COMPUTER-BASED COLLABORATIVE CONCEPT MAPPING: EFFECTS ON STUDENTS' ACADEMIC ACHIEVEMENT IN BIOLOGY IN SECONDARY SCHOOLS IN KENYA

BY

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DECLARATION

DECLARATION BY THE STUDENT

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DEDICATION

To my dear mother Esther for your love, encouragement and support in my education. I appreciate every sacrifice that you have made to enable me to go through school. Your determination and resilience have been my inspiration. Whenever I faced any challenges, you always said "The Lord Almighty knows". Today, I can attest to the fact that the Lord Almighty who knows the end of everything from the beginning has brought me this far. Mama, I pray that my completion of this degree makes you fulfilled.

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ABSTRACT

Researchers and educators alike have continually made efforts to conduct relevant studies on the effect of various teaching-learning strategies on student's achievement in science education. This study sought to address the problem of sub-par performance in Biology in secondary school by evaluating the effects of Computer-Based Collaborative Concept Mapping (CBCCM) on students' academic achievement in Biology. The study had four – fold objectives: determine the effects of CBCCM and conventional methods on student's attitudes towards Biology; evaluate the gender differences in students' attitudes towards Biology between control and experimental groups; examine the gender differences in students' academic achievement in Biology between control and experimental groups; and compare the effect of computer-based collaborative concept mapping and conventional methods on student's academic achievement in Biology. The study adopted Quasi-experimental research known as Solomon IV non-equivalent control group design. The study sample comprised of 345 forms two Biology students and eight biology teachers in eight secondary schools. A multistage sampling technique was used to select the eight schools from which a single stream per school was selected based on simple random sampling. The eight schools were randomly assigned into four groups where there were two experimental and two control groups. Each one of the four groups comprised two schools, one school for boys and one school for girls. There were two schools for girls and two schools for boys in the experimental group and two schools for girls and two schools for boys in the control group. A Biology Achievement Test (BAT) and a student attitude questionnaire (SAQ) were used for data collection. The research instruments were validated by university supervisors and two Biology examiners while the Cronbach's Alpha Coefficient of 0.9138 (pre-test) and 0.8361 (post-test) indicated that the instrument was reliable. Groups one and two took the pre-test while the post-test was administered to all the four groups. The intervention period was four weeks after which all groups were post-tested. The inferential statistics included t-test and one-way ANOVA were used to analyse the data generated with the aid of the Statistical Package for Social Sciences (SPSS). The hypotheses were tested at a 0.05 level of significance. The findings indicated that CBCCM had no significant improvement on the attitude of students towards Biology groups ($t = 0.052$, $p > 0.05$), but there were significant differences ($t = -2.740$, $p < 0.05$) in the academic performance of students in Biology. The findings further indicate that there were no statistically significant differences in attitude between sexes ($t = -0.0820$, $p > 0.05$) but there were significant differences in performance between the sexes ($t = -5.563$, $p < 0.05$), whereby girls outperformed the boys in the post-test after the intervention. Based on the results the study rejected the null hypotheses that there is no significant effect of CBCCM and conventional methods on academic performance in Biology. The study concluded that CBCCM enhances students' learning of school Biology, but does not minimize the gender disparities in the performance of science subjects in secondary schools. The findings provide a basis for the improvement of in-service and pre-service Biology teacher training programmes. The study therefore recommended that teachers in sciences should incorporate appropriate learning strategies for the achievement of intended learning outcomes and higher-order learning. CBCCM be emphasized both in the pre-service and in-service teacher education programmes.

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LIST OF ABBREVIATIONS

AAAS- American Association for the Advancement of Science

ANOVA- Analysis of Variance

BAT- Biology Achievement Test

ECCA-Experiential Collaborative Computer-Assisted

CCM- collaborative concept mapping

CCBM- Computer-based collaborative concept mapping

CMCLS-Consensus-Map Collaborative learning system

CSCL-Computer-Supported Collaborative Learning

ICT- information communication technology

K.C.P.E- Kenya Certificate of Primary Education

K.C.S.E- Kenya Certificate of Secondary Education

KNEC- Kenya National Examinations Council

MOEST- ministry of education science and technology

SAQ- Student Attitude Questionnaire

UNESCO- United Nations Education, Social and Cultural Organization

WWW- World Wide Web

CHAPTER ONE

INTRODUCTION TO THE STUDY

1.1 Overview

Various studies have emphasized the adoption of different pedagogical perspectives to address the learning challenges of the twenty-first century (Gutiérrez-Braojos & Salmerón-Pérez, 2015). This scenario has arisen because of the contrasting effects and results, which have raised questions concerning the effectiveness of the varied instructional methodologies on student learning and have raised considerable interest in the field of educational research (Sugano & Nabua, 2020).

Teaching needs to be participatory where all the domains of the student are engaged in learning, hence there is a need for the teachers to adopt the latest instructional techniques that can sustain learners' interest and help them to understand the concepts (Adesoji & Ibraheem 2009; Soong, 2010). In addition, teachers should develop their literacy of technology, content, and pedagogy for teaching effectiveness (Jang & Tsai, 2013).

Given that the world is embracing information technology, the study explores the possibility of using ICT as an aid in collaborative concept mapping to foster meaningful learning and creativity in Biology instruction. In this study, the researcher examines the effect of computer-based collaborative concept mapping as a complementary teaching technique in influencing learners' attitudes and performance in biology on the topic of respiration. This chapter also discusses the background of the study, the purpose of the study, objectives of the study, research hypotheses, the significance of the study, the scope of the study, justification of the study, assumptions, theoretical framework, conceptual framework and operational definition of terms.

