Learning is not a passive reception of information, but an active process where learners co-construct meaning through engagement with peers, teachers, and the environment (Graesser et al., 2003; Tudge & Rogoff, 2014). Vygotsky (1978) emphasized that cognitive development occurs when learners interact socially within their environment, and that intellectual growth is closely linked to these collaborative experiences.

Central to social constructivism is Vygotsky's Zone of Proximal Development (ZPD), which defines the difference between what a learner can achieve independently and what they can achieve with guidance or collaboration (Kearsley, 2001). The ZPD identifies three essential components: (i) learners' current developmental level, (ii) tasks they can perform with support, and (iii) scaffolding provided by more knowledgeable peers or adults (Karpov, 2003). In the context of this study, cooperative learning strategies placed students within their ZPD, enabling them to engage in complex scientific tasks that would have been challenging to complete individually.

Scaffolding plays a central role in supporting learners as they interact and co-construct knowledge in cooperative learning settings (Obukhova & Korepanova, 2009). Vygotsky's Zone of Proximal Development (ZPD) suggests that learners achieve higher levels of understanding when supported by more knowledgeable peers or the teacher, and this temporary guidance known as scaffolding enables students to progressively assume responsibility for their learning (Vygotsky, 1978). Firmasya and Dadang (2022) described scaffolding as structured assistance that is gradually withdrawn as learners gain competence. In the cooperative learning strategies used for this study, scaffolding occurs naturally through peer explanations, guided group tasks, and structured interaction, which helped students clarify difficulties related to the circulatory system. Johnson and Johnson (2008) and Spiro and DeSchryver (2009) emphasised that such structured peer support encourages active engagement and conceptual understanding, therefore reinforcing the effectiveness of cooperative learning in improving academic performance, knowledge retention, and student attitude towards science learning.

Social constructivism asserts that learning is embedded in cultural and social contexts, where knowledge is co-constructed rather than passively received (Amineh & Asl, 2015; Graesser et al., 2003). The theory emphasizes that learners' prior experiences, social interactions, and the learning environment collectively shape understanding. In the TVET science classroom, this meant that students' engagement in cooperative activities provided them with the opportunities to negotiate meaning, and clarify misconceptions in collaboration with peers.

Cooperative learning strategies such as Jigsaw, Think-Pair-Share, and Numbered Heads Together were selected for this study because they aligned with these social constructivist principles. Each strategy encouraged active participation, peer scaffolding, and interdependence among learners. Jigsaw required students to become "experts" in assigned subtopics and teach their peers, promoting accountability, deeper understanding, and peer teaching (Slavin, 2009). Think-Pair-Share allowed students to reflect individually, discuss with a partner, and then share with the larger group, promoting reflective thinking and peer learning (Kagan, 2009). Numbered Heads Together engaged students in group problem-solving while ensuring individual accountability, ensuring that all members contributed to the solution (Slavin, 2011). These strategies were carefully chosen because they supported active co-construction of knowledge, encouraged meaningful discussion, and facilitated scaffolding, all of which are central views of social constructivism.

Social constructivism also emphasizes that meaningful learning is situated in authentic tasks (Amineh & Asl, 2015). In this study, circulatory system was presented in ways that required students to work collaboratively. This approach encouraged learners to apply theoretical concepts to practical scenarios, enhancing understanding and retention of knowledge. Moreover, social constructivism suggests that learners develop cognitive, social, and affective skills simultaneously (Davin, 2011). By using structured cooperative learning activities, students do not only learn scientific content but also develop critical thinking, communication, teamwork, and problem-solving abilities (Kim, 2001; Asare, 2016). These outcomes directly supported the research objectives, which included assessing academic performance, knowledge retention, attitude toward learning, and the influence of gender on these variables.

Vygotsky (1978) emphasized that higher mental functions originate as social processes before becoming internalized. In this study, students' engagement in cooperative learning provided opportunities for shared problem-solving, discussion, and reasoning, which allowed learners to internalize scientific concepts and strategies for independent use. The dynamic and interactive nature of cooperative learning aligned closely with the ZPD, ensuring that all learners were challenged according to their developmental level while receiving necessary support (Karpov, 2003).

The integration of social constructivism in this study justifies the use of cooperative learning as the primary intervention. By providing learners with structured collaborative experiences, the study created an environment in which students actively co-constructed knowledge, scaffolded each other's learning, and developed positive attitudes toward science. The social constructivist framework also underscored the importance of peer interaction, contextualized learning, and learner-centered pedagogy (Kim, 2001), all of which were central to the study's design

2.3 Empirical Review

This section critically examined empirical studies on cooperative learning in science and mathematics education. It focused on the effects of cooperative learning on students' academic performance, knowledge retention, and attitudes. Both international and local studies were considered to highlight the widespread effectiveness of cooperative learning strategies.

2.3.1 Effect of Cooperative Learning on Student Academic Performance

Several studies have established that cooperative learning (CL) improves learners' academic performance across science subjects.

Zakaria et al. (2013) found that students taught mathematics through cooperative learning achieved higher post-test scores than those taught using conventional methods. Their quasi-experimental study involving 82 Form One students revealed that the experimental group (CL) significantly outperformed the control group, demonstrating that collaborative problem-solving creates deeper understanding and improves academic results.

Similarly, Aziz and Hossain (2010) compared cooperative learning with traditional teaching in secondary school science. Using 62 Grade IX girls assigned to experimental and control groups, their findings showed that the CL group significantly outperformed their counterparts after the intervention. This confirmed that active involvement and peer support in CL activities strengthened students' science performance.

Demirci (2010) reported comparable findings in a study examining achievement and attitudes under cooperative versus conventional learning environments. With 78 students using quasi experiment, the study established that cooperative learning led to superior achievement scores. Students in CL classrooms demonstrated better conceptual mastery because of increased interaction and shared explanation.

Kolawole (2008) conducted a study to investigate the effects of the cooperative and competitive learning on academic performance of students in mathematics. The study sought to find out which one of them is the more effective learning strategy. The sample of the study was 400 Senior Secondary Schools III Mathematics students made up of 240 boys and 160 girls randomly selected from four out of five States in South West Nigeria. Quasi experimental design was adopted for the study. The results showed that cooperative learning was more effective in improving academic performance than competitive learning. Notably, boys and girls performed similarly under cooperative learning, indicating that CL supports achievement across gender groups.

Jumoke-Bukunola and Idowu (2012) also demonstrated that cooperative strategies significantly enhanced Nigerian Junior Secondary School students' academic achievement in basic science. Students exposed to cooperative strategies recorded higher immediate achievement than those in lecture-based classrooms.

Mbacho (2013) investigated the effect of the jigsaw cooperative strategy on secondary school mathematics performance in Kenya. Using a Solomon Four-Group design, the study found that students taught using jigsaw performed significantly better than those taught using conventional methods.

Assan-Donkoh et al. (2019), in Ghana, found that CL positively influenced students' performance in mathematics. Using pre-tests, post-tests, and questionnaires with 60 students, they reported that cooperative instructional strategies significantly improved students' understanding of Circle Theorem concepts compared to traditional teaching. Mak-Mensah et al. (2018) also confirmed the positive effect of CL on science performance among upper primary pupils in Ghana. Their quasi-experimental design involving 32 students established that learners taught with CL recorded better academic performance than those taught with traditional approaches.

Overall, the reviewed studies demonstrate that the consistent improvements in students' academic performance under cooperative learning arise from the instructional mechanisms embedded in cooperative structures. Scholars such as Johnson and Johnson (2009), Slavin (2015), Gillies (2016), and Kagan (2009) emphases that when learners work in groups that require positive interdependence, mutual support, and individual accountability, they are more likely to engage in deeper cognitive processing than in competitive or individualistic classrooms. Peer explanation, shared problem-solving, and the requirement for each learner to contribute meaningfully help students clarify misconceptions and reinforce correct scientific ideas. These cooperative interactions also provide opportunities for scaffolding and elaborative learning, processes known to strengthen conceptual understanding. Consequently, cooperative learning remains a powerful pedagogical approach for enhancing academic performance, especially in science-based subjects where conceptual clarity and active engagement are essential (Slavin, 2015; Gillies, 2016).

2.3.2 Effect of Cooperative Learning on Students' Knowledge Retention

Several studies have shown that cooperative learning does not only improve academic performance but also enhances students' knowledge retention.

Tran (2014) investigated the effect of CL on achievement and retention among first-year university students in Vietnam. Using experimental and control groups (n = 110), the findings indicated that the CL group scored significantly higher on retention tests than those taught via lecture. This showed that peer interaction and repeated discussion help sustain long-term memory of learned content.

Odoh, (2012) conducted a study to determine effects of cooperative instructional strategy on chemistry students' achievement and retention in the three educational zones of Benue state, Nigeria. The study employed quasi experimental design with a sample of 230 senior secondary 2 chemistry students drawn randomly from six schools. The study concluded that students taught using cooperative strategies not only performed better but also retained content longer than those taught conventionally. The group-based learning experiences facilitated deeper processing of information, enabling students to store and recall concepts more effectively.

In Ghana, Osei and Appiah-Twumasi (2018) investigated the effect of CL on teacher trainees' retention of science concepts at Berekum College of Education. Using achievement tests and delayed post-tests, they found that CL significantly improved long-term retention. The study also revealed that CL promoted male and female students' retention equally.

Jumoke-Bukunola and Idowu (2012) investigated the effectiveness of cooperative learning strategies on Nigerian Junior Secondary students' academic achievement and knowledge retention in basic science in CSIT department, faculty of education, Olabisi Onabanjo University. Quasi experimental design was used with (n=120) students randomly assigned to experimental and control groups. Their study found that students in cooperative groups achieved higher delayed post-test scores, indicating superior long-term learning.

Taken together, the reviewed studies show that cooperative learning enhances not only immediate academic gains but also long-term knowledge retention. According to Johnson and Johnson (2009), Gillies (2016), and Slavin (2015), repeated engagement with peers through discussion, questioning, and collaborative problem-solving leads learners to revisit key concepts multiple times in varied contexts. This type of elaborative rehearsal strengthens memory consolidation and supports deeper understanding, making scientific ideas easier to recall later. Cooperative group work also encourages students to explain concepts in their own words, compare perspectives, and negotiate meanings (Graesser et al., 2003) These findings therefore suggest that cooperative learning provides a rich cognitive environment that supports the retention of science concepts far better than traditional lecture-based instruction.

2.3.3 Influence of Cooperative learning on Academic Performance in Science by Gender

The question of whether gender influences students' academic performance has been widely studied in educational research. Gender has been identified as a factor affecting students' academic performance in science concepts (Raheem, 2012; Bradly, 2013). Girls tend to perform worse than boys in science, and this gap broadens as students move up the academic lather (Bradly, 2013). In recent years, researchers have increasingly focused on how various instructional strategies, including cooperative learning, affect gender-based performance in the classroom. Cooperative learning, has been found to reduce gaps in academic achievement, including those related to gender (Josiah & Mankilik, 2020).

Several studies have established that cooperative learning builds an equitable environment that benefits both male and female students. For example, a study by Josiah and Mankilik (2020) found that cooperative learning promotes equal participation among genders and reduces competitive tension, which can sometimes disadvantage one gender over another. This has been supported by the meta-analysis conducted by Ndebil and Ali (2024) which found that there were no significant gender differences in academic performance when students were taught using cooperative learning strategies. They observed that cooperative learning supports collaboration, which tends to reduce the possible gender-based performance gaps mostly observed in traditional teaching methods.

Also, Kolawole (2008) found no significant difference in academic performance between boys and girls in cooperative learning groups, whereas boys performed better than girls under competitive learning conditions. Assan-Donkoh et al. (2019) also reported that both male and female students benefited from cooperative learning in mathematics, with performance improvements evident in both genders.

Johnson and Johnson (2009) explain that cooperative learning ensures positive interdependence and individual accountability, allowing students of both genders to participate equally and contribute meaningfully to group tasks. This equitable engagement reduces the influence of gender stereotypes and fosters an inclusive learning environment. Similarly, Demirci (2010) observed that cooperative groups encouraged active participation among all students, leading to improved outcomes for both males and females.

A study by Mbacho (2013) shows that cooperative learning improves social interaction and academic engagement for all students, irrespective of gender. In her study, both male and female students showed higher satisfaction and academic improvement after participating in cooperative learning activities. In a similar study, Gupta and Jain (2014) found that male and female students equally benefited from cooperative learning in terms of both cognitive and social outcomes.

Some studies have noted that while overall academic performance may not differ significantly between genders in cooperative learning environment, the form of participation sometimes varies. For instance, Boaler (2003) found that male students were more likely to take on leadership roles within groups, while female students were often more collaborative and less dominant. Despite these differences in participation styles, the academic results remained largely comparable across genders

Cooperative learning possesses several features that directly enhance female students' engagement in science lessons. Key elements such as positive interdependence, individual accountability, and structured group roles ensure that every learner participates meaningfully, thereby reducing the likelihood of male dominating discussions (Johnson & Johnson, 2009; Josiah & Mankilik, 2020). The emphasis on collaboration rather than competition creates a supportive social climate in which girls feel more confident to contribute, ask questions, and express scientific ideas without fear of ridicule (Boaler, 2003; Webb, 2008; Gillies, 2016). Furthermore, the peer-support mechanisms embedded in cooperative learning such as shared responsibility and mutual encouragement help to build girls' self-efficacy and interest in science activities (Slavin, 2011). These features collectively promote equitable participation, narrow gender gaps, and increase the motivation and active involvement of female students in science classrooms

2.3.4 Students' Attitude Toward Cooperative Learning in Science

Students' attitude toward cooperative learning has been a topic of interest for instructors seeking to implement this instructional strategy effectively. Research consistently shows that cooperative learning enhances not only students' academic performance but also promotes positive attitudes toward learning.

Zakaria et al. (2013) reported that students exposed to cooperative learning in mathematics exhibited improved motivation and enjoyment. Demirci (2010) and Assan-Donkoh et al. (2019) also found that cooperative strategies encouraged participation, confidence, and positive perceptions of learning. According to Gubbad and Mohammed (2010) and Trung and Truong (2023), cooperative learning develops social and communication skills by enabling students to work collaboratively, discuss ideas, and negotiate solutions. Pettibone (2006) further observed that students engaged in cooperative learning demonstrate higher-order thinking, critical analysis, and problem-solving abilities. Ross (2008) emphasized that group discussions and peer interactions foster diversity awareness, inclusion, and mutual respect, enhancing social cohesion within the classroom.

According to Sibomana et al. (2022), students who engage in cooperative learning often develop more positive attitudes toward learning and the subject matter than their peers peer who engage in the traditional learning method. Studies have revealed several reasons for students' positive attitude towards cooperative learning.

One of such reasons is that cooperative learning promotes a sense of belonging and social support within the classroom. Bachtold et al. (2023) argued that cooperative learning fosters interdependence among leaners, creating an enabling environment where they feel more comfortable sharing ideas, asking questions, and offering help to each other. This supportive environment mostly increases student motivation and engagement, leading to their positive attitude towards the subject matter. A study by Parvens et al. (2011) established that students appreciate the interactive nature of cooperative learning, especially in subjects that are often seen as difficult, such as science and mathematics. Students reported that working in small groups made it easier for them to understand complex concepts and solve tough mathematical problems. This agrees with findings from Sharan and Shachar (2012), who observed that students' attitudes toward learning improved when they were responsible for explaining concepts to their peers during cooperative learning sessions.

Another factor contributing to students' positive attitudes is the sense of ownership and responsibility that cooperative learning promotes. In a study by Akhtar et al. (2012), students specified that they enjoyed being part of a team and felt more accountable for their own learning and the learning of their group members. This sense of responsibility increased their engagement and also enhanced their overall satisfaction with the learning process.

The positive social interactions incorporated in cooperative learning also contribute to students' favorable attitudes. A study by Gillies (2016) found that students involved in cooperative learning developed stronger interpersonal relationships with their peers, which led to greater enjoyment of the learning process. Also, the collaborative nature of cooperative learning encourages students to appreciate diverse perspectives and learning styles (Amedu & Gudi, 2017).

2.4 Conceptual Framework

The conceptual framework for this study is grounded in the assumption that cooperative learning serves as an instructional approach capable of enhancing students' cognitive, affective, and behavioral outcomes in science classrooms. Cooperative learning structures promote positive interdependence, individual accountability, face-to-face interaction, and group processing. These elements create a learning environment in which students actively engage in tasks, support one another's learning, and assume responsibility both for their own understanding and that of their peers (Johnson & Johnson, 2008).

Within this framework, Cooperative Learning is posited as the independent variable that initiates a sequence of learner-related outcomes. When students work collaboratively, they participate more actively, interact more frequently, and become more involved in the learning process. As a result, the model proposes that CL enhances student participation, promotes equal engagement among both males and females, and promotes positive attitudes toward science learning.

These immediate affective and behavioral changes are expected to translate into cognitive gains. As students engage in peer explanations, group discussions, and shared problem-solving, they construct deeper and more meaningful understanding of scientific concepts. Therefore, the framework positions improved conceptual understanding as the first-level learning outcome.

Improved understanding subsequently contributes to higher academic performance, as students are better able to recall, apply, and transfer scientific knowledge. Over time, enhanced understanding and performance are expected to strengthen long-term knowledge retention, since students who learn through active interaction and explanation store information more meaningfully than those who learn passively (Choi et al., 2011).