1.2 Background of the Study

Extant literature has identified the intrinsic factors determining academic achievement in mathematics and science education (García *et al.,* 2016). Whereas, the achievement is influenced by individual factors (Han, Capraro & Capraro, 2015) such as the student's cognitive abilities as well as self–discipline (Shi & Qu, 2022; Liang *et al.,* 2020). Academic achievement is strongly associated with student attitude followed by classroom instruction and climate, home and community educational contexts, curriculum design and delivery and school demographics and organization in that order (Schneider & Preckel, 2017).

Academic achievement in science is determined by the learners' experiences, skills, and self-regulation as different cognitive learning strategies are deployed in a distinct learning context, whether in the classroom or laboratory (Aquino & Bautista, 2022). Academic achievement is also strongly associated with clarity and understandability, the teacher's stimulation of the student's interest, elocutionary skills and the teacher's enthusiasm about the course or its content (Schneider & Preckel, 2017; Nicol & Macfarlane-Dick, 2006). However, the effectiveness of teaching methods depends on their implementation. It is not only what teachers do on the micro-level but also how exactly they do it that critically affects achievement (Nicol & Macfarlane-Dick, 2006).

The cornerstone of academic achievement is students' attitudes towards learning affect achievement with Veas *et al.,* (2019) reporting that positive attitudes explain 21.3% of the variance in achievement in mathematics for upper elementary school. Next, students' learning approaches influence the achievement standard (Sengodan & Zanaton, 2012), and in particular, teaching strategies is indirectly linked to achievement through students' attitudes. This is illustrated by a meta-analytical study which reported that different teaching strategies affect students' attitudes differently. In particular, younger students tend to underperform when compared to older students (Savelsbergh *et al.,* 2016). Further, student perceptions of their cognitive learning practices are influenced by colleagues and teachers alike (Discipulo & Bautista, 2022). Because students exhibit differential achievement within the same learning environment, the most appropriate learning environment differs for each student by characteristic (Han, Capraro & Capraro, 2015).

Accordingly, a better understanding of learning strategies in the educational process may also help students to modify and improve their strategy use (Ruffing *et al.,* 2015). However, teachers in traditional classrooms did not encourage students' interest in STEM fields, while lecture-type classrooms do not facilitate students' improvement in critical thinking and problem-solving skills (Han, Capraro & Capraro, 2015). Thus, creating and adopting techniques, strategies, methodologies, as well as intervention programs, software, and application are at the helm of innovating classroom procedures which are expected to better the attainment of such competencies specific to the subject (Aquino & Bautista, 2022).

Students' interest and attitude to learning are the predominant factors in the mastery of any subject matter (Nja *et al.,* 2022). This attitudinal aspect tends to vary by topic and by gender; however, a similar general trend exists for mathematics and most of the sciences, with the decline occurring in most countries that have attained a certain level of wealth (Schreiner & Sjøberg, 2010). Villavicencio and Bernardo (2013) and Guy, Cornick & Beckford (2015) observed that students' affective emotions influence their learning outcomes and achievement. Furthermore, science teachers play an especially crucial role in the formation and reorganization of students' conceptions and attitudes towards science (Christidou, 2011).

Learners' attitude towards science is an essential part of instruction in science education and is influenced by three key factors; methodology of presentation of the content, resources and teaching aids used as well as gender bias. Thus, the inculcation of a scientific attitude is critically important in the learning process (Nja *et al.,* 2022). And as reported by Maltese and Tai (2011) the career choice in STEM in high schools is related to growing interest and attitude towards mathematics and science rather than enrolment or achievement. Muraya and Kimamo (2011) argued that students' negative attitudes towards science subjects are mainly due to student perception.

Different studies indicate that various teaching strategies ranging from inquiry-based, cooperative, project-based and problem-based learning have been adopted as the most effective teaching and learning methods in school (Ayaz & Sekerci, 2015; Aktamis *et al.,* 2016; Schroeder *et al.,* 2007). However, the achievement is higher when students employ a strategic learning approach, that is, use learning strategies in a task-dependent way, combined with their motivation for achievement (Nicol & Macfarlane-Dick, 2006). Therefore despite the differences in achievement among students in a classroom, changes in instructional approaches are based on their beliefs, attitudes, and expectations of students' ability levels (Han, Capraro & Capraro, 2015).

Effective teaching strategies can be organized into decisions regarding the motivational atmosphere, classroom management, and curriculum and instruction (Allen *et al.,* 2013). Literature shows that these instructional methods and their implementation in the classroom were among the most important predictors of student achievement in high school (Schneider & Preckel, 2017). However, the combination of teacher-centred and student-centred instructional elements is more effective than either form of instruction alone (Schneider, 2012). For instance, Sugano and Nabua (2020) examined the effects of the instructional methodology on the academic performance of secondary school students in chemistry. The findings indicated that varied teaching intervention strategies have a significant impact on academic achievement in contrast to the traditional teaching method.

The scientific and technological improvements have significantly impacted science education (Aktamiş, Hiğde & Özden, 2016).In a study, Sugano and Nabua (2020) observed that manipulative and modelling techniques form the most important teaching methods for examining academic achievement in science education. Within the higher education context, the role of information and communication technology has revolved particularly on whether CAI should complement or maybe even replace classroom instruction (Schneider & Preckel, 2017). Several studies suggest that technology is merely a vehicle that would transport content without changing (Kudish *et al.,* 2016; Cimpian, Kim, & McDermott, 2020) while others have claimed that technology has the potential revolutionized education by availing freely teaching and learning materials, providing quick individualized feedback and helping students to interact (Nicol & Macfarlane-Dick, 2006).

Whereas many initiatives relating to school science are driven by a concern to improve students' achievement (Sjøberg & Schreiner, 2010), schools, unfortunately, are not able to preserve the initial strength of students' attitudes toward science (Potvin & Hasni, 2014) in that the conventional approach to teaching science in schools effectively failed to prepare students for their experience of science beyond school and to present science as a fascinating, interesting and rewarding subject (La Velle, McFarlane & Brawn, 2003).

Effective teacher-student interactions linked to student achievement are the likelihood that high-quality interactions may come more easily among students who are already academically motivated and successful (Allen *et al.,* 2013). However, most educational systems have failed to engage students in effective creative tasks (Wu, Hwang, Kuo & Huang, 2013) because of the several challenges that students face when learning sciences in the school centres. These challenges include costs involved, time consumed and inaccurate data sets during the laboratory procedures. Practical work in science education helps learners develop procedural knowledge yet this is problematic (La Velle, McFarlane & Brawn, 2003).

This calls for a shift in the approach to learning as the advances in learning sciences indicate that acquiring and demonstrating new knowledge and skills occurs within an environment or pedagogical context. In particular, the advances in the learning sciences and technology have influenced new thinking and practices related to assessment (Shute & Rahimi, 2017). ICT provides a more effective method of developing both substantive and syntactic scientific understanding (La Velle, McFarlane & Brawn, 2003) with studies highlighting the potential benefits of information and communication technologies (ICT) that include the improvement in educational outcomes (Sangrà & González-Sanmamed, 2010).

1.1.1 Research studies on concept mapping

KNEC reports (2013-2020) show that performance in biology and science, in general, has persistently been average. In Kenyan secondary schools, the performance in Biology subject is average and satisfactory and as indicated by the reports the average scores (standard deviation) for the last four years (2017-2020) are 58.37(35.16), 37.85(23.45), 51.38(23.26) and 55.32(20.65) marks (KNEC, 2020). This indicates an average pass mark for all the students taking biology as a subject in secondary schools in Kenya. A report by the Standard media group indicated that the performance in the biology subject for three consecutive years has not been satisfactory with only a small number getting grades B and above (Standard Media, 2019).

Namasaka (2009) investigated the effects of concept and vee mapping strategy on students' motivation and achievement in biology in secondary schools in Kenya. The results of the study showed that the students taught using concept and vee maps performed significantly better in achievement and motivation compared to those taught using traditional methods. However, girls outperformed boys when taught using the same strategy of concept and vee mapping. Kinya and Wachanga (2013) investigated the effects of experiential concept mapping on the academic achievement of students in chemistry in secondary schools in Kenya. The findings showed that the experimental group performed significantly better than the control group but there were no gender differences in the performance of students in the experimental group.

Barchok et al (2013) examined the effects of collaborative concept mapping on students' attitudes towards chemistry in secondary schools in Kenya. Students worked in groups while constructing paper and pencil concept maps. The findings showed that was no significant difference in attitude between the experimental and control groups. Wambugu *et al.,* (2013) researched experiential cooperative concept mapping on the academic achievement of students in physics in secondary schools in Kenya. The experimental group that constructed concept maps performed significantly better than the group taught using the regular method but there were no gender differences in performance among those taught using concept mapping.

Githae et al (2015), investigated the effects of collaborative concept mapping on students' achievement in biology in secondary schools in Kenya. This study sort to compare the achievement of students taught using concept maps and those taught using regular methods. The results showed that the experimental group performed significantly better than the control group but there were no gender differences in performance among the students who constructed concept maps.

The five studies carried out in Kenya used paper and pencil concept maps and Solomon-Four Non-equivalent Control Group design. Except for Namasaka (2009), each study investigated the effects of concept mapping in a given subject on either achievement alone or motivation alone without considering the inter-play among the three variables which are teaching methodology, motivation and achievement/performance. Namasaka investigated the relationship among the three variables but looking at his study, there were two independent variables which were teaching methods and gender and each occurred at two levels hence the study should have used factorial designs instead of the Solomon-Four Non-equivalent Control Group design. The current study investigated the use of computer-based collaborative concept mapping and its effects on students' attitudes and performance in biology in secondary schools in Kenya.

1.3 Statement of the Problem

The reforms in science education have proposed techniques that encourage students' mental and scientific reasoning skills. These methods are strongly based on inquiry and aimed to improve their interest in science (Aktamiş, Hiğde & Özden, 2016). This is because science education in secondary schools contains many theoretical and abstract concepts, which may be difficult to understand, therefore students need visualization and modelling (Tekbiyik & Akdeniz, 2010).

The students' approaches to learning tend to predict learning or achievement outcomes, García, *et al.,* 2016; Sengodan & Zanaton, 2012; Savelsbergh *et al.,* 2016; Schroeder *et al.,* 2007). However, past research has critiqued the conventional approach to learning (Savelsbergh *et al.,* 2016) thus, there is a need for a paradigm shift in teaching and learning approaches (Schittek *et al.,* 2001). Because of the general tendency across studies on innovative teaching approaches to have positive effects, there is little clarity on how these interventions cause results in different outcomes, and under what conditions (Savelsbergh *et al.,* 2016).

Several studies (Wu & Ke, 2011; Abbas *et al.,* 2018; Kaddoura, Van-Dyke & Yang, 2016; Wu *et al.,* 2013; Chen, Liang & Liao, 2011) have highlighted the positive effects of concept mapping in the education setting. More so, at the university level as well as in different disciplines (Hwang *et al.,* 2013; Amadieu *et al.,* 2010; Kaddoura *et al.,* 2016). Previous studies have reported the effectiveness of the concept mapping approach, but it remains an open issue for investigating its effects on students' learning attitudes. And as elaborated by the foregoing reviews, there is a need to evaluate the different pedagogical practises used in science education at the high or secondary school level,, there is still paucity in the contextual and conceptual gaps on the effect of CBCCM on biology in Kenya. Thus, this study explored how computer-based collaborative concept mapping can be applied in teaching Biology concepts of respiration to students in selected secondary schools in Uasin Gishu County, Kenya.