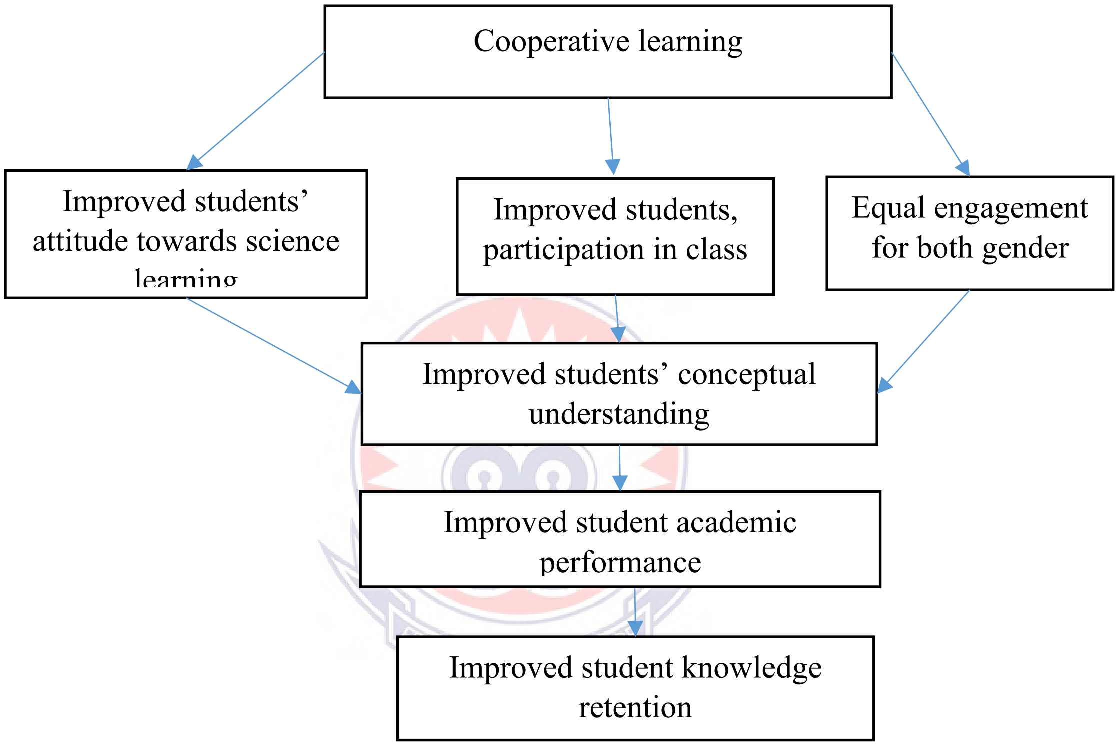

Figure 1: Conceptual framework for the study

Source: Researcher (2025)

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter describes the methods and strategies used in obtaining information for the research. It focuses on the following areas: design of the study, population, sample and sampling techniques, research instruments, validity and reliability of the instrument, intervention design and implementation, data collection and data analysis procedures.

3.1 Research Design

The research design employed for this study was action research design. An action research is a kind of research activity in which the researcher works collaboratively with other people to solve a perceived problem (Cohen et al., 2012).

Action research as its name suggests, is research design that impacts on, and focuses on practice. The purpose of action research is not merely to understand situations and phenomena but also to change them (Asamoah-Gyimah & Doudu, 2007). Its purpose in an educational setting is to solve a specific classroom or school problem, improve practice or make decision at a single local site (Asamoah-Gyimah & Doudu, 2007). It improves teaching and learning by taking a collaborative, reflective, and problem-solving approach in investigating classroom practice. Action research involves cycles of planning, implementing, observing, and reflecting on changes made to improve practice (Cohen et al., 2012).

Action research design was chosen because the researcher aimed at creating and implementing interventions to solve a problem in an educational setting, specifically in the classroom. This allowed him to improve the academic performance and knowledge retention of students in the circulatory system.

The three stages in every action research design were considered. These are pre - intervention, intervention and post- intervention. Pre-intervention stage considered administration of pre-test that measured students' performance in circulatory system prior to the intervention. The intervention stage considered implementation of cooperative learning to improve students' understanding and academic performance in circulatory system, and the post-intervention stage involved the administration of a post-intervention test to ascertain whether there were any significant improvements in students' average performance in circulatory system after the intervention was rolled out.

3.2 Population of the Study

Nwadinigwe (2002) defined population as the trait, event, people or subject that is being studied. Population can also be defined as the total collection of elements about which we wish to make some inference (Asiamah et al., 2017). These could be individuals, objects or events. This study was conducted at Have Technical Institute which had a student population of 2,324 at the time of this study. The target population was all the 2,324 students of Have Technical Institute. The accessible population for the study was all final year students of the Institute.

3.3 Research Sample and sampling technique

Out of the accessible population, final year Mechanical Engineering Technology (MET) students of Have Technical Institute was purposively selected to participate in the study. An intact class of 40 final year Mechanical Engineering Technology (MET) students were purposively selected to form the sample of the study. The researcher used final year class because it was only the final year students who had covered circulatory system. Thus, it was easier to assess them in a pre-intervention test before administering the intervention. The researcher also used an intact class because it was more convenient and ethical working with an intact class than working with students randomly picked from different classes.

Year three mechanical engineering technology class was purposively selected for this study because it is the only class that met the sex criterion set by the researcher. Since the study assessed the influence of gender on students' understanding of circulatory system when taught with cooperative learning, there was a need to work with class that had at least 25% of its members being either gender. Mechanical engineering technology was the only year three class in the Institute that met this criterion. 23 of the students in that class were males whereas 17 of them were females.

3.4 Research Instruments

Research instruments are tools used to collect information on the subject about the problem under study (Asamoah-Gyimah & Doudu, 2007). The main instruments used to collect data for the study were tests (pre- intervention test, post- intervention test and retention test) and questionnaire.

3.4.1 Test

Test is a task or series of tasks, which are used to measure specific traits or attributes in people (Yayra, 2017). According to Yayra (2017), test is the best instrument for measuring students' traits or characteristics. According to Gierl et al. (2017), a test is a series of questions which serve as a measuring tool used for collecting specific information from subjects to aid in finding solution to a research problem. Even though some respondents or testees may not supply accurate answers or may not be able to express their ideas adequately in writing which is weakness of test as an instrument, the researcher chose to use it because it is an effective way of securing information from students and also an ideal method that would help to measure students' performance since students put up their best when it comes to test (Yayra, 2017). The test used was in two set: pre-intervention and post-intervention test.

3.4.1.1 Pre-intervention test

The pre intervention test was known as Students' Diagnosis Test (SDT). It was used during the pre-intervention stage to ascertain the existence and the degree of the problem before the intervention was rolled out. The test covered key content areas such as the structure and function of the heart, blood vessels, components of blood and its function, disorders of the circulatory system, and types of blood circulation. The instrument consisted of two sections; Section A, comprised of 25 multiple-choice items, and Section B, contained 3 structured questions. Each multiple-choice item provided four alternatives (a–d), from which students were required to select the most appropriate answer.

The design of the items ensured coverage of factual knowledge, conceptual understanding, and basic application related to the circulatory system. Section B required deeper understanding through labeling of the human heart diagram, identification of blood vessels and their functions, and explanation of components of blood. Students responded directly in spaces provided, encouraging brief but accurate answers (Appendices B1). The entire test was completed within 60 minutes, and the marking scheme allocated 1 mark per correct option in Section A. The multiple choice items were marked over 25 and the subjective items were also mark over 25. In all, the test was marked over 50.

3.4.1.2 Post-intervention Test

The post-intervention test was administered after the cooperative learning strategies had been implemented. It was used both as Students Achievement Test (SAT) and Students Knowledge Retention Test (SKRT) to measure students' immediate learning gains and knowledge retention respectively. This test was similarly structured to the pre-intervention test but contained a different set of items to minimize recall while maintaining alignment with the same content areas. Like the pre- intervention test, it consisted of 25 multiple-choice items in Section A, each with four answer alternatives (a-d), and 3 structured items in Section B, which required written explanations, labeling, and diagram interpretation.

The multiple choice section assessed the same range of cognitive abilities; knowledge understanding and simple application, while ensuring content validity by covering all major topics taught during the intervention. Section B again relied on a diagram of the human heart but with different prompts, requiring students to identify specific blood vessels, describe the flow of blood and classify oxygenated and deoxygenated blood. Students responded directly in spaces provided, encouraging brief but accurate answers (Appendices B1). Just like the pre-intervention test, the post intervention test was completed within 60 minutes, and the marking scheme allocated one mark per correct option in Section A. The multiple choice items were marked over 25 and the subjective items were also mark over 25. In all, the test was marked over 50.

3.4.2 Questionnaire

According to Cohen et al. (2011), a questionnaire is a survey instrument that consists of a set of standardized questions intended to elicit information from respondents.

Questionnaire is one of the most commonly used data collection tools for action research, and can be both quantitative and qualitative, depending on the research question and objectives (Kaplan & Saccuzzo, 2009; Creswell & Poth, 2017).

It can be utilized to gather a large amount of information from a wide range of participants quickly and efficiently and are particularly suitable for collecting data on attitudes, perceptions, beliefs, and opinions (Kronsnick, 2018). This study used a five points Likert Type scale questionnaire. The scale ranged from strongly disagree to strongly agree. The questionnaire was made up two sections. The section A which was made up of 2 items, sought to gather respondent demographic information whereas the section B made up of 14 items sought to gather information on their attitude towards cooperative learning (Appendix D).

Questionnaires can be administered in various ways, such as through face-to-face interviews, postal mail, online surveys, Paper-and-pencil or telephone interviews. The choice of administration method depends on the sample size, accessibility of the participant, and research objective (Bowling, 2005). Paper-and-pencil questionnaire administration was used to administer the questionnaire for the study because the sample size was quite small, and also the participants were readily available.

3.4.3 Validity of Tests

According to Yayra (2017), validity refers to the extent to which an instrument measures what it is supposed to measure. Content validity of both the pre-test and post-test were ensured by structuring the questions according to the demands of the Integrated Science syllabus. Also, the items were given to the researcher's supervisor as well as other experienced science teachers to examine and help correct any validity problem.

They were made to review the items to assess whether:

- only the concepts relevant to the study were examined
- the instruments were suitable for use by TVET learners.
- there were no factual errors.
- the items covered the entire concepts taught sufficiently and proportionally
- The items were constructed to fit the purpose of the study.

Poorly constructed items were substituted with more appropriate ones after examination of the items by other experienced science teachers. The test items were arranged in descending order of difficulty and conscious effort was made to avoid carry-over effect and ceiling effect which could interfere with the soundness of the interpretation and use of the assessment results.

3.4.4 Validity of Questionnaire

To ensure validity of the questionnaire, the researcher first developed a research framework that clearly defined the variables being investigated and their conceptual and operational definitions. The questions in the questionnaire were then aligned with the variables and were written in simple language to minimize confusion and ambiguity. The researcher also conducted a pilot study to test the clarity and relevance of the questions and made the necessary clarifications before administering the questionnaire to the subjects of the study.

Additionally, the researcher involved experts in the development and review process of the questionnaire. The experts ensured that the questions were relevant, appropriate, and accurately reflected the construct been measured.

3.5 Reliability of instrument

Reliability is a measure of the extent to which measurement is consist and stable when measuring the same phenomenon multiple times under the similar condition (Yayra, 2017). It depicts the degree of consistency of assessment results. 22 form three students (11 boys and 11 girls) were used to conduct a pilot study prior to the main study. They were randomly selected from classes that were not chosen for involvement in the main study. One of the main purposes of the pilot study was to collect data to determine the reliability of the instruments.

3.5.1 Reliability of Test

In this study, test-retest was used to establish the reliability of the tests used to collect data on the academic performance of TVET students in the circulatory system. Test-retest is a common method used to determine the reliability of a test by measuring the consistency of scores over time (Polit, 2014). The test items were administered to the participants of the pilot study twice. The time gap between the two administrations of the instruments was two weeks. The duration of two weeks is thought short enough for learners not to have gained considerable amounts of new knowledge at the second administration of the instruments, and sufficiently long for them not to remember their previous responses (Polit, 2014).

Polit suggests that there is a need for a sufficient time gap between test administrations to ensure that the initial test scores do not impact subsequent test scores. Two weeks is considered an optimal period as it is not too long to create new learning opportunities, nor too short to erase the effect of the initial administration of the test. The test-retest reliability coefficient was determined using Pearson correlation between the two pilot scores. The results showed a high reliability coefficient of 0.72 and 0.74 for pre-intervention and post-intervention test respectively, indicating a high level of consistency between the two test scores. This, according to Polit, 2014 indicates that the test instrument was highly reliable.

3.5.2 Reliability of questionnaire

The reliability of questionnaire was determined by using Cronbach alpha reliability coefficient. According to DeVellis (2017), Cronbach alpha is a coefficient that estimates the extent to which all items on a scale measure the same underlying construct. It ranges from 0 to 1, with higher values signifying greater internal consistency reliability. According to Taber (2018), the commonly accepted limit for Cronbach alpha is 0.70, though researchers may choose a higher or lower verge based on the study's purpose, the number of items, and nature of the construct been measured. It is a widely used measure of internal consistency reliability in research that involves multiple items measuring the same construct. It is mostly used to assess the reliability of questionnaires and surveys (Kennedy, 2022).

Data from the pilot study was computed for the Cronbach alpha. The results of the analysis shown that the Cronbach alpha reliability coefficient was 0.73, which indicated an accepted internal consistency. This value according to Taber (2018) suggests that the items on the questionnaire were reliable in measuring the students' attitude towards cooperative learning. As such, no item was modified, changed or deleted.

3.6 Data Collection Procedure

The first step in the data collection procedure was administering a SDT to the participants. This test aimed to ascertain the prior knowledge of the participants in the circulatory system before the intervention was rolled out. It was used as a baseline measure to determine the starting point of the participants' knowledge of the circulatory system. The test was designed in such a way that it covered all essential concepts in circulatory system, as captured in the Integrated Science syllabus. The participants were given the test in a controlled environment, and they were asked to submit their scripts when they had completed the test. The test was scored using a scoring rubric that was carefully and objectively prepared by the researcher, and students score were recorded The SAT was administered to the participants at the end of the intervention. The purpose of the SAT was to gather data to assess the participants' academic performance after the intervention. The participants were again given the test in a controlled environment and enough time was given for all participants to complete it comfortably. The test was scored using a scoring rubric that was carefully and objectively prepared by the researcher, and students score were recorded

Two weeks after the intervention was rolled out, the final step in the data collection procedure was carried out. This was done by administering post intervention test to the participants unannounced. The post intervention test this time served as Students' Knowledge Retention Test (SKRT). It sought to assess the participants' ability to retain the information they learned from the intervention. A gap of two weeks was allowed between the two tests because Farr (2012) and Polit, (2014) suggests that the two weeks duration is short enough for learners not to have gained considerable amounts of new knowledge, and sufficiently long for them not to remember their exact previous responses. The participants were again given the test in a controlled environment and enough time was given for all participants to complete it comfortably. The test was scored using the same scoring rubric used for scoring the SAT, and students' score were recorded.

The questionnaire was administered after administering the SAT. The questionnaire aimed at obtaining information on the participants' attitudes towards the use of cooperative learning in teaching the circulatory system. The questionnaire was administered using the paper-pencil method. The questionnaire was administered in person. Bowling (2005) opined that when the questionnaire is administered in person, it gives the researcher opportunity to brief the respondent to understand exactly what each item means so as to obtain the right responses. In line with this, the researcher used twenty minutes to explain the items before the respondents started answering the items. Throughout the process, the researcher provided assistance to respondents who required clarification. Respondents were given 20 minutes to complete the questionnaire, and those who could not finish within the said duration were given extra time to complete it. All the 40 questionnaire given out were collected which gave a return rate of 100%.

3.7 Data Analysis

In order to address the research questions that guided the study, the data obtained from the respondents were analysed using Statistical Package for Social Sciences (SPSS) and Excel. A combination of descriptive and inferential statistics was used to analyse the data to provide results. The demographic characteristics of the respondents were analysed using percentages and frequencies.

3.7.1 Test Data Analysis

Descriptive statistics were used to summarize students' performance on the pre-intervention test, post-intervention test, and retention test. Measures of central tendencies and dispersion including the mean, standard deviation, minimum, and maximum scores were computed for the appropriate data set.

For Research Question 1, the descriptive statistics were used to compare students' pre-intervention test and post-intervention test scores to provide initial insight into the effect of the cooperative learning intervention on students' academic performance.

For Research Question 2, the descriptive statistics were used to summarize the post-intervention test performance of male and female students, offering an overview of gender-related performance patterns.

For Research Question 3, the descriptive statistics were used to compare students' post-intervention test and retention test scores, thereby providing an initial understanding of the extent to which students retained the content taught.

Inferential statistical analyses were conducted to determine whether the differences observed in the various compared test scores were statistically significant.

For Research Question 1, a paired-samples t-test was used to compare students' pre-intervention test and post-intervention test scores. This test helped determine whether the cooperative learning intervention produced a statistically significant improvement in academic performance. An effect size (Cohen's d) was calculated to estimate the magnitude of the improvement.

For Research Question 2, an independent-samples t-test was conducted to compare the post-invention test performance of male and female students to determine whether the differences observed in test scores were statistically significant. An effect size was also computed to determine the strength of any gender-based performance differences.

For Research Question 3, a paired-samples t-test was used to compare students' post-intervention test and retention test scores to determine whether any differences observed in the test scores were statistically significant. A computed effect size provided an estimate of the degree of the differences.

All inferential tests were conducted at the .05 significance level, ensuring adequate statistical precision in the interpretation of findings.

3.7.2 Questionnaire data analysis

Data for Research Question 4, which examined students' attitudes toward the cooperative learning approach after the intervention, was analyzed using descriptive statistics. The Likert-scale questionnaire responses were summarized using means and standard deviations, which allowed for the identification of general trends and levels of agreement among students regarding their experiences with cooperative learning.

Although Likert-scale data are ordinal in nature, parametric statistics such as the mean and standard deviation could be appropriately applied for summarizing responses, particularly when the scale contains five or more points (Mircioiu & Atkinson, 2017; Norman, 2010; Yaska & Nuhu, 2024). Consequently, the mean and standard deviation for each item were calculated and interpreted according to predefined ranges.