1.4 Purpose of the study

The study examined the effects of computer-based collaborative concept mapping on students' performance and attitudes in Biology among secondary school students in Kenya.

1.5 Objectives of the study

1. To evaluate the gender differences in students' attitudes towards Biology between control and experimental groups.
2. To determine the effects of CBCCM and conventional methods on student's attitudes towards Biology
3. To examine the gender differences in students' academic achievement in Biology between control and experimental groups.
4. To compare the effect of computer-based collaborative concept mapping and conventional methods on students' academic achievement in Biology.

1.6 Research Hypotheses

$H0_1$: There is no significant gender difference in students' attitudes towards Biology between control and experimental groups.

$H0_2$: There is no significant difference in students' attitudes towards Biology between control and experimental groups.

$H0_3$: There is no significant gender difference in students’ academic performance in Biology between control and experimental groups.

$H0_4$: There is no significant difference in students' academic performance in Biology between the control and experimental groups.

1.6 Justification of the study

The study is important because science education is critical to the economic growth and development of the nation. The average mark in science education is a worry as it doesn't portend well with the national agenda of having more and more students undertaking Science, Technology, Engineering and Mathematics (STEM) disciplines at higher levels. Therefore, the average national grade must be raised in order to help the students pursue STEM-related fields in higher education and drive innovation activities at the national level.

STEM (science, technology, engineering, and mathematics) education is becoming more important because the STEM career fields of the 21st century enable countries to improve their economic growth, global competitiveness, innovation, and living standards(Terzi & Kirilmazkaya, 2020). The increasing number of students pursuing degrees in STEM (science, technology, engineering, and mathematics), calls for improvements in techniques for teaching mathematics and science education. The interest in school science and technology remains an important issue as it is linked to achievement and the intention to pursue studies or careers in science and technology subjects (Potvin & Hasni, 2014).

Since science education is important to the educational systems of different countries, many governments have endeavoured to have scientific literacy for all individuals at the end of their schooling years. Thus, countries have sought to improve science education and make it possible to educate students enabling them to acquire the necessary information, interpret the newly acquired information based on experiences and have problem-solving skills (Aktamiş, Hiğde & Özden, 2016).

The conventional approach to teaching science education in schools has not only failed to effectively prepare students' science experience beyond school but also in presenting science as a fascinating, interesting and rewarding subject at the fulcrum of human existence (La Velle, McFarlane & Brawn, 2003). Thus, there is a need to make learning more applicable and life-long after the learning process. The students therefore should be encouraged to pursue science education at secondary and high levels as well as apply the scientific concepts in their lives after leaving secondary schools and higher learning institutions. Success in mathematics and science is a significant predictor of a student's orientation to a STEM-related career (Terzi & Kirilmazkaya, 2020).

1.7 Significance of the study

The study is significant to the following stakeholders in the education sector: the students, as the consumers of education, the teachers, the school administration, and the ministry of education, science and technology as the main government agency, the

Kenya Institute of Curriculum Development as a policy maker and a stakeholder and other interested parties such as academicians.

First, the findings are relevant to the students as the first stakeholder who will most likely be affected by turbulence in the education sector. The findings would provide the students with information and knowledge on the range of available teaching strategies that have a significant impact on their academic achievement.

Second, the teachers are the person of interest because of their day–to–day decisions and learning processes which influence the academic achievement of their students. The teachers would gain from the understanding of the most effective pedagogical approaches that can be adopted and are beneficial to their students.

Third, the school administrators as the main important stakeholder because of the demands of the standard mean achievement for the schools. The study will provide the administrators with important information on the most effective learning and teaching strategies and pedagogical approaches that would improve the learning outcomes.

Fourth, the ministry of education is the main corporate stakeholder in the education sector as it implements the education policy. The ministry would benefit from the study as the findings would improve the overall academic achievement of students in science education.

Fifth, the Kenya Institute of Curriculum Development being the other important stakeholder in the development of pedagogical approaches would benefit from the information generated from the study as part of the ongoing efforts to understand the soundness of the current and new pedagogical trends and approaches.

Lastly, the other interested parties such as the academicians stand to benefit from the information generated by the study as an advancement of the knowledge generated and the repository of available information on the pedagogical approaches in Kenya.

1.8 Scope of the study

This study examined the impact of the computer-based collaborative concept mapping using an experimental design which allowed for comparisons with the traditional teaching approach**.** Therefore, the present study was restricted to a comparative study of two teaching methods, namely, computer-based collaborative concept mapping and traditional teaching methods.

The study was quasi-experimental and Solomon IV non-equivalent control group design and was confined to the subject of Biology for secondary classes. The study only used eight secondary schools in Uasin-Gishu County, Kenya.

The study also relied on existing empirical studies and literature on computer-based learning, concept mapping and collaborative learning techniques that were accessed from physical and electronic repositories.

1.9 Limitations of the study

The study was limited to the application of a readily available concept–mapping tool, CMapTools software that was downloaded from the internet. CMapTools software is a versatile tool that can be used to construct concept maps, and share the maps through collaboration with other users either in the same room or at a distance, place and in real-time, it can be used to import videos and pictures from the internet that can be used to enrich a concept map being constructed and the maps can be stored in servers for reference or public viewing. The application of the concept–mapping learning tool, CMapTools software was limiting as students did not exploit this resource fully because none of the schools had internet connectivity. Due to this limitation, the researcher only emphasized the basic application of the concept–mapping software in the generation of the concept maps.

Collaboration between students in individual schools was limited to small discussion groups and besides, the students working in a class could not see the work being done by the other groups through the computer because their computers were not networked. Due to these limitations, therefore, the students and teachers in the experimental schools did not realize the full benefits of CMapTools software. The study emphasized the classroom-wide discussion to encourage collaborative learning activities to take place.

The Solomon Four non – equivalent was applied as the main design and the instruments used to conduct the study. The attitudinal component of the study was derived from a questionnaire and the Biology test was used to measure the achievement. These instruments were limited to the study and thus required validation from a panel and a review.

1.10 Assumptions of the study

This study had the following assumptions;

There are various teaching methods used by teachers when handling different topics in Biology but the most predominant is the traditional method; the choice of a teaching method depends on factors such as the availability of resources which include textbooks, laboratory equipment, computers and time among others; teacher factors such as experience and competence may also influence the choice of a teaching method; the use of computer-based collaborative concept mapping is likely to impact differently on different students. This impact may in turn influence the attitude and performance of students in Biology.

1.11 Theoretical framework

1.11.1 Constructivism Theory

This study was guided by the constructivism theory. Constructivism as a worldview posits that learning is an active constructive process and the learner is an information constructor. People actively construct or create their subjective representations of objective reality. New information is linked to prior knowledge thus mental representations are subjective. Originators and important contributors to this theory are Vygotsky (1962, 1978), Piaget (1970), and Bruner (1962, 1979). Constructivism is about building new ideas on old knowledge, and creativity and thinking are emphasized. Learners can therefore flexibly construct their mental modes and cognition.

The original concept map that Novak developed is theory-driven (Trowbridge & Wandersee, 1998). When a teacher introduces a proposition (concept), a knowledge set is also introduced. Faced with such a Proposition, students begin to make associations and then select, organize, and categorize these associations, connecting ideas and drawing graphs to represent their understanding. Theories that address this process include knowledge representation, subsumption, constructivist learning and meaningful learning theories. During the thinking process, awareness and reflection help foster students' meta-cognition to enhance their learning and creativity abilities. Therefore, students must construct knowledge and experience reflective thinking through interaction with peers (Hwang, Shi & Chu, 2011).

From constructivism, Piaget's thought is found on the following bases: knowledge is not passively received either through the senses or by way of communication; knowledge is actively built up by the cognizing subject. Further, the function of cognition is adaptive and tends towards fit or viability and cognition serves the subject's organization of the experiential world, not the discovery of objective ontological reality (Glasersfeld, 1991). The effect of cognitive abilities occurs through the student's ability to encode key information more quickly and accurately in memory, thus enabling the brain to output more and more effective information, resulting in improved academic achievement. Cognitive abilities are also important in students' learning activities and the way the student use their different abilities (Shi & Qu, 2022).

According to the constructivism theory, learning is a process of establishing an association between new information and the existing information in an individual. The individual establishes the basis of information by creating their content. Because of this aspect teachers play an important role during learning by guiding and helping learners access the information and use it to construct new content (Ayaz & Sekerci, 2015). Further, teachers intermediate between the students and education programs, thus helping the students to learn and to develop themselves (Holt-Reynolds, 2000).

Teachers organize the learning process according to students' interests and needs by inciting the students to undertake queries, create new ideas, make observations and observations, and work collaborative (Kim, 2005). Concerning these aspects, constructivism requires the regulation of the academic environment which must be different from the traditional classroom environment. Inquiry learning is considered a constructivist teaching intervention that is concerned with academic achievement (Sugano & Nabua, 2020).

Essentially, constructivism says that learners are the centre of learning, and knowledge is constructed based on their past experiences; new knowledge is constructed based on experience or old knowledge; learning incorporates and gives meaning to the old and the new, and knowledge is complicated and contextual, and learners must exhibit their understanding in complex situations (Jonassen, 2000). The thought process during the learning process is divided into either experiential thinking or reflective thinking. Experiential thinking refers to a learning process of decisions or personal experiences, while reflective thinking shows deeper reflection that happens when students add novel descriptions, revise old ones and compare the two to construct their knowledge (Hwang, Shi & Chu, 2011).

Constructivist learning theories emphasize learners' active contribution and self-regulative processes. Active learners have a high level of inquiry skills, and they construct their knowledge base by continuously learning, reflecting on, and controlling their learning processes. Thus, in a classroom, rather students need to construct knowledge actively in their minds (Birgili, Seggie, & Oğuz, 2021). During active participation, students can socialize with their classmates and the instructor. The interaction between students during socialization can boost their performance, their collaboration skills, and motivation. In addition, in line with cognitivism, students can enhance their procedural knowledge into declarative knowledge such that the previous knowledge gained in a pre-class activity affects the new higher-order skills they gain in in-class activities (Birgili *et al.,* 2021).

Metacognition includes the knowledge of one's own cognitive and affective processes and states as well as the ability to consciously and deliberately monitor and regulate those processes and states. Flavell (1976) also identified three 'metas' that children gradually acquire in the context of information storage and retrieval. These are: the child learns to identify situations in which intentional, conscious storage of certain information may be useful in the future; the child learns to keep current any information which may be related to active problem-solving and have it ready to retrieve as needed; and the child learns how to make deliberate systematic searches for information which may help solve a problem, even when the need for it has not been foreseen.

Metacognition is significant in a wide range of applications which included reading, oral skills, writing, language acquisition, memory, attention, social interactions, self-instruction, personality development and education. The components of metacognition can be activated intentionally, as by a memory search aimed at retrieving specific information, or unintentionally, such as by cues in a task situation. Metacognitive processes can operate consciously or unconsciously and they can be accurate or inaccurate. They can also fail to be activated when needed and can fail to have an adaptive or beneficial effect. Metacognition can lead to the selection, evaluation, revision or deletion of cognitive tasks, goals, and strategies. They can also help the individual make meaning and discover behavioural implications of metacognitive experiences.