The mean score for each item was interpreted using exact, equal-interval ranges derived from the scale (1–5). The interval width was calculated as follows, according the guidelines of Mircioiu and Atkinson, (2017).

$$\text{Interval width} = \frac{\text{Highest scale value} - \text{Lowest scale value}}{\text{Number of categories}}$$

$$\text{Interval width} = \frac{5-1}{5}$$

$$\text{Interval width} = 0.8$$

The resulting mean ranges and corresponding interpretations are presented in Table 1.

Table 1: Mean ranges and their corresponding interpretation

Mean range	Interpretation	
1.00 – 1.80	Strongly Disagree	Positive attitude
1.81 – 2.60	Disagree	
2.61 – 3.40	Neutral	Neutral
3.41 – 4.20	Agree	Negative attitude
4.21 – 5.00	Strongly Agree	

The standard deviation was calculated to determine the dispersion or variability of responses for each item. The standard variation on a five point Likert scale can theoretically range from 0 to 2 (Sangthong, 2020). A lower standard deviation (SD ≤ 0.8) indicated that responses were clustered closely around the mean, whereas a higher standard deviation (SD > 0.8) suggested greater variability among respondents. Although no single source prescribes this exact threshold, it follows a common practice of using roughly one–third of the highest possible range on a five point Likert scale (2/3 ≈ 0.67). Rounding it up to 0.8 provided a clear and interpretable boundary, and avoid narrowly cutoffs. This approach is consistent with previous studies that interpreted Likert-scale dispersion (DeVellis, 2017; Mircioiu & Atkinson, 2017; Sangthong, 2020).

3.8 Research implementation strategy

3.8.1 Pre-intervention

The researcher tested students, knowledge in the circulatory system on his first visit to the class. The researcher did this by administering the pre-intervention test (SDT) to determine the students' strength and weakness in the concept. The SDT was given to students during normal teaching period to answer individually. Answers provided by students were marked using a carefully prepared scoring rubric, and it was revealed that most of the students performed extremely poor on the test. Based on this outcome the researcher designed an intervention to solve the problem. Before the intervention was rolled out, all the cooperative learning groups were formed. The researcher formed different groups for various activities. Groups of three, four, and five students were formed for various Jigsaw activities. Students were also paired up for various Think-Pair-Share activities.

3.8.2 Intervention process

The senior high school teaching syllabus for Integrated Science served as a guide for the researcher to create a daily lesson plan for four lessons (Appendices A1, A2, A3 and A4). Cooperative learning method of instruction was used by the research for each lesson.

The goal of the intervention was to use cooperative learning to improve the students' academic performance in circulatory system of human. There are several models of cooperative learning, however three of these models were used for the intervention. These include Numbered Heads Together, Think Pair Share and Jigsaw cooperative learning. These models were used for various activities in different lessons throughout the intervention process. The model used for a particular activity depended on the nature of that activity. Some lessons used only one of these models whereas others used two or three of the models. The circulatory system was divided in to three main sub topics; the heart, blood and blood vessels. The heart was taught in one lesson. This lesson covered the location of the heart in human, the structure of the heart and parts of the heart and their functions. Blood vessel was also taught in one lesson. This lesson covered the types, structure and functions of the three blood main blood vessels and types of blood circulation in human. Blood was taught in one lesson. This lesson covered nature of blood, components of blood, function of blood, and the last lesson covered disorders of the circulatory system. It took care of the causes and preventive measures of various disorders of the circulatory system.

Each of the cooperative learning model used has its own steps, thus the researcher used different steps for various activities depending on the cooperative learning model used for that activity.

Think Pair Share strategy

The Thin Pair Share cooperative learning strategy has three phases; the Think Phase, the Pair phase and the Share phase.

During the think phase, students were asked to think about a question posed to them. Student thought about their own responses and jot down their ideas. Books, diagrams, handouts on circulatory system and other relevant materials were made available to students for reference. Right after the think phase, the pair phase followed.

During the pair phase, students were paired up with their class mates to share their thoughts, expand the ideas they came up with during the think stage and engaged in dialogue. Through a brief conversation students shared their individual understanding of the question and tried to make connection with their partners' response.

Activities that used this strategy ended with the share phase. During this phase, different pair of students presented their thoughts to the whole class. Students got the chance to hear and learn from the perspectives of their peer which potentially changed or expanded theirs.

Jigsaw strategy

The Jigsaw strategy contains four phases or stages. The first stage of Jigsaw Cooperative learning is the formation of heterogeneous home groups, which are the original group of students who work together and are assigned to learn a specific topic or section of the material. The researcher formed the jigsaw cooperative groups prior to the lessons by dividing the class into heterogeneous home groups. Jigsaw groups of three, four or five students were formed and used for various activities depending on the number of sub themes in the objective been worked on. Since the sample had more males than females, most of the groups had more males than female. During jigsaw activity, each group received a worksheet with questions divided into three, four or five sub topics, depending on the number of students in each group for that activity. Students were provided with the required resources such as books, diagrams and pictures related to their assigned topics. They were given ample time to gather information on their respective topics.

Expert group formation is the second phase. In this phase, students from different home groups who had the same topic came together to form expert group, which is a temporary group formed by gathering students from different home groups who have been assigned to learn the same topic or section of the material. In the expert group, students work together to become "experts" on their assigned topic, and then return to their home groups to share their knowledge with their group members.

This step ensured in-depth understanding as students discussed their specific topic with others who had researched the same topic. Within each expert groups, students discussed their topics comprehensively, ensuring every member grasped the content. They prepared to teach this information to their original home group members.

After expert group discussions, students returned to their respective home groups. Here, they took turns in teaching their assigned topic to the other group members. Group members actively asked questions for clarification, which were answered by the presenting student or the researcher when the need aroused. The researcher moved around to supervise the discussion, observe students' participation and gave students guidance. Following the experts' presentations, group members engaged in a brief discussion to synthesize the information learned from each expert.

The final stage involved assessing the students individually on the content they had learned. Scores obtained by members of each home group were averaged. The group with the highest average score received an award. Additionally, any group that performed above a certain threshold was also awarded. This was mostly done a day after the lesson because the researcher could not mark student exercise and award them same day due to the class size.

Numbered Heads Together strategy

The Numbered Heads Together has three phases. These include group formation phase, question and responses phase, and the assessment phases. The researcher used the four-member jigsaw groups for number heads together activities. Each member of a group was assigned a unique number from one to four.

During the second stage the researcher posed questions to the entire class, prompting each group to work together to formulate answers. Groups were provided with various resource materials, including books, diagrams, charts, and pictures, to aid in their discussion and for better understanding of the concepts. Members of each group collaborated, utilizing peer validation to ensure that everyone grasped the material.

Assessment forms the final stage of this model. After the group discussion, the researcher randomly selected a number from each group. The student with the corresponding number was responsible for providing the group's answer to the class.

Marks were awarded to the entire group based on the accuracy and completeness of the answer provided by the selected student. This phase continued with multiple questions, ensuring that each student in every group had the opportunity to be assessed through this random selection process. The cumulative scores of each group was tallied. The group with the highest score at the end of the activity was awarded a prize.

3.8.3 Lessons presentations

Lesson one

Date:12/06/2024

Class: MET3

Class size: 40

Duration: 120 minutes

Topic: Circulatory system of mammals

Sub-topic: The heart

Relevant previous knowledge: student learned circulatory system in J.H.S

Objectives: By the end of the lesson, a student will be able to:

1. identify the main components of the circulatory system.
2. describe the location and structure of the human heart.
3. identify the parts of the human heart and state their functions.

Teaching and learning materials:

Whiteboard and markers, projector and computer, worksheets, diagrams of the heart, a chart of the circulatory system, colored - pencils (blue and red pencils), integrated science text books, handout, index cards

Teacher-Learner's Activities

Introduction: The researcher introduced the lesson by showing a short animation of the circulatory system to the students. Students watched attentively and some pointed out components they recognized from their previous knowledge. The researcher asked the students "What parts of the circulatory system can you identify?" "The blood, heart and blood tubes" were students' responses. This engaged students and set the stage for the lesson.

Activity one: the researcher distributed worksheet **A** to every student. He asked students to individually read through and fill part I. Students individually thought about and filled in part I of the worksheet presented to them. Students appeared focused, with some students looking thoughtful as they wrote their answers. The researcher moved through the class for supervision as students penned down their responses. The researcher instructed students to pair up with a classmate and share their answers. The researcher encourages them to discuss and compare their thoughts, and come to a consensus on the answers. Lively discussions were observed as students compared answers and corrected each other. Pairs were seen nodding and making notes. The researcher randomly selected four pairs to share their answers to the whole class. Pairs shared their answers with the class, and the researcher discussed with the class, students' responses, clarified misconceptions, and provided additional explanations. Students were actively engaged and most of them raised hands to volunteer answers.

Some pairs pointed out errors in their initial answers and how they corrected them after discussing with their partners.

Activity two: In a pre-formed groups of five students with students in each group numbered 1 to 5, the researcher gave each group an Integrated Science text book and a handout on circulatory system and instructed students in each group to discuss part II of the worksheet using the resource material provided to them, ensuring everyone in the group understands the material. Members of each group collaborated, with some students explaining concepts to others. There was a buzz of discussion as students filled out the worksheet. As the students discussed, the researcher moved around and provided students with the needed support. The researcher observed that students intensively discussed the structure of the heart. After the discussion, the researcher randomly called a number, and the student with that number from each group stood up and shared their group's answers. This continued till every number was mentioned. The selected students confidently presented their group's findings, while others listened and sometimes questioned for clarity. The researcher then discussed the students' responses with the class and provided additional explanations as needed. The researcher elaborated on complex points and used diagrams to better illustrate the structure of the heart, enhancing understanding.

Activity three: with the same groups and resources as used in activity two, the researcher instructed students to work together on part III of the worksheet provided to them, ensuring everyone in the group understands the material. Members of each group collaborated, with some students explaining concepts to others. Continued group collaboration was observed, with students using colored pencils to differentiate oxygenated and deoxygenated blood. As the students discussed, the researcher moved around and provided students with the needed support. After the discussion, the researcher randomly called a number, and the student with that number from each group stood up and shared their group's answers. This continued till every number was mentioned. The selected students confidently presented their group's findings, while others listened and sometimes questioned for clarity. Presentations were more detailed as students had become more confident. The researcher then discussed the students' responses with the class and provided additional explanations as needed. The researcher collected the worksheets for assessment.

Conclusion: the researcher concluded the lesson by conducting a whole-class discussion to consolidate learning. Students asked questions and discussed any remaining uncertainties. They engaged actively, seeking clarifications. The teacher answered questions, ensuring all students understood the material and summarised the key points of the lesson.

Evaluation

1. list the main components of the circulatory system

Students' response: The heart, blood and blood vessels

2. Give the function the following parts of the heart

a. Septum

b. aorta

c. vena cava

d. Pulmonary artery

Students' response:

- it prevents oxygenated blood from deoxygenated blood.
- it carries oxygenated from the heart to all parts of the body.

- it carries deoxygenated blood back to the heart.
- it transports deoxygenated blood from the heart to the lungs

3. what is the main function of the circulatory system?

Students' responses: it transports substances throughout the body.

Lesson Two

Date: 17/06/2024

Class: MET3

Class size: 40

Duration: 120 minutes

Topic: Circulatory system of mammals

Sub-topic: Blood vessels

Relevant previous knowledge: student learned circulatory system in J.H.S

Objectives: By the end of the lesson, a student will be able to:

1. identify the types of blood vessels
2. give the function of each blood vessels
3. compare the various blood vessel

Teaching and learning material

Whiteboard and markers, projector and computer, worksheets, diagrams of the of blood vessel, integrated science text books, chart paper

Teacher-learner activities

Introduction: the researcher introduced the lesson by showing a short video of the various blood vessels to the students. Students watched attentively, some whispering comments about the differences they noticed between the vessels. The researcher asked, "Tell me the three main types of blood vessels we just saw in the video?" Several students had their hands raised, and one of them answered correctly, "Arteries, veins, and capillaries."

Activity One: In a pre-formed jigsaw groups of three students each, the researcher assigned each student in the group a specific blood vessel to become an expert on: arteries, veins, or capillaries. The researcher gave each group an Integrated Science text book and a handout on circulatory system from which they gathered information. The researcher distributed worksheet B to students and asked them to fill out part I based on their assigned blood vessel by using a pencil. Students gathered information and filled out the worksheet as instructed. The researcher instructed all the students assigned to each of the blood vessel to form another group (expert group) and discuss their assigned blood vessel. In their expert groups, students engaged in discussions, asking each other questions like, "Why do veins have valves?" and "How do arteries maintain high pressure?" One student in the arteries group asked, " Why are arteries located deep in the body?" Her group member explained that it is to protect them from damage. Since they carry blood under high pressure, much blood would be lost when they are damaged". The researcher moved among the groups, providing guidance. When asked about the function of capillaries, a group member explained, "Capillaries are crucial for the exchange of materials between the blood and body tissues". Students updated their worksheets and prepared a short presentation to teach their home group members as the discussion progressed.

Activity Two: The research instructed students to return to the home groups and takes turn to teach their group members about the blood vessel type they studied. Students returned to their home groups and took turns presenting, with some using diagrams to illustrate their points. One student asked, "What makes the walls of arteries so thick?"

The presenter from the arteries expert group explained, "They need to withstand the high pressure of blood being pumped from the heart". The researcher was much impressed by the students' response and praised her. The researcher monitored the presentations, ensuring accuracy and completeness. The researcher also clarified points as needed, such as elaborating on the role of valves in veins to prevent backflow of blood. Each student took note on the other blood vessels as their group mates presented and filled part III of the worksheet.

Activity three: The researcher instructed students in their home groups to work together to fill out the final section (IV) of the worksheet that compares the three types of blood vessels and present their comparison chart to the class. Groups engaged in lively discussions, debating the similarities and differences between the blood vessels. One student asked the group, "Why do veins carry deoxygenated blood except for pulmonary" Another student responded, "Because these veins carry oxygenated blood from the lungs back to the heart ". The researcher moved around guiding students and clarifying students' ideas as each group prepared a comparison chart to present to the class. Groups presented their comparison charts to the class. The researcher facilitated a discussion on the similarities and differences between the blood vessels, emphasizing key points captured on the comparison charts. The researcher praised the thoroughness of the presentations and corrected any remaining errors.

Conclusion: The researcher concluded the lesson by conducting a brief whole-class discussion and summarized the main points of the lesson.

Evaluation:

The researcher evaluated the worksheets and comparison chat filled out by the students.

Students were made to answer the following questions individually

1. state the three main types of blood vessels

Students' response: Arteries, veins and capillaries.

2. State two arteries that carry deoxygenated blood.

Students' response: Pulmonary artery and umbilical artery

3. What are the function of blood capillaries?

Students' response: They ensure the exchange of substances between blood and body tissues.

4 State two differences between arteries and veins

Students' response:

Arteries	**Veins**
carry blood away from the heart	Carry blood towards the heart
Carry blood under high pressure	Carry blood under low pressure
Have thick and elastic wall	Has thin and less elastic wall
Are deeper in the body	Are closer to the body surface
Have narrow lumen	Have wide lumen

Lesson three

Date:19/06/2024

Class: MET3

Class size: 40

Topic: Circulatory system of mammals

Sub-topic: Blood

Relevant previous knowledge: student learned circulatory system in J.H.S

Objectives: By the end of the lesson, a student will be able to:

1. identify the main components of blood.

2. describe the function of each blood component.
3. explain the types of blood circulation in humans

Teaching and learning material

Whiteboard and markers, projector and computer, worksheets, diagrams of the of human heart, integrated science text books, chart paper, Colored pencils

Introduction: The researcher introduced the lesson by brainstorming students to come out with various components of blood. Students eagerly participated, mentioning components like "red blood cells," "plasma," and "white blood cells." One student mentioned, "Platelets are also a part of blood, right?" The researcher confirmed the correct responses and added, "Excellent! Today we are going to delve deeper into these components and understand their functions."

Activity One: In a pre-formed jigsaw groups of four students each, the researcher assigned each student in a group a specific blood component to become an expert on: plasma, white blood cells, red blood cells or blood platelet. The researcher gave each group an Integrated Science text book and a handout on circulatory system from which they gathered information. The researcher distributed worksheet C to students and asked them to fill out part I based on their assigned blood component by using a pencil. Students gathered information and filled out the worksheet as instructed. The researcher instructed all the students assigned to each of the blood components to form another group (expert group) and discuss their assigned blood component in details. In their expert groups, students engaged in discussions, asking and answering one another questions. One student from the red blood cells group asked "What is haemoglobin, and why is it important?".

A group member explained, "Haemoglobin is an iron containing compound that binds to oxygen, allowing red blood cells to transport it throughout the body." The researcher moved among the groups, providing guidance. A member of the white blood cell expert group threw more light on the function of white blood cells when a student asked, "How do white blood cells fight infections?" He explained that some white blood cells such as microphages engulf and digest pathogens through a process called phagocytosis. Others like lymphocytes produce antibodies that target and destroy specific infection. Students updated their worksheets and prepared a short presentation to teach their home group members as the discussion progressed

Activity Two: The research instructed students to return to the home groups and take turn to teach their group members about the blood component they specialised in. Students returned to their respective home groups and each student took turns teaching their group members about the respective blood component. During the presentation, one student asked “How important are platelets?” A group member explained that platelets are crucial for blood clotting. They form a plug at the site of injury preventing blood lost. Another student asked, "How do platelets form a stable clot?" A group member explained, "Platelets release chemicals that activate the clotting cascade, solidifying the initial plug." Why is plasma straw-coloured?" another student asked, his group member explained, "The colour comes from the proteins and other substances dissolved in it." The researcher monitored the presentations, ensuring accuracy and completeness. The researcher clarified points as needed and praised the students for their insightful explanations. Each student took note on the other blood components as their group mates presented and filled part III of the worksheet.