Metacognitive strategies are designed to monitor cognitive progress. Metacognitive strategies are ordered processes used to control one's cognitive activities and to ensure that a cognitive goal (for example, solving a math problem, writing an effective sentence, or understanding reading material) has been met. A person with good metacognitive skills and awareness uses these processes to oversee his learning process, plan and monitor ongoing cognitive activities, and compare cognitive outcomes with internal or external standards. Flavell (1979) indicated that a single strategy can be invoked for either cognitive or metacognitive purposes and to move toward goals in the cognitive or metacognitive domains. He gave the example of asking oneself questions at the end of a learning unit to improve knowledge of the content or to monitor comprehension and assessment of the new knowledge.

Within the constructivist literature, one of the most frequently quoted statements is that by David Ausubel, "The most important single factor influencing learning is what the learner already knows" (Ausubel, 1968). Discovering what each student knows (rather than trying to anticipate it) can be achieved in the classroom using concept maps (e.g. Novak, 1990; 1996; 1998). This is as effective in revealing patterns of understanding and misunderstanding as conducting personal interviews (Edwards and Fraser, 1983), and is more practical as a classroom strategy. In addition to showing what knowledge a student holds, concept maps illustrate how that knowledge is arranged in the students' minds.

During early childhood, children develop the ability to ignore distractions inhibit pre-potent and inappropriate responses, shift between different sets of tasks and then integrate these abilities to solve more complex problems(Best, Miller & Naglieri, 2011). Where, learners employ distinct strategies to facilitate rote learning processes, i.e., memorizing and processing concepts, particularly in science. However, science, as a technical subject, requires the application of both cognitive and metacognitive learning strategies (Discipulo & Bautista, 2022). Cognitive abilities such as impulse controlling, planning, and monitoring are crucial for both areas of learning (reading and mathematics) (Best *et al.,* 2011). Executive function skills can help the development of academic standards in children as they provide apt opportunities for learning. Children that can concentrate on the learning content, retain information components in the mind, and deal with challenges are more successful in the academic environment (Duncan *et al.,* 2017).

Metacognitive knowledge centres on the learners' knowledge and beliefs about their thinking processes. This is related to the learners' interests, abilities, and goals that complement their cognitive and metacognitive knowledge. Learners integrate their information, memories, and a-priori experiences which accounts for the generation of strong affective responses in the process of building better cognitive and metacognitive knowledge. Preceding the learning process is the development and improvement of knowledge about a certain concept or problem. When realized, learners tend to draw goals and tasks through an ordered process and strategies (Discipulo & Bautista, 2022).

As the problem of improving the teaching/learning process preoccupies educators, concept mapping promises to be useful in enhancing meaningful learning. Concept maps help learners to make evident the key concepts or propositions to be learned and suggest connections between new and previous knowledge. Concept maps have been used in a variety of educational contexts and each context reflects an alternative theory of knowledge acquisition. On the one hand, the rationalist theory of learning suggests that disciplines have inherent structures that should be conveyed to learners. Therefore, concept maps should be evaluated by relating them to ideal maps, teacher-constructed maps or expert concept maps. On the other hand, constructivists highlight the uniqueness of each individual's representation of concepts (Beyerebach & Smith, 1990) leading them to devise various mechanisms to evaluate students' concept maps. Nevertheless, both theories concur that meaningful learning occurs when concepts are organized in an individual's cognitive structure.

Logical reasoning skills can significantly affect students' performance in science and chemistry (Grass *et al.,* 2017). Metacognitive strategies empower students to evaluate their thinking mechanisms. Awareness of the learning process enhances control over earning and also enhances the personal capacity for self-regulation and managing one's motivation for learning. Metacognitive activities can include planning how to approach learning tasks, identifying appropriate strategies to complete a task, evaluating progress, and monitoring comprehension. Individuals with well-developed metacognitive skills can think through a problem or approach a learning task, select appropriate strategies, and make decisions about a course of action to resolve the problem or successfully perform the task (Discipulo & Bautista, 2022).

Knowledge representation theory organizes knowledge somewhat structurally (Lin, 2002). Learners conclude the concept map's hierarchy and graphics (Novak & Gowin, 1984). According to Ausubel's (1963) theory of subsumption, individuals recognize, connect and incorporate new information into higher-level concept groups. That is to say, learners put new concepts into a larger, more comprehensive category and then reorganize or classify the new and old information. In combination with new knowledge, learners generate knowledge and meaning from their past experiences. At first, learners assign simple meanings to objects and phenomena. Knowledge becomes more complicated as learners become more experienced (Jonassen, 2000).

This arrangement of knowledge and the nature of the links between concepts suggest practical implications for the student's future learning. Concept mapping is used to develop logical thinking and study skills by revealing connections and helping students see how individual ideas form a larger whole. It organizes knowledge in an understandable visual way and connects prior knowledge with new concepts by utilizing a visual structure for planning and thinking (Christodoulou, 2010). Christodoulou further argues that the human mind can organize knowledge in an orderly fashion. Knowledge is organized upon an existing framework or the learner’s prior knowledge. When new ideas are presented to a learner, a framework of prior knowledge is constructed for the new ideas to attach to.

1.11.2 Social Cognitive Learning Theory

Vygotsky (1978) indicated that knowledge is also constructed through social interactions among peers whereby student interactions in the real world enable students to reflect upon different past experiences and thoughts. Vygotsky, further emphasized that cognition originates from social activities, so learning is not only learners’ reception and adaptation of new knowledge but a process of merging into a knowledge community (Hwang, Shi & Chu, 2011). Fostering creativity is increasingly seen as a key direction and focus for pedagogic approaches from nursery education through the compulsory years to higher education and work-based environments (Cheng, 2009).