Activity three: The researcher instructed students in their home groups to work on part IV of the worksheet individually using the available resources. Students worked on Part IV of the worksheet individually as instructed and the researcher went round providing students with guidance. The researcher instructed each group to discuss their answers within their team and prepare a summary chart on the card provided. Students engaged in lively discussion of the types of circulation with most groups using diagrams and coloured pencils to trace the path of blood through the heart, lungs and the body. One student asked, "How does the heart manage both pulmonary and systemic circulation simultaneously?" "The heart has separate chambers for each type of circulation, allowing it to handle both efficiently." A group member explained. The researcher moved among the groups providing guidance, and ensured every student participated and understood the material. "Why does the right side of the heart handle only deoxygenated blood?" One student asked. "This is because deoxygenated blood from the veins return to the right part of the heart which pumps it to the lungs for oxygenation." Her group member replied. Each team presented their summary charts to the class.

Conclusion: The researcher concluded the lesson by conducting a whole-class discussion to consolidate learning. Students asked questions and discussed any remaining uncertainties.

Evaluation:

1. state two functions of blood.

Students' response: transportation, regulation, protection, and reproduction.

2. Describe the pathway of pulmonary circulation in human

Students' response: Deoxygenated blood in the right atrium is pumped to the right ventricle through the tricuspid valve. The right ventricle contracts to pump blood through the pulmonary artery to the lungs for oxygenation. Oxygenated blood moves through the pulmonary vein to the left atrium.

Lesson four

Date: 24/06/2024

Class: MET3

Class size: 40

Duration: 120 minutes

Topic: Circulatory system of mammals.

Sub-topic: Disorders of the circulatory system.

Relevant previous knowledge: student learned circulatory system in J.H.S

Objectives: By the end of the lesson, a student will be able to:

1. identify at least four disorders associated with the circulatory system
2. mention at least one cause of each disorder.
3. state at least two ways of preventing each disorder

Teaching and learning material

Whiteboard and markers, worksheets, chart of some disorders of the circulatory system, students' handout, integrated science text books, chart papers.

Teacher-learner activities

Introduction: The teacher introduced the main disorders of the circulatory system and their impact on health through brainstorming. Students suggested disorders such as heart attack, stroke, and anemia. The teacher provided an overview of the lesson objectives and emphasized the importance of understanding circulatory system disorders for maintaining good health.

Activity One: In a pre-formed jigsaw groups of five students each, the researcher assigned each student in the group a specific disorder of the circulatory system to become an expert on: blood pressure, heart attack, leukaemia, anaemia, or hole in heart. The researcher gave each group an Integrated Science text book and a handout on circulatory system from which they gathered information. The researcher distributed worksheet D to students and asked them to fill out part I based on their assigned disorder by using a pencil. Students gathered information and filled out the worksheet as instructed. The researcher instructed all the students assigned to each of the disorders to form another group (expert group) and discuss their assigned disorder in details. Students engaged in lively discussions within their expert groups.

One student in the "heart attack" group asked, "Why does high cholesterol cause heart attacks?" Another student explained, "High cholesterol leads to the build-up of plaques in arteries, which can block blood flow." In the anaemia group, a student asked, "How does iron deficiency lead to anaemia?" His group member explained, "Iron is crucial for haemoglobin production in red blood cells. Without enough iron, the body can't produce enough healthy red blood cells." A student from the "leukaemia" group asked, "Is leukaemia inherited?" His group leader answered, "not really but genetic factors can contribute to the risk of developing leukaemia." The researcher was amazed with her response and praised her. The researcher facilitated group discussions, and polished students' idea. Students updated their worksheets and prepared a short presentation to teach their home group members as the discussion progressed.

Activity Two: The research instructed students to return to the home groups and take turn to teach their group members about the disorders they specialised in. Students returned to their respective home groups and each student took turns teaching their group members about the disorders they expertise in. During the presentations, one student asked, "Why is smoking a risk factor for stroke?" The presenter in her group responded, "Smoking damages blood vessels and increases blood pressure, leading to a higher risk of stroke." Another student asked, "What is the most common cause of high blood pressure?" His group member explained, "High blood pressure is often caused by a combination of factors, including genetics, obesity, and high salt intake." As each student presented, group members filled out their worksheets with the information being shared. Each group prepared a summary chart of the disorders, their causes, and preventive measures. The researcher guided the presentations, ensuring accurate information was shared and clarifying any misconceptions.

Activity three: Each group presented their summary charts to the whole class. During the presentations, one student asked, "What are the symptoms of low blood pressure?" A group member answered, "Symptoms include dizziness, fainting, and fatigue. “Another student asked, "How can we prevent heart attacks?" A member of the presenting group replied, "Preventive measures include eating a heart-healthy diet, exercising regularly, avoiding smoking, and managing cholesterol levels." A student from the audience asked, "What lifestyle changes can reduce the risk of high blood pressure?" The presenting group responded, "Maintaining a healthy weight, reducing salt intake, and managing stress are key lifestyle changes." The teacher provided feedback on each group's presentation, highlighting strengths and offering suggestions for improvement

Conclusion: The teacher concluded the lesson by conducting a whole-class discussion to consolidate learning and summarised the key points of the lesson.

Evaluation

1. State four disorders of the circulatory system.

Students' response: high blood pressure, low blood pressure, leukaemia, anaemia, hole in heart, heart attack

2. Mention two cause and two preventive measures of high blood pressure

Students' response:

Causes: Dehydration, prolonged standing, malnutrition. Endocrine problem, blood loss through severe injury, prolonged bed rest, some medication,

Preventive measures: Stay hydrated, avoid standing for long periods, eat small meals frequently, manage medication, avoid alcohol.

3.8.4 Post-intervention

After the intervention, the researcher again tested students' knowledge in circulatory system for the second time. The researcher did this by administering the post-intervention test which served as Students' Achievement Test (SAT) to students to determine the effectiveness of the intervention. Questionnaire was administered to participants to obtain information on the participants' attitudes towards the use of cooperative learning in teaching the circulatory system. Two weeks later, the researcher once again administered the post intervention test to students unannounced. This time around it was used as Students' Knowledge Retention Test (SKRT) to assess the participants' ability to retain the information they learned during the intervention for a longer period.

3.9 Ethical Consideration

The following ethical considerations were implemented during study.

First of all, the researcher sought official permission in the form of writing from the Headmaster of Have Technical Institute. The Head of Department of the MET was also informed about the study and he gave his approval for it to take place in the department. Also, all participants were informed about the purpose and nature of the study before they agreed to participate. The researcher made sure that the participants were aware of their rights as participants, which included but not limited to their freedom to pull out from the study at any time without any consequences. Before the study began, participants were made to sign a written consent form of which all consented to.

The participants' confidentiality was upheld throughout the study to ensure the protection of their privacy and prevent any breach of trust. All data collected from participants were kept confidential and stored in a secured place that was accessible only to the researcher. Participants were also guaranteed their anonymity, which meant that their names and other identifiable information were not disclosed in any report or presentation related to the study. The data was used only for the purpose of the study and was not shared with anyone.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

This chapter presents statistical analysis of research data, findings and discussion. Data gathered from students' tests (pre-test (SDT), post-test (SAT) and retention test (SKRT)), and questionnaire were analysed, presented and discussed. The analysis was done based on the research question. The chapter is presented in two parts. The first part presents the demographic information of the participants of the study, and the second part presents the findings of the study based on the research questions.

4.1 Demographic Data

This part presents and discusses background data of the study. Two characteristics of the study respondents were sought for which were deemed necessary for the study in order to address some research questions. In addition, the characteristics provided understanding to readers as to the category of students who were involved in the study in relation to their gender and level of maturity. The characteristics are the sex and age categories of respondents. Results of the characteristics are shown in Table 2.

Table 2: Characteristics of respondents

Variable	subscale	frequency	Percentage (%)
Sex	Male	23	57.5
	Female	17	42.5
Age (years)	Below 16	3	7.5
	16-19	25	62.5
	Above 19	12	30

Source: Field work, 2024

It is clear from Table 2 that male students (57.5% of the sample) dominated the study. As indicated in the table, only 17 participants were female students, representing 42.5% of the sample. The dominance of male students in the study's sample is a common phenomenon in the Engineering Departments of TVET Institutions.

It is also clear from Table 2 that the majority (n = 25, 62.5%) of the participant were within the age range of 16 to 19 years, followed by those above 19 years (n = 12, 30%) and only few (m = 3, 7.5%) students were below 16 years. Results on the varying ages show that students may come with different experiences and possibly maturity to the learning groups, and might have the chance to tap the ability of each other within the learning groups.

4.2 Presentation and Discussion of main Findings

This section presents and discusses the main findings in relation to the research questions that guided the study. The results of each research question are presented and discussed.

4.2.1 Research question 1: What is the effect of cooperative learning on TVET students' academic performance in circulatory system?

This research question sought to determine whether the use of cooperative learning had any effect on the academic performance of TVET students in the circulatory system. To answer this question, descriptive statistics were first used to summarize students' performance before and after the intervention. This was followed by inferential statistics using a paired samples t-test to determine whether the observed differences were statistically significant.

Table 3 presents the descriptive statistics of students' pre- intervention test and post-intervention test scores. The pre intervention-test results represent students' initial performance in the circulatory system before cooperative learning was used, while the post- intervention test results represent performance after the intervention.

Table 3: Descriptive Statistics of Pre-test and Post-test Scores (N = 40)

Test	Minimum score	Maximum score	Mean score	SD
Pre-intervention test	8	34	19.83	7.55
Post-intervention test	20	48	34.56	7.33

From Table 3, students' score in the pre-intervention test ranged between 8 and 34, with a mean of 19.83 (SD = 7.55), indicating generally low prior knowledge. Most of the students (31 students) scored below 25 marks, which is the pass mark, 2 students scored 25 marks, with only 7 students scoring above 25 marks. This implies that only 9 students representing 22.5% passed the test, and the remaining 31 students representing 87.5% scored below that pass mark. Generally, this indicated low prior knowledge of the students. After the cooperative learning intervention, students' post-intervention test scores ranged from 20 to 48, with a mean of 34.56 (SD = 7.33). Most of the students (36 students) scored above 25 marks, 2 scored 25 mark, with only two scoring below 25 marks. This means that 38 students represent 95% passed the post-intervention test, and only 2 student representing 5 % scored below the pass mark. This shows a considerable improvement in students' performance after the intervention.

A mean difference of 14.73 points suggests substantial academic gains after the intervention. The descriptive statistics reveal that a much larger proportion of students scored above the pass mark in the post-intervention test compared to the pre-intervention test, demonstrating improved conceptual understanding.

To determine whether the observed improvement was statistically significant, a paired samples t-test was conducted. The results are shown in Table 4.

Table 4: paired sample t-test comparing students' pre-test and post-test scores

Test	N	Mean	SD	df	t-value	p-value
Pretest	40	19.83	7.55	39	45. 41	P < 0.001
Posttest	40	34.56	7.33			

Statistically significant at α = 0.05

The results in Table 4 show that the difference in means of students' pre-intervention test and post-intervention test scores was statistically significant, $t(39) = 45.41$, $p < .001$. This indicated that cooperative learning had a significant positive effect on students' academic performance in the circulatory system. This suggested that the improvement in academic performance of students after the intervention did not occur by chance.

To determine the magnitude of the intervention's impact, Cohen's d was calculated. Using the mean difference and pooled standard deviation, Cohen's d was determined, $d = 1.95$. According to Cohen's (1988) guidelines, an effect size above 0.80 is considered large. An effect size of 1.95 indicated a very large effect, meaning cooperative learning produced substantial improvement in students' academic performance.

The findings show that cooperative learning significantly enhanced students' understanding of the circulatory system. Therefore, cooperative learning has positive effect on student' academic performance in the circulatory system.

This fining is consistent with the findings of Mark-Mensah et al. (2018) who employed a quasi-experimental design to investigate the use of cooperative learning in enhancing the performance of upper primary pupils in science. The study found that students taught with the cooperative learning approach exhibited higher academic performance. Also, this finding agree with the finding of Assan-Donkoh et al. (2019) who employed action research to investigate the impact of cooperative learning strategy on mathematics achievements of students in Brentu Senior High Technical School, and found out that cooperative learning improved students' academic performance.

This finding is also supported by Osei and Appiah-Twumasi (2018) who used action research design to examine the effect of cooperative learning strategy on teacher trainees' performance and retention of science concepts in Berekum College of Education, and found that cooperative learning strategy increased students' academic performance.

Also, this finding is in line with that of Zakaria et al (2013) who carried out a quasi-experiment to determine the effect of cooperative learning on mathematics achievement and attitude towards mathematics in a Nigerian secondary school, and found out that cooperative learning methods improve students' achievement in mathematics.
This finding also agrees with the finding of Ali and Raza (2024), who used a quasi-experimental design to investigate the use of cooperative learning in enhancing the academic achievements of Science students in Pakistan, and found that cooperative learning was superior to traditional methods in General Science achievement of students.

The finding of Khan et al. (2024) also supports this study's finding. The researchers investigated the impact of cooperative learning on students' academic achievement and social behavior and found that cooperative learning positively influences students' academic performance.

Many other studies including Kolawole (2008), Aziz and Hossain (2010), Demirci (2010), Jumoke-Bukunola and Idowu (2012), Odoh (2012), Mbacho (2013), Tran (2014), and Altun (2015) found that cooperative learning improves the academic performance of students.

The improvement in students' academic performance after the intervention can be explained through the lens of Vygotsky's Social Constructivist Learning Theory, which emphasises the central role of social interaction in the construction of knowledge. According to Vygotsky (1978), learning occurs most effectively when learners interact with more knowledgeable peers or collaborate within a supportive social environment. This idea is reflected in the cooperative learning activities implemented during the intervention.

Firstly, Vygotsky posits that learning takes place within the Zone of Proximal Development (ZPD), where students are capable of achieving higher levels of understanding with the assistance of others (Amineh & Asl, 2015). In this study, cooperative learning created opportunities for students to operate within their ZPD. Group discussions, peer explanations, and shared problem-solving allowed learners to receive scaffolding from peers who had a better grasp of certain concepts. This interaction and immediate feedback students received from peers helped clarify misconceptions, strengthened understanding, and ultimately contributed to improved academic performance.

Additionally, the intervention promoted collaborative learning roles that align with Vygotsky's notion of guided participation. Through assigned tasks and responsibilities, each learner contributed to the group's success, fostering positive interdependence. This did not only increase motivation but also ensured that students remained accountable during the learning process. Such guided collaboration supported gradual transfer of responsibility from social interactions to independent problem-solving, which explains the observed improvement in post-intervention test scores.

4.2.2 Research question 2: What is the influence of gender on students' academic performance in circulatory system when taught with cooperative learning?

This research question examined whether male and female students differed in their academic performance after being taught the circulatory system using cooperative learning. To answer this question, descriptive statistics were computed for the post-intervention test scores of male and female students, followed by an independent samples t-test to determine whether any observed differences were statistically significant.

Table 5 presents the descriptive statistics for the post-intervention scores of males and females.

Table 5: Descriptive Statistics of post-test scores of male and female

Gender	N	Mean score	SD
Male	23	34.00	7.73
Female	17	35.41	7.21

From Table 5, male students scored between 20 and 48, with a mean of 34.00 (SD = 7.73) in the post-intervention test. 22 males representing 95.7% passed the post-intervention test, and only 1 male representing 4.3% scored below the pass mark. Female students scored between 22 and 47, with a mean of 35.41 (SD = 7.21). 16 female representing 94.1% passed, and only 1 representing 6.9% scored below the pass mark. There is a slight mean difference of 1.41, with females performing slightly better than the males.

To determine whether this observed difference was statistically significant, an independent samples t-test was performed.

Table 6 : Independent samples t-test comparing male and female post-test scores

Gender	N	Mean	SD	df	t-value	p-value (2 tailed)
Male	23	34.00	7.73	38	0.62	0.54
Female	17	35. 41	7.21			

Statistically significant at $\alpha = 0.05$

The results in Table 6 indicated that the difference in performance between male and female students was not statistically significant, t(38) = 0.62, p = .54. To determine the magnitude of the gender difference, the effect size was computed. The effect size, measured using Cohen's d (d = 0.19), indicated a very small practical difference in performance between male and female.

The findings showed that male and female students performed similarly after being taught the circulatory system using cooperative learning. The slight difference in mean scores did not translate into any meaningful statistical difference. It was merely my chance. This indicated that cooperative learning benefitted both genders equally and supported equitable learning outcomes across genders.

Thus, gender has no influence on students' academic performance in circulatory system when taught with cooperative learning.

This finding agrees with the finding of Njoroge and Githua (2013) who employed a quasi-experimental design to investigate effects of cooperative learning strategy on learners' mathematics achievement by gender in a secondary school in Kenya, and found that there were no significant gender differences in students' mathematics achievement after they were taught scale drawing topic through co-operative learning strategy.

Also the finding confirmed that of Olson (2002) who used quasi experimental design to evaluate the effectiveness of cooperative learning in a liberal arts mathematics course and to examine any gender-related differences in the effects of cooperative learning in terms of achievement, composition of the cooperative groups, mathematics anxiety, attitudes toward mathematics, attendance, and retention, and found that there was no significant difference in academic performance between male and female students.

This finding is also in line with the finding of Mobark (2014) who employed quasi-experimental design to investigate the effect of using cooperative learning strategy on graduate students' academic performance and gender differences in educational statistics and educational research method courses in King Saudi University, and found that there was no significant difference in academic performance of male and female students after they were exposed to cooperative learning.

This finding is also supported by Ndebil and Ali (2024) who used quasi-experimental design to examine the effectiveness of cooperative learning as a strategy of improving mathematics performance and attitudes, and found that there was no statistically significant difference between the performance of male and female.

Achor et al (2013) also had similar finding to this study. These researchers used quasi-experimental design to examined gender as a factor in the achievement of biology students taught using Students' Team Achievement Division (STAD) and Jigsaw cooperative learning strategies in Wamba Local Government Area of Nasarawa state in Nigeria, and found that there was no significant difference in mean achievement between male and female students.

Mbacho (2013) who used Solomon Four non-equivalent control group design to examine the effect of Jigsaw Cooperative Learning strategy on students' Mathematics achievement by gender in secondary schools in Laikipia County, Kenya also had similar finding. He found that gender did not have any influence on students' academic performance when they were taught with Cooperative Learning strategy.

Few studies however disagree with this finding. Prieto-Saborit et al. (2021) used a quasi-experimental design to investigate the influence that cooperative learning has on academic performance and on the gender gap in the subject of Mathematics, and found that males performed significantly higher than female in the experimental group after they were exposed to cooperative learning.

Also, Amedu (2015) used action research design to examined the effect of gender on the achievement of students in biology using the cooperative learning and found that there was a significant difference between the mean scores in favor of the males.

Puiggalí et al (2023) used exploratory design to examined the effect of gender on the achievement of students in Science using the cooperative learning, and found that girls significantly performed better than boys in both homogeneous and heterogeneous groups

Khoshsima and Saed (2014) who used quasi-experiment to investigate the gender differences in using cooperative learning and to find out how it can improve reading comprehension ability of intermediate-level students at Chabahar Maritime University, Iran, found that there was significant difference in academic achievement between male and female in favor of female after students were exposed to cooperative learning. This finding suggest that no gender related advantage or disadvantage occurred as a result of the intervention. When students engage actively with peers, share ideas, and participate in group problem solving, the learning benefits are distributed equally across genders (Gillies, 2016).

Key elements of cooperative learning such as positive interdependence, individual accountability, and structured group roles ensured that every learner irrespective of his/her gender participated meaningfully, thereby reducing the likelihood of single gender dominating discussions, and created a more inclusive learning environment where both gender equally participated. The emphasis on collaboration rather than competition created a supportive social climate in which both gender felt more confident to contribute, asked questions, and expressed scientific ideas without fear of ridicule. These features collectively promoted equitable participation, narrowed gender gaps, and equally improved the academic performance of both male and female students

4.2.3 Research question 3: What is the effect of cooperative learning on students' knowledge retention?

This research question sought to determine the effect of cooperative learning on students' knowledge retention. To answer this question, descriptive statistics were computed for post-test and retention test scores, followed by a paired samples t-test to determine whether any observed differences were statistically significant. Table 7 presents the descriptive statistics for the post-intervention test and retention test scores.

Table 7 : Descriptive Statistics of post-test and retention test scores (N = 40)

Test	Minimum score	Maximum score	Mean score	SD
Post-test	20	48	34.56	7.33
Retention test	21	47	34.25	7.27

From Table 7, students scored between 20 and 48 in the post-intervention test, with a mean of 3.46 (SD = 7.33), and scored between 21 and 47 in the retention test with a mean score of 34.25 (7.27), giving a small means difference of 0.31. This is an indication that students' performance remained almost unchanged weeks after the intervention, suggesting retention of learned concepts.

To determine whether this small difference was statistically significant, a paired samples t-test was performed to compare students' mean scores in post-intervention test and retention test.

Table 8 : Paired sample t-test comparing the results of retention test and post intervention test

Test	N	Mean	SD	df	t-value	p-value
Post-test	40	34.56	7.34	39	1.41	0.17
Retention test	40	34.25	7.27			

Statistically significant at ά = 0.05 level

The results in Table 8 indicated that the difference in students' performance between post-intervention and retention test was not statistically significant, $t(39) = 1.41$, $p = .17$. The effect size, measured using Cohen's d ($d = 0.22$), indicated a very small practical changes in performance of student between the post-intervention test and retention test.

The results showed that students were able to retain the knowledge acquired through cooperative learning. No significant difference in students' performance in post-intervention and retention test, coupled with a small effect size, indicated that cooperative learning supported long-term retention of knowledge. Cooperative learning improved students' knowledge retention in the circulatory system. Therefore, cooperative learning has positive effect on students' knowledge retention in the circulatory system.

This finding is supported by Toklucu and Tay (2016) who used experimental design to investigate the effect of cooperative learning method and systematic teaching on students' achievement and knowledge retention in Biology lessons, and found that student in the experimental group secured knowledge retention while those in the control group could not retain their knowledge within a two-week period.

This finding also agrees with the finding of Sibomana et al. (2022) who used quasi-experimental design to examine the effect of cooperative learning on students' knowledge retention and attitude in Chemistry in a Rwandan secondary school, and found that the experimental group exposed to cooperative learning had significantly higher retention of knowledge than their counterparts in the control group.

Osei and Appiah-Twumasi (2018) who used action research to examine the effect of cooperative learning strategy on teacher trainees' performance and retention of science concepts in Brekum College of Education also confirm this result with their finding that, cooperative learning increases students' knowledge retention.

This result is also in line with the finding of Adeyime and Oluwo (2024) who used a quasi-experiment to examine the effect of cooperative learning strategy on the achievement and knowledge retention of students in business studies in Lagos State, Nigeria, and found that the implementation of cooperative learning in the experimental group significantly improved their knowledge retention.

The improvement in students' knowledge retention after the cooperative learning intervention could be attributed to several pedagogical mechanisms inherent in the cooperative learning approach. Cooperative learning promoted active participation, as students were required to engage in discussion, questioning, and explanation of concepts rather than relying solely on teacher-led instruction. Such active engagement deepened students' cognitive processing, which, in turn, supported long-term memory. By interacting with learning materials and classmates, students processed information at multiple cognitive levels, which is a condition known to facilitate knowledge retention. Also, peer-to-peer explanation enabled learners to reorganize and internalize information in their own words. When students were required to explain content to others, they revisited the material more critically, which might have contributed to their improved knowledge retention.

Furthermore, working collectively on shared goals pushed students to think more analytically and considered multiple perspectives before arriving at solutions. This deeper engagement with the material likely supported the development of stronger memory traces. The cooperative structure used for the intervention also created a supportive social environment that increased students' motivation and reduced learning anxiety. Students were able to learn from one another, seek clarification more freely, and participate in a less intimidating environment than traditional whole-class settings. This supportive atmosphere likely promoted confidence and persistence, both of which are important for retaining content over time.

Finally, the repeated reinforcement of key concepts through group interaction offered multiple exposures to the same material across different voices and explanations. This repeated and varied exposure enhanced long-term retention of knowledge. Students did not only hear information from their peers but also revisited ideas during group tasks, discussions, and feedback sessions. Such ongoing reinforcement might have made it easier for learners to recall the material during the retention test.

4.2.4 Research question four: What is the attitude of TVET students towards the use of cooperative learning during Integrated Science lessons?

The essence of this research question was to determine whether TVET students had positive or negative attitude towards cooperative learning after it was used to teach them circulatory system. In order to answer this research question, participants' response to the questionnaire on their attitude towards cooperative learning was analysed using mean and standard deviation. The results are summarized in Table 9.

Table 9: Students' attitude towards cooperative learning

Statement	Mean	SD
I will willingly participate in group activities.	4.28	0.78
Group work makes learning more easy and interesting.	4.05	0.70
The workload is mostly less when I work with others.	3.95	0.78
I prefer group learning when the concepts are complex to learn.	4.05	0.90
My group members explain things to me when I don't understand.	4.03	0.73
When I work with other students, I achieve more than when I work alone.	4.08	0.79
I enjoy learning more when I work with others.	4.0	0.78
Group discussions help me to share my ideas.	4.2	0.61
Group discussion enhance my participation in class.	4.15	0.80
Group work triggers creativity.	3.73	0.85
Through group work, I have learned to work with students who are different from me.	4.5	0.51
My work/thought are well organised when I work in a group.	3.7	1.02
I easily recollect what I learn in group.	4.33	0.76
I prefer that my facilitator uses more group activities.	4.03	0.73
Mean of means/ Average standard deviation.	4.06	0.81

Source: Field work, 2024

From Table 9, the mean scores of participants' response ranged from 3.7(SD = 1.02) to 4.5(SD = 0.51) with an overall mean of 4.06 (SD = 0.81), which indicates the students' general preference of cooperative learning.

Students agreed (mean = 4.28) that they would willingly participate in group activities. This indicates that the use of cooperative learning certainly met the learning preference of the participants. This positive attitude suggests that students recognised the value of team work. The moderately low standard deviation (0.78) suggests that most students share this willingness to participate in cooperative learning. This willingness to participate is very important for the success of cooperative learning, as the effectiveness of group work relies on the involvement of all group members. This finding is consistent with the work of Tran (2019), which indicated that cooperative learning motivates students to actively engage in class activities.

Students' positive attitude towards cooperative learning is fueled by how easy learning becomes when students work in groups. Students agreed (mean = 4.05) that group activities make the learning easier and interesting. Student mostly get frustrated when concepts are too difficult to learn, thus would be willing to engage in cooperative learning since the difficulty in learning is reduced and learning gets more interesting when students work within cooperative learning groups. The standard deviation (0.7) suggests that there was congruence in student's response that group work makes learning easier and interesting. This indicates the consistent positive experience students have in group work. When students find learning both interesting and easy, they are more likely to remain motivated and strive through challenges (Lai & Wang, 2013).

The large content student has to work on as an individual has been to some extent reduced by group work. Students agreed (mean =3.95) that workload is usually less when they work with other students. This means students generally agree that, working in groups reduces their workload. The outcome of group work is achieved with less stress on students as each student can handle section of the work instead of handling everything as an individual. The standard deviation (0.78) shows that most students hold the view that group work reduces their workload. When students in a group feel that the workload is lighter, they are more likely to be motivated to participate in the group's activities and contribute to the success of the group.

The students agreed (mean = 4.05) that they prefer group learning when the concepts are difficult to learn alone. However, the standard deviation (0.90) indicates some inconsistency in preference, which could be individual difference in learning styles or experiences with group work. Most students find it difficult to learn when concepts are complex and might require explanation from others (Felder & Brent, 2007). Student may not give up easily on learning when they know they can get help from others. This will encourage them to work forward rather than giving up.

The preference of learners for cooperative learning when the concepts are complex is engineered by the fact that students are offered explanations by their colleagues when they do not understand something. Students generally agreed (mean =4.03) that group members explained concepts to them when they did not understand. Students prefer a learning environment where they can easily interact with others and receive the necessary help when required. Students showed high homogeneity (SD = 0.73) in response in relation to help they receive from colleagues during group work. Johnson and Johnson (2002) highlight the importance of positive interdependence in cooperative learning, where students take responsibility for each other's success. This leads to deeper understanding of concepts as students explain concepts to each other and work together through challenges.

The students had positive attitude towards cooperative learning because they had achieved intellectual growth under such condition. Students generally agreed (mean = 4.08) that they acquire more information when working in group. When various tasks are being performed by different students within a group, unique ideas may be generated which would provide the group with richer and broader information, thus increasing students' achievement. The degree of homogeneity (SD = 0.79) of students' response was high. This indicates that, it is a widely shared experience among the students. Slavin (2011) stated that cooperative learning environment provides students with access to broader range of perspectives and information. In cooperative work, students can share resources, and fill in gap in each other's knowledge. With their responses, students acknowledged the essence of group work in knowledge acquisition.

Because students attain higher achievements when they work in group, they have come to enjoy learning in groups. Students generally agreed (mean = 4.0) that they enjoy learning more when they are in groups. The standard deviation (0.78) suggests that most of the student share this view. Gillies et al. (2007) stated that students mostly report higher level of enjoyment and satisfaction when learning in cooperative environments, as these environments are more interactive and supportive. Enjoyment and satisfaction are closely connected to motivation, and when students are motivated, they are more likely to engage deeply in the learning process and persevere through challenges. The enjoyment students have when learning in groups might also motivate them to always engage in group activities since they find it entertaining. This could help students to develop social skills required for team work in the corporate world.

Again, students generally agreed (mean = 4.20) that group work give them the opportunity to share their ideas. The standard deviation (0.61) suggests that this is a common experience among the students. Most often, shy students find it difficult to share their ideas in a whole class discussion simply because they cannot express themselves well. However, in group discussions, students have the opportunity to share their thoughts, receive feedback and refine their ideas (Gillies, 2016). Felder and Brent (2007) noted the role of social interaction in learning, stating that discussing ideas with others can lead to new insights, deeper understanding of concepts and confidence building.

Also, students agreed (mean = 4.15) that group work enhances their participation in class. This revelation was not surprising because once students get help from others, and share their ideas with others, they would be much confident and comfortable to actively participate in the teaching and learning process rather than being passive participants. Once their participation in class is enhanced, their learning is likely to improve. The standard deviation (0.80) suggests some inconsistency in response which could be attributed to difference in groups dynamics or individual student's personality. Some students may feel comfortable sharing their ideas in group setting while others prefer to work alone and not ready to share any idea with someone.

Most students had positive attitude towards cooperative learning because they felt cooperative learning enhances creativity. Students generally agreed (mean =3.73) that group work enhances their creativity. In cooperative environment, students are able to operate at higher level of thinking where they can easily synthensise information and come out with something new. A learning environment that provides students with this ability would definitely be welcomed by students. The standard deviation (0.85) proposes students had diverse opinion on this matter, possibly due to varying experience with group work. Most students might have found that group activities spark new ideas, with few other feeling constrained by group dynamics.

Generally, students strongly agreed (mean = 4.50) that group work have helped them to work with other students who are different from them. The standard deviation (0.51) suggests that this is a common experience among the students. The ability to work with others with diverse ability is very crucial because working in diverse groups exposes students to diverse points of view and problem solving approaches, which enhances their cognitive and social skills (Johnson & Johnson, 2008). Johnson and Johnson (2008) further enphasised the importance of heterogeneity in group composition as it promotes empathy, reduces prejudice and prepares students for effective cooperation in the corporate world.

On general basis, students agreed (mean = 3.7) that group work helps them to organize their thoughts better. This revelation is not surprising because since each member of a group comes with different experience, thus, it is possible to shape the thoughts of each other, and this may lead to better organization of individual's thought. However, the high standard deviation (1.02) indicates that there was wide range of students' responses. Whiles most students might find group discussion and collaboration helpful in the effective organization of their ideas, others possibly felt otherwise. These students might have struggled with undesirable group dynamics or had less contribution from group members. (Jocobs & Renandya, 2019) stated that, well organized group activities could help students articulate their thinking more clearly, leading to better organisation of ideas. However, the wide range of responses suggests that not all students had this benefit of group work. This could be attributed to factors such as group formation and individual preference.

Students agreed (mean = 4.33) that they can recall information more easily when they learnt it in group setting. The degree of homogeneity in the responses of the respondents was high (SD = 0.76). This implies that student commonly share the view that information learned in cooperative setting can be easily recalled. This finding was not surprising because (Alrayah, 2018) enphasised that social interactions in group work can enhance memory retention through repetition and reinforcement of key concepts by group members. When students discuss and explain concepts to each other, they are more likely to internalize the information and remember it more easily.

Based on the findings so far, students undoubtedly agreed (mean = 4.03) that they preferred their facilitators use more group activities. There is high congruence (SD = 0.73) in students' response to this item, suggesting that this preference is commonly shared by the students. Looking at the numerous benefits of cooperative learning, per the students' response to earlier items, it was not surprising that most of them prefer their facilitator uses more group activities. Most of them have realized the essence of working in cooperative groups rather than working alone, and have therefore developed positive attitude towards cooperative learning. The students' preference is likely engineered by the numerous benefits students get from cooperative learning, which is in consistent with Walker et al. (2017)'s assertion that students always prefer cooperative learning environment to the traditional learning environment.

The mean of means (4.06) and the average standard deviation (0.81) indicates student's general preference for cooperative learning. This finding is well grounded as many studies (Amedu and Gudi, 2017: Asare, 2016: Er & Anku-Atac, 2014: Erdem, 2009: Kose et al., 2010: Reda, 2015: Saborit et al., 2016: Sibomana et al., 2022: Vollinger & Supanc, 2020) found that students have positive attitude towards cooperative learning. The students' positive attitude towards cooperative learning is a clear indication that cooperative learning strategy is an effective pedagogical tool that facilitates students learning and improve their academic achievements.

Few studies (Herrmann, 2013: McLeish, 2009) however had different finding. These studies found that students had negative attitude towards cooperative learning. It can therefore be concluded that generally, the students developed positive attitude towards cooperative learning.

CHAPTER FIVE

SUMMARY OF FINDING, CONCLUSION AND RECOMMENDATIONS

5.0 Overview

This chapter provides summary of the main findings and conclusion drawn from this study. It also presents recommendations for various stakeholders and suggestions for further studies.

5.1 Summary of Findings

The study revealed that:

1. cooperative learning significantly improved students' academic performance in the circulatory system, with a large effect size (d = 1.95).
2. gender had no significant influence on students' academic performance when taught using cooperative learning (p = 0.54).
3. cooperative learning had a positive effect on students' knowledge retention, with no significant difference between post-test and retention test scores (p = 0.17).
4. students developed a positive attitude towards cooperative learning, with a mean score of 4.06 (SD = 0.81) indicating a general preference for cooperative learning.

5.2 Conclusion

The findings of this study indicated that cooperative learning is an effective instructional approach for improving students' academic performance in the circulatory system. The significant improvement observed between the pre- and post-intervention tests confirmed that students benefited academically from being taught using cooperative learning methods. Furthermore, the study demonstrates that gender does not influence academic performance when students are taught using cooperative learning, as both male and female students performed equally well after the intervention.

Additionally, cooperative learning supports long-term knowledge retention, as evidenced by the lack of significant difference between post-intervention and retention test scores. Lastly, the positive attitude shown by students toward cooperative learning demonstrates its potential for promoting an engaging and collective learning environment in science education. Undoubtedly, cooperative learning does not only enhance students' academic achievement but also promotes gender equity in learning outcomes, improves knowledge retention, and is well-received by students. This proposes that cooperative learning is a valuable strategy for teaching complex scientific concepts like the circulatory system in TVET institutions and schools.

5.3 Recommendations

Based on the findings, the following recommendations are made.

1. Teachers of Have Technical Institute should design and use cooperative learning activities to involve students in the teaching and learning process especially in concepts which seems to be abstract in science
2. Teachers of Have Technical Institute should involve all students irrespective of their gender equally and fairly during group activities.
3. Teachers of Have Technical institute should design a follow-up activities or assessments within their lesson to leverage the long-term retention benefits of cooperative learning

4. Teachers of Have Technical Institute should seek regular feedback from students to identify teaching methods they enjoy/ accept and use them to actively engage their students
5. Teachers of Have Technical Institute should promote a positive attitude toward learning through student feedback sessions and reflective exercises.