Social cognitive theory subscribes to a model of emergent interactive agency (Bandura, 1986). Persons are neither autonomous agents nor simply mechanical conveyors of animating environmental influences. Rather, they make a causal contribution to their motivation and action within a system of triadic reciprocal causation. In this model of reciprocal causation, action, cognitive, affective, and other personal factors, and environmental events all operate as interacting determinants. Any account of the determinants of human action must, therefore, include self-generated influences as a contributing factor.

Vygotsky (1978) indicated that knowledge is also constructed through social interactions among peers whereby student interactions in the real world enable students to reflect upon different past experiences and thoughts. Vygotsky further emphasized that cognition originates from social activities, so learning is not only learners' reception and adaptation of new knowledge but a process of merging into a knowledge community (Hwang, Shi & Chu, 2011). Self-efficacy beliefs function as an important set of proximal determinants of human motivation, affect, and action. They operate on action through motivational, cognitive, and affective intervening processes. Some of these processes, such as affective arousal and thinking patterns, are of considerable interest in their own right and not just as intervening influencers of action.

Self-efficacy beliefs affect thought patterns that may be self-aiding or self-hindering. These cognitive effects take various forms. Much human behaviour is regulated by forethought embodying cognized goals, and personal goal setting is influenced by self-appraisal of capabilities. The stronger their perceived self-efficacy, the higher the goals people set for themselves and the firmer their commitment to them (Bandura, 1989). Self-efficacy beliefs usually affect cognitive functioning through the joint influence of motivational and information-processing operations. This dual influence is illustrated in studies of different sources of variation in the memory performance. The stronger people believe in their memory capacities, the more effort they devote to the cognitive processing of memory tasks, which, in turn, enhances their memory performances (Berry, 1987).

Monitored enactments serve as the vehicle for transforming knowledge into skilled action. Thus, performances are perfected by corrective adjustments during behaviour production until a close match is eventually achieved between conception and action (Bandura, 1989). Classroom instruction and learning are complex processes characterized by intensive cognition of the causal nature of student and teacher outcomes (Wang & Hall, 2018).

Facilitators with whom students identify, such as peers, can also serve as role models for academic success and interest in science. Identification can ameliorate incompatibilities students perceive between science and their core beliefs and habits. Good facilitators model conventions of language and behaviour and provide scaffolds such as targeted explanations or Socratic questions (Kudish *et al.,* 2016). strongly achievement is affected by social interaction and student-directed activity(Schneider & Preckel, 2017).

Peers have remarkable potential as facilitators because they embody instructional congruence by bridging gaps between fellow students' perceptions of science and themselves or their desired future selves. Importantly, a sense of self-efficacy is essential for scientific identity formation and observing successful peers bolsters students' self-efficacy beliefs (Bandura, 1977). Social interaction is strongly associated with achievement in both formal and informal learning settings. In particular, social interaction aspects of the classroom such as teachers' availability and helpfulness as well as friendliness, concern, and respect for students create a comfortable atmosphere where students are answer questions, share views, and engaging in social interactions with their teacher and with one another(Nicol & Macfarlane-Dick, 2006).

A reaction to didactic approaches such as behaviourism and programmed instruction, constructivism states that learning is an active contextualized process of constructing knowledge rather than acquiring it. Knowledge is constructed based on personal experiences and hypotheses about the environment. Learners continuously test these hypotheses through social negotiation. Each person has a different interpretation and construction of the knowledge process. The learner is not a blank slate (tabula rasa) but brings past experiences and cultural factors to a situation. A common misunderstanding regarding constructivism is that instructors should never tell students anything directly but instead should always allow them to construct knowledge for themselves. This is confusing a theory of pedagogy (teaching) with a theory of knowledge. Constructivism assumes that knowledge is constructed from the learner's previous knowledge, regardless of how one is taught. Thus, even listening to a lecture involves active attempts to construct new knowledge.

1.12 Conceptual framework

The conceptual framework shows the relationship between the independent and the dependent variables and the extraneous variables which may influence the interplay between these variables under investigation. The teaching method used may impact learners positively or negatively and this impact may lead to high or low performance in a subject. The study was based on the assumption that computer-based collaborative concept mapping is more likely to impact the learning outcomes differently as compared to traditional teaching methods. This is because concept mapping allows learners to construct maps based on their understanding of the concepts taught. Learning is an active process where students are actively involved in the construction of meaning rather than having a teacher serve as a dispenser of facts (Duit & Treagust, 1998). Through the construction of these maps, the teacher was able to discover the misconceptions held by the learner concerning a particular concept.

In this study, the following variables were investigated: independent variables were; the methods of teaching and which comprised computer-based collaborative concept mapping and traditional methods of teaching. The independent variable that was manipulated was the collaborative concept mapping and its impact on learning outcomes as compared to that of traditional methods of teaching. The dependent variables included learners' academic performance in Biology and learners' attitudes towards Biology. Extraneous variables were teacher factors which include training and experience and student factors which included gender, age, and category of the school attended. However, the extraneous variables were controlled by the study design.