5.4 Suggestion for further study

The following suggestions are made for further research.

1. Further research should be conducted to investigate specific cooperative learning strategies (e.g., Jigsaw, Think-Pair-Share) that are most effective for teaching the circulatory system.
2. Further research should be conducted to examine how males and females interact in mixed-gender cooperative groups while learning the circulatory system.
3. Further research should be conducted to identify factors that contribute to students' positive attitude toward cooperative learning for the circulatory system at Have Technical Institute.

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APPENDICES

Appendix A1

Lesson plans for teaching circulatory system using cooperative learning.

LESSON 1

Date:

Class: MET3

Class size: 40

Duration: 120 minutes

References: Obeng, A. K. B., (2019), *Approaches series; Integrated Science for Senior High Schools*, 7th edition, pg. 600, Published by APPROACHERS (GHANA) Limited.

Peter A. & Henric A. B., (2011), *AKI- OLA series; Integrated Science for Senior High Schools*, 4th ed, printed and published in Ghana by AKI- OLA Publications.

WASSCE/ WAEC Integrated Science Teaching Syllabus, (2010), pg. 29

Topic: Circulatory system of mammals

Relevant previous knowledge: student learned circulatory system in J.H.S

Objectives: By the end of the lesson, a student will be able to:

1. identify the main components of the circulatory system.
2. describe the location and structure of the human heart.
3. identify the parts of the circulatory system and state their functions.

Teaching and learning materials:

Whiteboard and markers, projector and computer, worksheets, diagrams of the heart, a chart of the circulatory system, colored - pencils (blue and red pencils), integrated science text books, index cards.

Teacher- learner activities

Introduction: teacher introduces the lesson by showing a short animation of the circulatory system to the students.

Activity One: teacher distributes worksheet **A**. He/she asks students to individually think and fill part I. He/she instructs students to pair up with a classmate and share their answers. Teacher encourages them to discuss and compare their thoughts, and come to a consensus on the answers. Each pair is instructed to shares their answers with the class. Teacher discusses students' responses with the class and clarify any misconceptions.

Activity two: In a group of five students with students in each group numbered 1 to 5, teacher instructs students in each group to work together on part II of the worksheet. Teacher randomly call out a number and student with that number from each group shares their group's answers. Teacher discusses students' response with class and provides additional explanations as needed.

Activity three: with the same groups as used in activity two, teacher instructs students to work together on part II of the worksheet provided to them through discussion. Teacher randomly call out a number and student with that number from each group shares their group's answers. Teacher discusses students' response with class and provides additional explanations as needed. Teacher collects work sheet for assessment

Core points

Circulation system. It is a group of organs that work together to transport substance throughout the body.

Components of the circulatory system: the components of the circulatory system are the heart, blood and blood vessels

The heart

The human heart is a pear shaped and fist-sized organ that pumps throughout the body. It is made up of cardiac muscles and located in thoracic cavity, between the two lungs and slightly shifted to the left. It is enclosed in a pericardial membrane filled with fluid known as pericardial fluid which minimises friction during the pumping movement of the heart. The heart is made up of four chambers: the ventricles and the atria. The two atria form the upper chambers of the heart and the two ventricle forms the two lower chambers of the heart. the ventricles are separated by interventricular septum, preventing the mixing of oxygenated and deoxygenated blood.

The main function of the heart is to pump blood to all parts of the body.

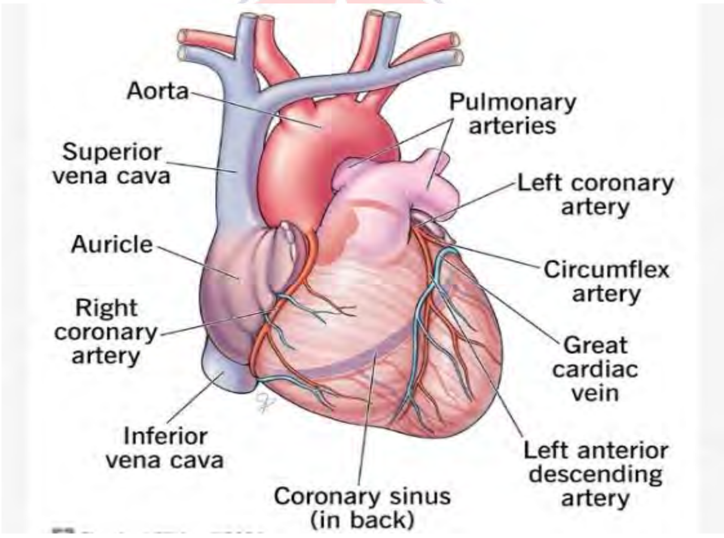


Figure 2: The external view of human heart

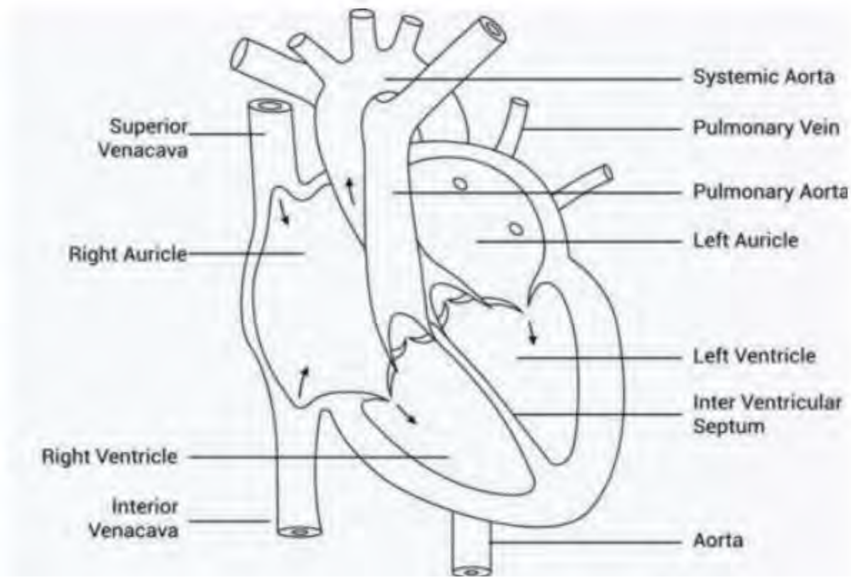


Figure 3: Longitudinal section of human heart

Functions of parts of the heart:

Aorta: it carries oxygenated from the heart to all parts of the body

Vena cava: it carries deoxygenated blood back to the heart

Pulmonary artery: it transports deoxygenated blood from the heart to the lungs

Pulmonary vein: it carries oxygenated blood from lung to heart

Right atrium: it receives blood from the vena cava and pumps it to the right ventricle

Right ventricle: it receives blood from the right atrium and pump it through to the lungs

Left atrium: it receives blood from the lungs and pumps it to the left ventricle

Left ventricle: it receives blood from the left atrium and pumps it to all parts of the body

Septum: it prevents oxygenated blood from deoxygenated blood

Bicuspid valves: it prevents the backflow of blood from the left ventricle to the left atrium

Tricuspid valve: it prevents the backflow of blood the right ventricle to the right atrium.

Semi-lunar valves: they prevent the backflow of blood to the ventricles

Conclusion: teacher concludes the lesson by conducting a whole-class discussion to consolidate learning. Allow students to ask questions and discuss any remaining uncertainties.

Evaluation

1. list the main components of the circulatory system
2. give the function the following parts of the heart
   a. septum
   b. aorta
   c. vena cava
3. what is the main function of the circulatory system?

Appendix A2

LESSON 2

Date:

Class: MET3

Class size: 40

Duration: 120 minutes

References: Obeng, A. K. B., (2019), *Approaches series; Integrated Science for Senior High Schools*, 7th edition, pg. 600, Published by APPROACHERS (GHANA) Limited.

Peter A. & Henric A. B., (2011), *AKI- OLA series; Integrated Science for Senior High Schools*, 4th ed, printed and published in Ghana by AKI- OLA Publications.

WASSCE/ WAEC Integrated Science Teaching Syllabus, (2010), pg. 29

Topic: Circulatory system of mammals

Relevant previous knowledge: student learned circulatory system in J.H.S

Objectives: By the end of the lesson, a student will be able to:

1. identify the types of blood vessels
2. give the function of blood vessels
3. compare the various blood vessel

Teaching and learning material

Whiteboard and markers, projector and computer, worksheets, diagrams of the of blood vessel, integrated science text books, chart paper

Teacher-learner activities

Introduction: Teacher introduces the lesson by showing a short video of the various blood vessels

Activity One: In a jigsaw groups of three students each, teacher assigns each student in the group a specific type of blood vessel to become an expert on: arteries, veins, or capillaries. Teacher students with integrated science text books and instructs each student to fill part I of the worksheet with pencil based on their blood vessel. Teacher instructs all the students assigned to each of the blood vessel to form another group (expert group). Teacher provides each expert group with text books and pictures of their respective blood vessels. Each group is instructed to discuss its blood vessel fill out part II of the worksheet and prepare a short presentation to teach their home group members as their discussion progress.

Activity Two: teacher instructs students to return to the home groups and takes turn to teach their group members about the type of blood vessel they studied. As each student presents, all group members should fill out part III of their worksheets with the information being shared.

Activity three: teacher instructs students in their home groups to work together to fill out the final section (IV) of the worksheet that compares the three types of blood vessels and present their comparison chart to the class. Teacher facilitates a discussion on the similarities and differences between the blood vessels, emphasizing on key points students captured on their worksheet

Core points

Types of blood vessels:

There are three types of blood vessels. These are arteries, veins and capillaries

Arteries: They are blood vessels that carry blood away from the heart. They are comprised of smooth muscles and carry blood under high pressure. Artery is made up of three layers: outer fibrous connective layer, thick middle elastic layer and thin inner elastic membrane. It has narrow lumen with no valves. They are mostly located deep in the body

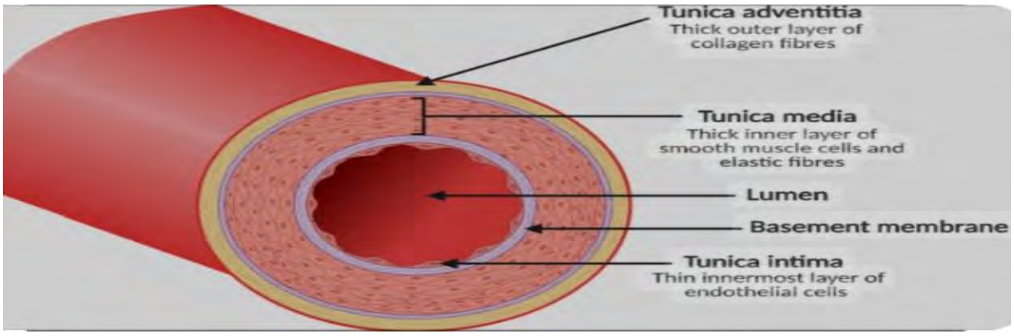


Figure 4: Cross section of an artery

Veins

They are blood vessels that carry blood towards the heart. veins are comprised of three layers. The outer layer is made up of connective tissues but less fibrous. The middle layer is thin and less elastic. The innermost layer has valves the prevents the backflow of blood. The veins carry blood under low pressure. They are mostly located closed to the surface of body. All veins carry deoxygenated blood except pulmonary and umbilical veins

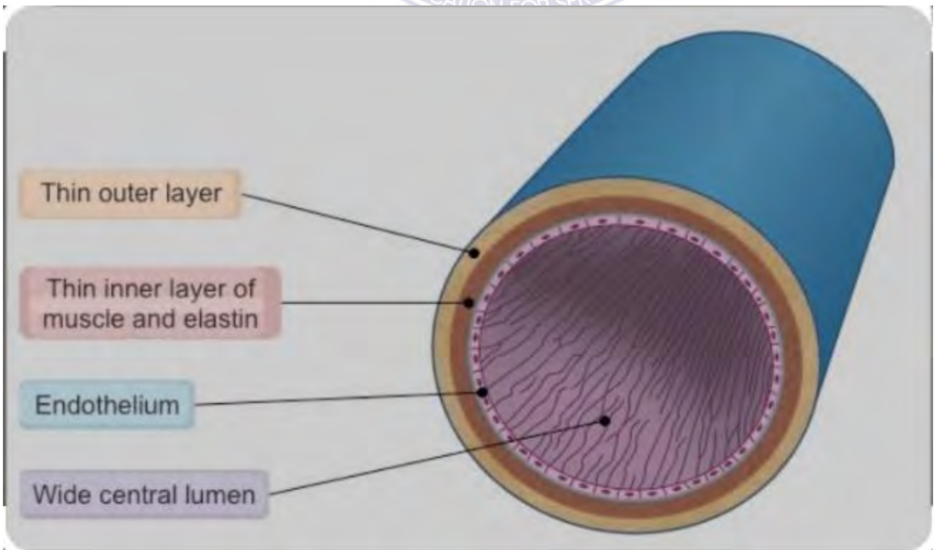


Figure 4: Cross section of a vein

Capillaries

They are very narrow, single cell layered vessels. They divide from the arteries and rejoin with the veins. Thousands of capillaries intertwine to form a network. They are in direct contact with the body tissues and are responsible for the exchange material between blood and the body tissues

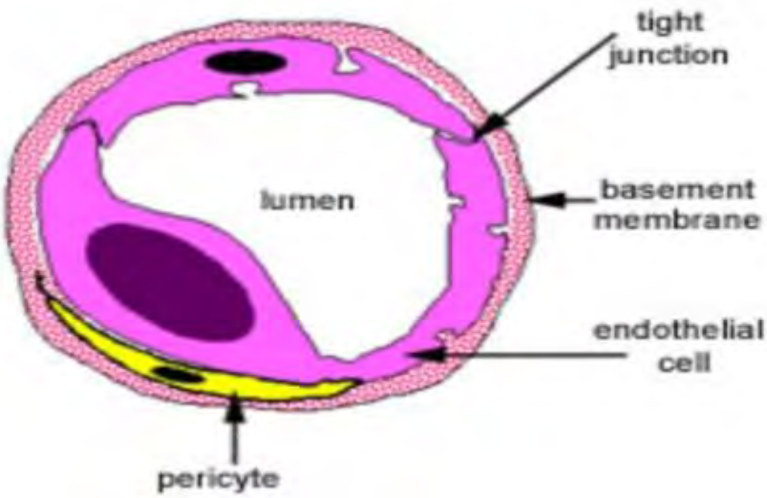


Figure 6: Cross section of a blood capillary

Conclusion: teacher concludes the lesson by conducting a whole-class discussion to consolidate learning. Allow students to ask questions and discuss any remaining uncertainties

Evaluation

1. state the three main types of circulatory system
2. State two arteries that carry deoxygenated blood.
3. What are the function of blood capillaries?
4. State two differences between arteries and veins

Appendix A3

LESSON 3

Date:

Class: MET3

Class size: 40

Duration: 120 minutes

References: Obeng, A. K. B., (2019), *Approaches series; Integrated Science for Senior High Schools*, 7th edition, pg. 600, Published by APPROACHERS (GHANA) Limited.

Peter A. & Henric A. B., (2011), *AKI- OLA series; Integrated Science for Senior High Schools*, 4th ed, printed and published in Ghana by AKI- OLA Publications.

WASSCE/ WAEC Integrated Science Teaching Syllabus, (2010), pg. 29

Topic: Circulatory system of mammals

Relevant previous knowledge: student learned circulatory system in J.H.S

Objectives: By the end of the lesson, a student will be able to:

1. identify the main components of blood.
2. describe the function of each blood component.
3. explain the types of blood circulation in humans

Teaching and learning material

Whiteboard and markers, projector and computer, worksheets, diagrams of the of human heart, integrated science text books, chart paper, Colored pencils

Introduction: Teacher introduces the lesson by brainstorming students to come out with various components of blood.

Activity one: In a heterogeneous group groups of four students each, teacher assigns each student in the group a specific blood component to become an expert on: blood plasma, white blood cell, red blood cell or blood platelet. blood component to become an expert on: plasma, white blood cells, red blood cells or blood platelet. Teacher gives each group an Integrated Science text book and a handout on circulatory system. The researcher distributes worksheet C to students and instructs them to fill out part I based on their assigned blood component by using a pencil. Teacher instructs all the students assigned to each of the blood component to form another group (expert group). Each expert group is instructed to discuss its blood component and fill out part II of the worksheet and prepare a short presentation to teach their home group members

Activity Two: Teacher instructs students to return to their respective home groups and takes turn to teach their group members about the blood component they studied. As each student presents, group members fill out part III of their worksheets with the information being shared

Activity three: teacher instructs students in their home groups to work on part IV of the worksheet individually. Teacher instructs each group to discuss their answers within their team mates. Teacher facilitates the group discussion, checking for understanding and clarifying any misconceptions.

Core points

Components of blood: the main components of blood are the plasma and blood cells. The blood cells are made up of red blood cells, white blood cells and platelets

Plasma: it is the straw colored fluid part of the blood. It is responsible for the transport of the blood cells as well as other important substances. It is made up of about 90% water. It also contains other substances like protein, mineral salt, dissolved food, waste substances and hormones.

Red blood cells(erythrocytes): they are responsible for carrying oxygen to the rest of the body and returning carbon dioxide to the lungs for exhalation. They contain hemoglobin, a protein that binds to oxygen. Red blood cells are biconcave in shape, which increases their surface area oxygen exchange. They lack nucleus to maximize space for hemoglobin.

Figure 7: Red blood cells

White blood cells (leucocytes): they are essential part of the immune system. They protect the body against infections by identifying and destroying pathogens. They are several types of white blood cells, including monocytes, lymphocytes, neutrophils, oenophils, macrophage, T cell, B cell and basophils, each with a specific function. White blood cells have nucleus with varied shapes

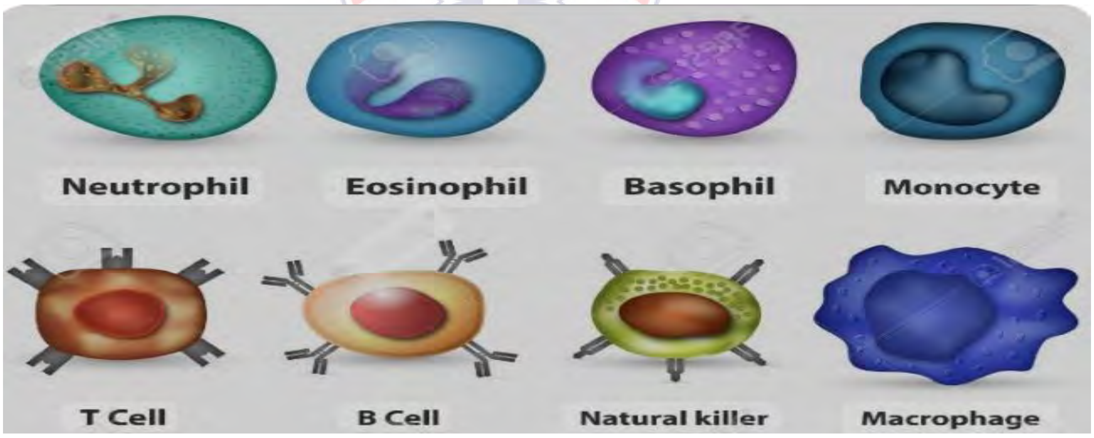


Figure 8: White blood cells

Platelet (thrombocytes): they are tiny disc shaped cell fragments, crucial for blood clotting. When a blood vessel is injured, platelets gather at the site and form temporal plug by sticking together. They release chemicals that activates the clotting cascade which solidifies the initial plug into stable clot, preventing excessive loss of blood

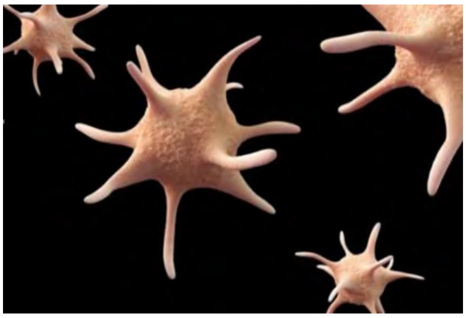


Figure 9: Blood platelet

Types of circulation: there are two types of circulation in human. These are pulmonary circulation and systemic circulation.

Pulmonary circulation is the movement of blood from the heart to the lungs and back to the heart. Deoxygenated blood in the right atrium is pumped to the right ventricle through the tricuspid valve. The right ventricle contracts to pump blood through the pulmonary artery to the lungs for oxygenation. Oxygenated blood moves through the pulmonary vein to the left atrium

Systemic circulation is the movement of blood from the heart to all parts of the body and back to the heart. oxygenated blood in the left atrium is pumped to the left ventricle through the bicuspid valve. The left ventricle pumps the blood through the aorta to all parts of the body. The blood gives off oxygen to body tissues and picks up carbon dioxide. The deoxygenated blood is returned to the right atrium through the superior and inferior vena cava.

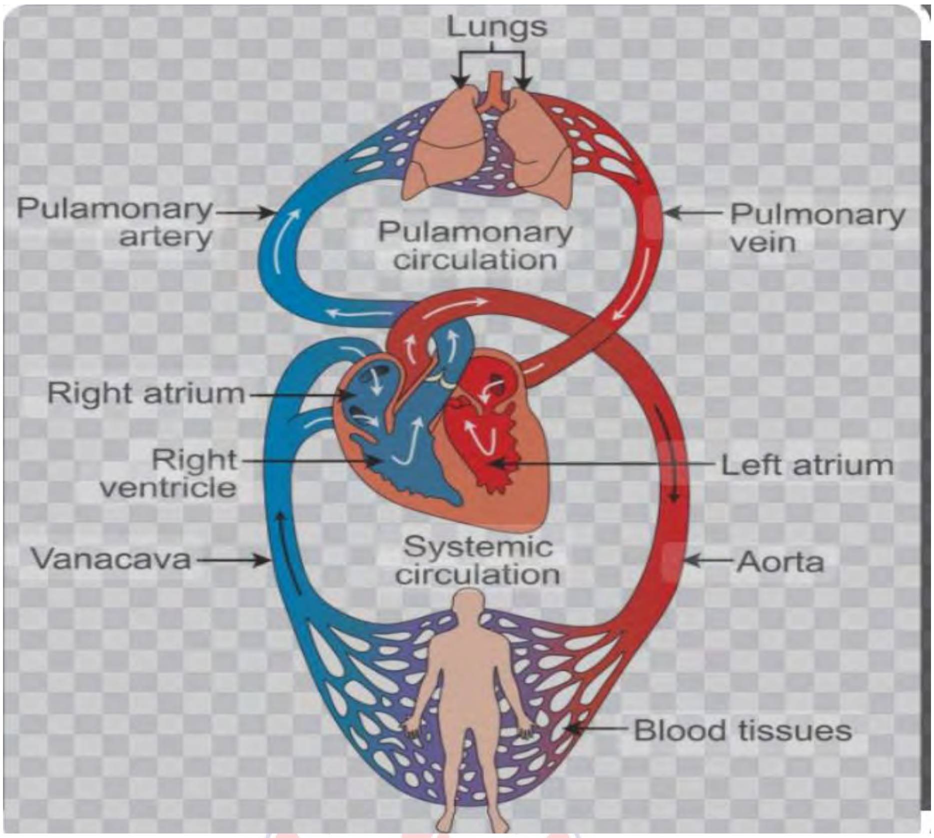


Figure 10: Diagram showing the two types of circulation

Conclusion: teacher concludes the lesson by conducting a whole-class discussion to consolidate learning. Allow students to ask questions and discuss any remaining uncertainties.

Evaluation

Evaluate the worksheets filled out by the students.

Observe group interactions and participation during the activities.

Let students answer the following questions individually

1. state two functions of blood.
2. Describe the pathway of pulmonary circulation in human

Appendix A4

LESSON 4

Date:

Class: MET3

Class size: 40

Duration: 120 minutes

References: Obeng, A. K. B., (2019), *Approaches series; Integrated Science for Senior High Schools*, 7th edition, pg. 600, Published by APPROACHERS (GHANA) Limited.

Peter A. & Henric A. B., (2011), *AKI- OLA series; Integrated Science for Senior High Schools*, 4th ed, printed and published in Ghana by AKI- OLA Publications.

WASSCE/ WAEC Integrated Science Teaching Syllabus, (2010), pg. 29

Topic: Circulatory system of mammals

Relevant previous knowledge: student learned circulatory system in J.H.S

Objectives: By the end of the lesson, a student will be able to:

1. identify at least four disorders associated with the circulatory system
2. mention at least one cause of each disorder.
3. state at least two ways of preventing each disorder

Teaching and learning material

Whiteboard and markers, projector and computer, worksheets, chart of some disorders of the circulatory system, students' handout, integrated science text books, chart papers, internet access

Teacher-learner activities

Introduction: through brainstorming, teacher introduces the main disorders of the circulatory system and their impact on health.

Activity one: In a heterogeneous group groups of five students each, teacher assigns each student in the group a specific disorder of the circulatory system to become an expert on. The teacher gives each group an Integrated Science text book and a handout on circulatory system from which they can gather information. The teacher distributes worksheet D to students and instructs them to fill out part I based on their assigned disorder by using a pencil. Teacher instructs all the students assigned to each of the disorder to form another group (expert group). Teacher instructs each expert group to discuss its disorder taking in to consideration the causes and preventive measures, and fill out part II of the worksheet as well as prepare a short presentation to teach their home group members.

Activity two: teacher instructs students to return to their respective home groups and take turn to teach their group mates about the disorder they specialized on. As each student presents, group members fill out their worksheets with the information being shared. Each group prepares a summary chart of the disorders, their causes, and preventive measures.

Activity three: teacher instructs each group to presents their summary chart to the class.

Core points

Disorders of the circulatory system include: high blood pressure, low blood pressure, hole in heart, anemia, leukemia, stroke, heart attack, hemophilia etc.

Table 6: Disorders of the circulatory system, their causes and preventive measures

Disorder	Causes	Preventive measures
High blood pressure	Genetics, obesity, lack of physical activity, high salt intake, stress	Maintain a healthy weight, exercise regularly, eat a balanced diet, reduce salt intake, manage stress
Low blood pressure	Maintain a healthy weight, exercise regularly, eat a balanced diet, reduce salt intake, manage stress	Stay hydrated, avoid standing for long periods, eat small meals frequently, wear compression stockings
Hole in heart	Genetic factors, pre-natal drug abuse, maternal conditions, Maternal nutrients deficiency, Exposure to toxin during pregnancy	Prenatal care, avoiding harmful substances during pregnancy, regular check-ups, eating balanced diet during pregnancy
leukemia	Genetic factors, exposure to radiation or chemicals, certain infections	Avoid exposure to radiation and harmful chemicals, maintain a healthy lifestyle, regular medical check-ups
Anemia	Iron deficiency, chronic diseases, genetic conditions, vitamin deficiency, excessive bleeding	Eat an iron-rich diet, take vitamin supplements if necessary, regular medical check-ups
heart attack	Atherosclerosis, high cholesterol, smoking, obesity, lack of exercise	Eat a heart-healthy diet, exercise regularly, avoid smoking, manage cholesterol levels, maintain a healthy weight
stroke	High blood pressure, smoking, heart disease, diabetes, high cholesterol	Control blood pressure, quit smoking, eat a healthy diet, exercise regularly, manage diabetes and cholesterol

Conclusion: teacher concludes the lesson by conducting a whole-class discussion to consolidate learning. Allow students to ask questions and discuss any remaining uncertainties.

Evaluation

Evaluate the worksheets and summary chats filled out by the students. Also evaluate students' interaction and presentations

Let students answer the following questions individually

1. State four disorders of the circulatory system.
2. Mention two cause and two preventive measures of high blood pressure.

Appendix B1

Pre-intervention test (SDT)

Name. …………………………………….. Duration: 60

School: Have Tech. Institute Class: MET3

This paper consists of two sections, section **A** and **B**. Section **A** consist of twenty-five multipole choice items. For each item**, circle** the alternative that best answer the question. For section **B**, write your answer in the space provided below each question. **Your response should be as brief as possible**. You are required to answer all questions.

1. What is the **main** function of the circulatory system?

a. digestion

b. respiration

c. transportation

d. excretion

2. The blood vessel that carries blood away from the heart is called

a. arteries

b. auxiliaries

c. capillaries

d. veins

3. Which of the following structures of the heart prevents oxygenated blood from mixing with deoxygenated blood?

a. pulmonary valve

b. septum

c. tricuspid valve

d. semi lunar valve

4. The heart is made of which of the following muscles?

a. cardiac muscle

b. rough muscle

c. smooth muscle

d. skeletal muscle

5. Which of the following is the largest artery in human?

a. aorta

b. vena cava

c. pulmonary artery

d. carotid artery

6. Blood vessel that supplies blood to the head is called……

a. carotid vein

b. carotid artery

c. renal artery

d. renal vein

7. which of the following blood vessels supply blood to the heart muscles?

a. pulmonary vein

b. coronary vein

c. pulmonary artery

d. coronary artery

8. which of the following is the correct sequence of blood flow through the mammalian heart?

a. right ventricle → right atrium → left ventricle → left atrium

b. left atrium → left ventricle → right atrium → right ventricle

c. left atrium → right ventricle → left ventricle → right atrium

d. right atrium → right ventricle → left atrium → left ventricle

9. Why is the walls of the left ventricle thicker? This is because it

a. receives blood from all parts of the body

b. pumps blood under high pressure

c. receives blood from the lungs

d. pumps blood under low pressure

10. Which of the following blood vessels have valves?

a. arteries

b. veins

c. capillaries

d. auxillaries

11. Which of the following is a disorder of the heart?

a. hemophilia

b. sickle cell anemia

c. leukemia

d. hole in heart

12. Which of the following is ***not*** a function of blood.

a. regulation

b. reproduction.

c. protection

d. hydration

13. Which of the following vessels serves as point of exchange of substance between blood and body tissues?

a. arteries

b. veins

c. capillaries

d. auxillaries

14. Which of the following components of blood transports oxygen?

a. white blood cell.

b. red blood cell

c. blood platelet

d. blood plasma

15. Which of the following blood vessels have widest lumen?

a. artery

b. vein

c. capillary

d. auxiliary

16. Mr. Mensah's blood pressure reads 160/125 mmHg. He is likely to have which of the following disorder

a. hypertension

b. hypotension

c. leukemia

d. coronary thrombosis

17. which of the following is ***not*** a cause of heart failure?

a. stress

b. smoking

c. heredity

d. eating sugary food

18. Which of the following types of blood circulation involves the movement of blood from the heart to all parts of the body and back to the heart?

a. systemic circulation

b. pulmonary circulation

c. open circulation

d. closed circulation

19. Too much intake of fat foods can lead to which of the following disorders?

a. leukemia

b. stroke

c. hemophilia

d. heart cancer

20. The tricuspid valve is found between

a. right atrium and left ventricle

b. right atrium and right ventricle

c. right ventricle and left atrium

d. left atrium and left ventricle

21. Which component of blood is responsible for blood clotting?

a. red blood cells

b. white blood cells

c. platelets

d. plasma

22. Which of the following is ***not*** a cause of high blood pressure?

a. lack of exercise

b. smoking

c. low sodium intake

d. high intake of fats

23. Which of the following is ***not*** a symptom of anemia?

a. fatigue

b. pale skin

c. high blood pressure

d. headache

24. What is the medical term for low blood sugar?

a. hypertension

b. hypoglycemia

c. hyperglycemia

d. isoglycemia

25. Which component of blood is responsible for transporting nutrients, gases, and hormones?

a. white blood cells

b. red blood cells

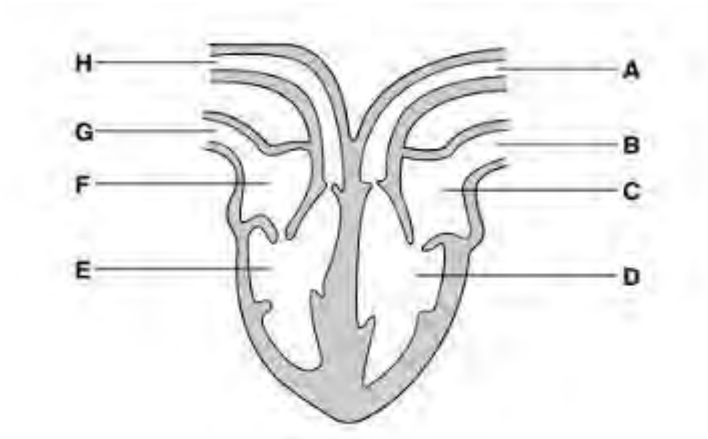
c. plasma

d. platelets

SECTION B

Answer all questions in this part. Write your answer in the space below each question.

1a. The diagram below shows a longitudinal section of the human heart. Study it carefully and answer the questions that follow.



i. Label the parts A to H

A……………………………………………………………………………………

B……………………………………………………………………………………

C……………………………………………………………………………………

D……………………………………………………………………………………

E……………………………………………………………………………………

F………………………………………………………………………………………

G……………………………………………………………………………………

H……………………………………………………………………………………

ii. Which letters are used to label the two chambers of the heart that contain oxygenated blood……………………………………………………

iii. Where does blood leaving the heart through **H** go to?

………………………………………………………………………………………

iv. What causes blood to flow from **F** to **E**

………………………………………………………………………………

v. What prevent the blood in **E** from flowing back in to chamber **F.**

………………………………………………………………………………

2a. What are blood vessels?

……………………………………………………………………………………………

b. state the three main types of blood vessels and give one function each.

Vessel	Function

3a. what is blood plasma

……………………………………………………………...........……………………

……………………………………………………………………………………………..

b. state four substances found in blood plasma

………………………………………………………………………………………………

……………………………………………………………………………………………..

Appendix B2

Marking scheme for pre-intervention test (SDT)

Section A. Each correct answer is awarded 1 mark.

1. c	11. d	21. c
2. a	12. d	22. c
3. b	13. c	23. c
4. a	14. b	24. b
5. a	15. b	25. b
6. b	16. a	
7. d	17. d	
8. d	18. a	
9. b	19. b	
10. b	20. b	

Section B

1 (a)i

A----------- Aorta

B----------- Pulmonary vein

C------------ Left atrium/ auricle

D------------ Left ventricle

E------------ Right ventricle

F----------- Right atrium/ auricle

G---------- Vena cava

H---------- Pulmonary artery

One mark for each correctly labelled part.

(b)

i. C and D 1 mark

ii. Lungs 1 mark

iii. The contraction of F causes blood to flow to E 1 mark

v. Tricuspid valve 1 mark

2 (a). Blood vessels are tubes/channels through which blood flows through the body.

1 mark

(b).

Blood vessel	Function
Arteries	They carry blood from the heart to all parts of the body
Veins	They return bloods from all Parts of the body back to the heart
capillaries	They connect arteries to veins and serve as the point of exchange of substance between blood and body tissues

6 marks

One mark for each correctly stated blood vessel and one mark for each function

3 (a). Blood plasma is the liquid component of blood that serves as medium for transporting blood cells, hormones, nutrients and other substances. It is straw coloured and makes up of about 55% of the total volume of blood. It is about 90% water and dissolves most soluble substances in blood.

2 marks

(b) substance contained in blood plasma include; blood protein, food nutrients, water, mineral salts, ions, hormones, waste products, gases etc. **4 marks**

One mark each for any correctly stated four

Appendix C1

Post-intervention test (SAT/ SKRT)

Name. …………………………………….. Duration: 60

School: Have Tech. Institute Class: MET3

This paper consists of two sections, section **A** and **B**. Section **A** consist of twenty-five multipole choice items. For each item**, circle** the alternative that best answer the question. For section **B**, write your answer in the space provided below each question. **Your response should be as brief as possible**. You are required to **answer all questions**.

1. Which of the following organs regulate the circulation of blood in mammals?
   a. kidney
   b. lungs
   c. liver
   d. heart.
2. Which of the following blood vessels carry blood toward the heart?
   a. Arteries
   b. Veins
   c. Capillaries
   d. Arteriories
3. Which of the following structures divide the heart in to right and left chambers?
   a. Semi lunar valve
   b. Bicuspid valve

c. Septum

d. Pulmonary valve

4. Which of the following muscles generate internal electrical impulse for its movement?

a. Smooth muscle

b. Rough muscle

c. Skeletal muscle

d. Cardiac muscles

5. Which of the following is the largest vein in mammals?

a. Vena cava

b. Aorta

c. Renal vein

d. Pulmonary vein

6. Which of the following blood vessels carry blood away from the head to the heart?

a. Carotid artery

b. Carotid vein

c. Renal artery

d. Renal vein

7. Which of the following blood vessels carries oxygenated blood from the lungs to the heart?

a. Coronary artery

b. Coronary vein

c. Pulmonary artery

d. Pulmonary vein

8. From the right ventricle, where is the blood pumped to?

   a. Kidney

   b. Lungs

   c. Right atrium

   d. Left atrium

9. Which of the following pair of blood vessels lack valve?

   a. Arteries and veins

   b. Veins and capillaries

   c. Arteries and capillaries

   d. Exteriorise and veins

10. Which of the following parts of the heart has the thickest wall?

   a. Right atrium

   b. Right ventricle

   c. Left atrium

   d. Left ventricle

11. Which of the following disorders of blood is associated with red blood cells?

   a. Haemophilia

   b. Leukaemia

   c. Sickle cell anaemia

   d. Thrombosis

12. Which of the following is the reason why capillaries have very thin walls? To

   a. allow substance move through them under high pressure

   b. allow substance move through them under low pressure

   c. facilitate easy diffusion of substance in and out of the vessel

   d. maintain its elasticity

13. What percentage of blood plasma is water?

    a. 90%

    b. 75%

    c. 55%

    d. 25%

14. Which component of blood protects the body against disease causing organism?

    a. White blood cell

    b. Red blood cell

    c. Blood platelet

    d. Blood plasma

15. Mr. Agambila's blood pressure reads 80/55mmHg. He is likely to have which of the following disorders?

    a. Hypertension

    b. Hypotension

    c. Leukaemia

    d. Coronary thrombosis

16. Which type of circulation involves the movement of blood from the heart to all parts of the body?

    a. Pulmonary circulation

    b. Systemic circulation

    c. Opened circulation

    d. Closed circulation

17. Which of the following disorders is associated with white blood cells?

    a. Leukaemia

b. Haemophilia

c. Coronary thrombosis

d. Sickle cell anaemia

18. Bicuspid valve is found between which of the following?

a. Right atrium and right ventricle

b. Right atrium and left ventricle

c. Left atrium and left ventricle

d. Left atrium and right ventricle

19. Which of the following is more likely to cause heart failure?

a. Regular exercise

b. Stress

c. Intake of sugary foods

d. Indigestion

20. Blood platelets are also called

a. Erythrocytes

b. Leucocytes

c. Thrombocytes

d. Phagocytes

21. What is the function of pulmonary artery? Its transports

a. Oxygenated blood to the body

b. Deoxygenated blood to the lungs

c. Oxygenated blood to the lungs

d. Deoxygenated blood to the body

22. Blood pressure is measured in which of the following units?

a. Pascal

b. Millimetre of mercury

c. Newton/metre

d. Newton

23. The main function of the circulatory system is to

a. Breakdown food

b. Regulate body temperature

c. Transport nutrients, oxygen and waste products

d. Fight infections

24. The upper chambers of the heart are called

a. Valves

b. Atria

c. Ventricles

d. Septa

25. Which of the following is the medical term for heart attack?

a. Myocardial infarction

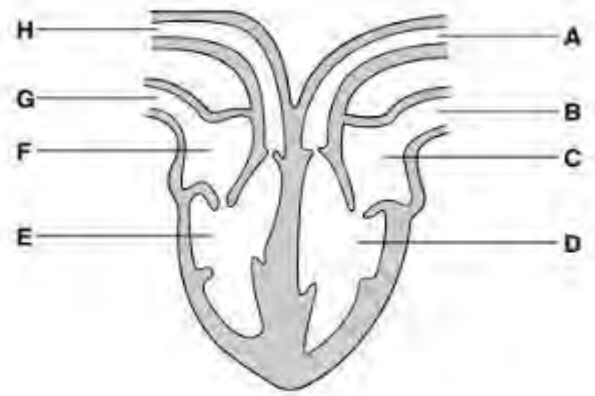
b. Aneurysm

c. Angina pectoris

d. Thrombosis

SECTION B

1 The diagram below shows a longitudinal section of the human heart. Study it carefully and answer the questions that follow



a) Write down the letter that matches part of the heart described.

i. The largest and main artery of the circulatory system. ………….

ii. Blood vessel that carries blood from all parts of the body back to the heart. ………………………………………………

iii. Part that carries blood to the lungs ………………………………….

iv. Part that returns from lungs to the heart. ……………………………..

v. The chamber that receives deoxygenated blood from vena cava. …………………………..

b) Which type of blood is carried by the blood vessel marked

i. H …………………………………………………………

ii. A ………………………………………………………

c) In the diagram of the heart above, use pencil to draw arrows showing the flow of blood through the heart.

d) Identify and label septum on the diagram above and give its function in the space below……………………………………………………

2. a) Give the function of each of the following blood vessels

arteries. …………………………………………………………………

veins. ………………………………………………………………………

capillaries………………………………………………………………………

b. state three difference between arteries and veins

Arteries	veins
1	
2	
3	

3. Name the three blood cells and give one function each.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

Appendix C2

Marking scheme for post intervention test (SAT/ SKRT)

Section A. Each correct answer is awarded 1 mark.

1. b	11. **c**	21. c
2. a	12. **c**	22. b
3. c	13. **a**	23. c
4. d	14. **a**	24. b
5. a	15. **b**	25. a
6. b	16. **b**	
7. d	17. **a**	
8. b	18. **c**	
9. c	19. **b**	
10. d	20. **c**	

Section B

1(a)

i. A

ii. G

iii. H

iv. B

v. F **1 mark each**

(b). i. Deoxygenated blood **1 mark**

ii. Oxygenated blood **1 mark**

(c) refer to the diagram for blood flow throw the heart. **3 marks**

(d) refer to the diagram for a labelled septum. **1 mark**

The septum prevents deoxygenated blood from mixing with oxygenated blood. **1 mark**

2(a).

i. Arteries carry blood from the heart to all parts of the body **1 mark**

ii. Veins return bloods from all Parts of the body back to the heart **1 mark**

iii. capillaries connect arteries to veins and serve as the point of exchange of substance between blood and body tissues **1 mark**

(b)

Arteries	Veins
carry blood away from the heart	Carry blood towards the heart
Carry blood under high pressure	Carry blood under low pressure
Have thick and elastic wall	Has thin and less elastic wall
Are deeper in the body	Are closer to the body surface
Have narrow lumen	Have wide lumen
Carry oxygenated blood except pulmonary artery	Carry deoxygenated blood except pulmonary vein
Lack valves	Have valves

4 marks

Any four are correct. One mark each.

3.

i. Red blood cells(erythrocytes): they are responsible for carrying oxygen to the rest of the body and returning carbon dioxide to the lungs for exhalation. **2 marks**

ii. White blood cells (leucocytes): They protect the body against infections by identifying and destroying pathogens. **2 marks**

iii. Platelet (thrombocytes): they help in blood clotting **2 marks**

Appendix D

Questionnaire on students' attitude towards cooperative learning

Dear respondent,

This questionnaire is to help the researcher gather data on students' attitude towards cooperative learning. The questionnaire is solely for research purposes. Please kindly provide an objective and sincere responds to the items. You are assured that any information you provide will be treated strictly as confidential.

SECTION A (Demography of respondents)

Please put a check mark (√) where appropriate in the box corresponding to your choice connecting each statement.

1. Sex Male ( ) Female ( )
2. Age group Below 15years ( ) 15-18 years ( ) Above 18 years ( )

SECTION B (Students attitude towards cooperative learning)

Instruction: to respond to the questionnaire, put a check mark (√) in the appropriate box to indicate your level agreement or disagreement on each of the statements:

1 (Strongly Disagree); 2 (Disagree); 3 (Neutral); 4 (Agree); 5 (Strongly Agree)

	Statement	1	2	3	2	5
3	I will willingly participate in group activities					
4	Group work makes learning more easy and interesting					
5	The workload is mostly less when I work with others					
6	I prefer group learning when the concepts are complex to learn					
7	My group members explain things to me when I don't understand					
8	When I work with other students I achieve more than when I work alone					
9	I enjoy learning more when I work with others					
10	Group discussions help me to share my ideas					
11	Group discussion enhance my participation in class					
12	Group work triggers creativity					
13	Through group work, I have learned to work with students who are different from me					
14	My work/thought are well organised when I work in a group					
15	I easily recollect what I learn in group					
16	I prefer that my facilitator uses more group activities					

Appendix E1

Worksheet A

Student Number......32.. Group Number. .....7.......

Part I

List the main components of the circulatory system of human.

The heart

Blood

Blood vessels

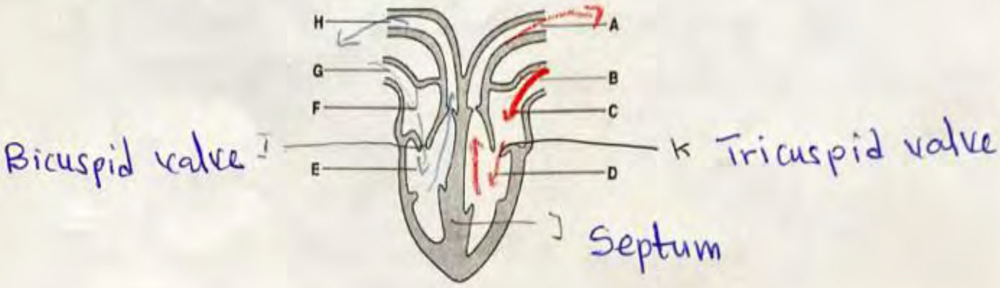
Part II

a. Describe the human heart in relation to the themes in the table below

Theme	Description
Location	It is located in the thoracic cavity between the lungs, slitely twards the left.
Size	It is about the size of a clenched fist.
Shape	It is pear shaped
Type of muscle	It is made up of cardiac muscles
Numbers of chambers. Name them	It has four chambers. They include: right artrium, right ventricle, left artrium and left ventricle.

Part III

a. i. The diagram below is a human heart. Study it carefully and label the parts



A. Aorta

B. Pulmonary vein

C. left artrium

D. left ventricle

E. right ventricle

F. right artrium

G. Vena cava

H. Pulmonary artery

ii. Use coloured pencils to trace the path of blood through the heart. Use red pencil for oxygenated blood and blue pencil for deoxygenated blood.

iii. Identify and label any other part (s) on the diagram.

I. Tricuspid valve

J. ~~Bicuspid valve~~ Septum

K Bicuspid valve

b. Give the function of the following parts of the heart

1. Vena cava. It carries de-oxygenated blood from ~~heart to~~ the body back to the heart.

2. Aorta. It carries oxygenated blood from the heart to all parts of the body.
3. Right atrium. It receives blood from the vena cava and pumps it to the right ventricle
4. Left atrium. It receives blood from the pulmonary artery and pumps it to the left ventricle
5. Tricuspid valve. It prevents the back flow of blood from the right ventricle to the right artrium
6. Bicuspid valve. Prevent the backflow of blood from the left ventricle to the left artrium.
7. Right ventricle. It receives blood from the Right artrium and pumps it to the lungs
8. Left ventricle. It receives blood from the left atrium and pumps it through the oarta
9. Pulmonary artery. It transports de-oxygenated blood from the heart to the lungs
10. Pulmonary vein. It carries oxygenated blood from the lungs back to the heart
11. Septum. Prevents the mixing of oxygenated and deoxygenated blood.

Appendix E2

Worksheet B

Student Number............14.. Group Number. ...3.........

Part I

Fill the following table according to the assigned blood vessel using pencil

Blood Vessel	Features	Function(S)
~~Atbe~~ries	Has thick muscular wall - It is elastic - It has relatively small lumen - It has value - It has three distinct layers - Located deeper in the body - carry blood under high pressure	They carry blood away from the heart to other parts of the body

Part II

Discuss and consolidate your findings with students assigned the same blood vessel. Update your note if necessary and jot down key points to share.

- The three distint layers are tunica intima, tunica media and tunica externa.
- The small lumen aid in maintaining pressure
- Its elasticity cater for pressure changes.

....

Part III

Present your findings to your jigsaw group and take note on other blood vessels as your group mates present

Blood Vessel	Features	Functions
Veins	- carry blood under low pressure - large lumen - Have thin wall - Have valve. - less elastic - They lie close to the skin	carry blood from all parts of the body back to the heart.
Capillaries	- Have very thin wall - They are small in size - Link arteries to venules - Their wall are semi permeable - found within body tissue	Serve as a site for exchange of substances between blood and body tissue

Part IV

Compare the various blood vessels by completing the following table

	Artery	Veins	Capillaries
Thickness of wall	Thick wall	Thin wall	very thin wall
Direction of blood	from heart to tissues	From tissues to heart	within tissue

Type of blood	Oxygenated blood	Deoxygenated blood	Both
Pressure	High pressure	Low pressure	Very low pressure
Location	Deep in the body	Close to the skin	Within body tissues
Valves	No value	has value	No value
Sizes of lumen	Smaller	Larger	Very small
Elasticity of wall	Very elastic	less elastic	Not elastic

Appendix E3

Worksheet C

Student Number........8.................................... Group Number. ...2.........

Part I

Fill the following table according to your assigned blood component with a pencil

Blood component	Features	Function(s)
Blood plasma. It is the liquid part of the blood.	-It is yellowish in colour. -It makes up about 50% of the blood. -About 90% of it is water. -It carries many substances including water, hormones, gases, waste substances, Protein dissolved minerals and many others.	-it carries the blood cells around the body. -It carries nutrient to all parts of the body. -It carries away waste substances to excretory Organs. -It regulates the body temperature.

Part II

Discuss and consolidate your findings with students assigned the same blood component.

Update your note if necessary and jot down key points to share.

- It is the liquid that transports substance around the body.

- It is yellowish in colour. The colour is as a result of dissolved substances.
- It contains mineral salts in form of ion like Na^+, Ca^{2+} etc.

Part III

Present your findings to your jigsaw group and take note on other blood vessels as your group mates present

Blood Component	Features	Functions
Red blood cells	- It contains haemoglobin. - Made in the bone marrow. - Red in colour. - Biconcave in shape. - No nucleus. - Small and flexible. - live for a bout 120 days.	- Carry oxygen form lungs to all parts of the body. - carry carbondioxide from body parts back to the lungs
White blood cells.	- Colourless - Have no specific shape. - Have nucleus. - Short life spant.	- It fight germs and protect the body from disease.
Blood platelet.	- Smallest blood cell. - colourless. - No nucleus. - Have irregular shape.	- They stop bleeding by forming a clot when get a cut.

Part IV

a. Fill in the following individually and discuss your findings with your group members

1. State the two types of circulation in human.

Pulmonary circulation.
Systemic circulation.

ii. Describe each type of circulation, Cleary indicating their route

Pulmonary circulation is the movement of blood form the heart to the lungs and back to the heart. Deoxygenated blood in the right atrium is pumped to the right ventricle through the tricuspid valve. The right ventricle contracts to pump the blood through the pulmonary artery to the lungs for Oxygen. Oxygenated blood moves through the pulmonary vein to the left atrium.

Systemic circulation is the movement of blood from the heart to all parts of the body and back to the heart. Oxygenated blood in the left atrium is pumped to the left ventricle through the bicuspid valve. The left ventricle pumps the blood to all parts of the body tissues and pick carbondioxide form the body tissues. The deoxygenated blood returns to the right atrium through the superior and interior vena cava.

Appendix E4

Worksheet D

Student Number............25.................................... Group Number. ....5......

Part I

Fill the table below based on your assigned disorder using a pencil

Disorder	Causes	Preventive Measures
High blood Pressure It occur when your too hard againts your blood Vessels.	- Eating too much salt - Eating too much fatty food - Not exercising - Stress - Smoking - Eating too much junk food - Taking too much cafeine - Not drinking water - Kidney problem - Genetics - Drinking alcohol	- Dont put too much salt in your food - Dont eat too much fatty food - Regular exercise - Avoid stress - Dont smoke - Avoid junk food - Dont take too much caffeine - Drink plenty water - stop over eating - Sleep well - Regular check -up

Part II

Discuss and consolidate your findings with students assigned the same disorder. Update your note if necessary.

Part III

Present your findings to your jigsaw group and take note on other disorders as your group mates present

Disorder	Causes	Preventive Measures
Heart Attack	-High blood pressure -Smoking -Diabetes -Lack of exercise -Over weight -stress -Eating fatty food	-Manage your blood pressure -Stop smoking -Manage your diabetes -Do more exercise -Control your weight -Manage stress -Avoid fatty food
Leukamia	-Exposure to radiations -certain chemicals -Smoking -Weak immune system -Infections	-Avoid too much radiation -Stay away from certain chemicals -Avoid smoking -Eat a lot of fruits and Vegetables
Hole in Heart	-Pre-natal drug abuse -Genetic factors -Maternal nutrient deficiency -Exposure to toxin during pregnancy	-pregnant women should not take drugs -pregnant women should eat balance diet -Avoid exposure to toxins -Regular maternal checkup