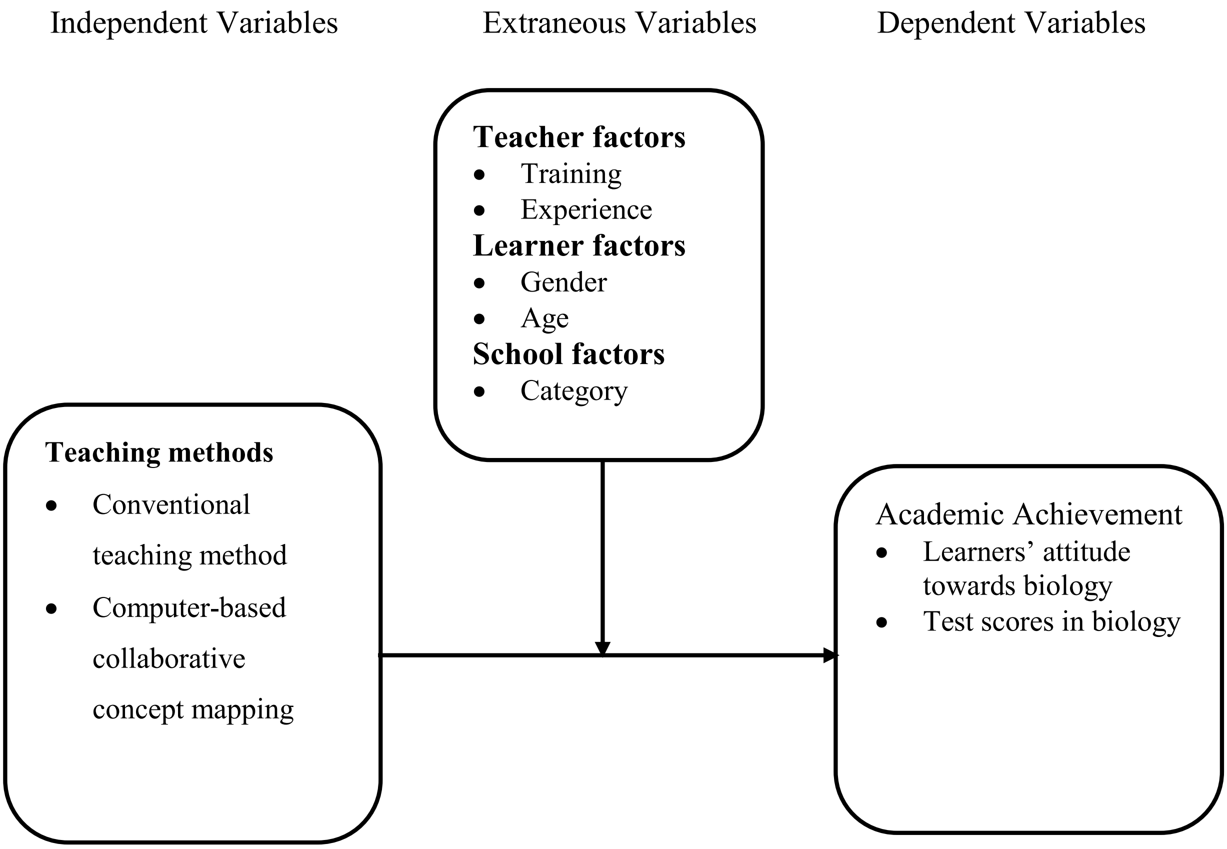

Figure 1.1: Conceptual Framework

Source: Researcher (2020)

Under the intervening variables, teacher factors such as training and experience affect the independent variable which is the type of teaching method used. In the schools where the study was undertaken, teachers were not aware of concept mapping and were therefore not using it. However, after being trained by the researcher, the teachers who were research assistants were able to use concept mapping during the treatment period. Concerning learner factors as an intervening variable, gender and age may affect a learner's attitude towards a subject. The kind of experiences that a learner has had may cause him/her to 'like' or 'hate' a subject. For example, children may hear their older siblings who are in secondary schools talking about a subject being good or bad or easy or difficult or essential for entry into a certain lucrative career. As a result, such children may form opinions about certain subjects long before they enter secondary school. Likewise, a student joining form one is likely to form an opinion about a subject depending on the comments made by students in upper classes about that particular subject. A learner in a school with sufficient resources and facilities is more likely to have a positive attitude towards subjects taught compared to a learner in a school with meagre resources and facilities. The two intervening variables may compete with the independent variables in determining the outcome of the study hence they must be controlled. The independent variables which were teaching methods that are computer-based collaborative concept mapping and conventional methods were expected to influence the dependent variables. Teaching methods affect a learner either positively or negatively and this may, in turn, affect the learner's performance in that subject.

In this study, the effect of independent variables on the dependent variables was tested while the intervening variables were controlled in the following ways: teachers' training and experience were controlled by involving trained teachers who had at least three years of teaching experience. Learners' gender was controlled by using single-sex schools of both boys and girls. Learners' age was controlled by involving form two students who were exposed to the examinable biology concepts and were assumed to be more concerned with learning as opposed to examination scores. The type of school was controlled by involving extra-county schools only.

1.13 Operational definition of terms

Academic achievement is the actual performance of a student's mastery of academic knowledge and skills as demonstrated through examinations after systematic knowledge and skills learning (Shi & Qu, 2022).

Attitude-someone's opinion or feelings about something, especially as shown by their behaviour. In this study, it is the way students think and feel about biology subjects in secondary schools

Biology- the scientific study of living things. It is one of the three science subjects (biology, chemistry and physics) taught in secondary schools

Biological concept- an idea or a principle in the field of biology

Collaborative- involving people or groups working together to produce something. In this study it involves students working together to produce a biology concept map

Collaborative concept mapping- is where students work together in groups to generate concept maps during Biology instruction

Concept map- a schematic device for presenting a set of biological concept meanings embedded in a framework of propositions

Information communication technology- a combination of developments based on computers but including communications used in the processing of information. In this study, it involves the use of concept mapping tools to display the biology concepts learnt

Instruction- processes of imparting knowledge through a deliberately managed environment to enable a learner to emit or engage in specified behaviours under specified conditions. In this study, computer-based collaborative concept mapping is the conditions under which Biology knowledge is imparted

Learning- the process of gaining knowledge and experience. In this study, it is the process of gaining knowledge and experience in biology

Performance- the standard to which someone does something such as a job or examination. In this study, it refers to the grades obtained by students in biology examinations

Rote learning- the process of learning a concept by repeating it many times rather than by understanding it

Teaching method- it is an overall plan or pattern to structure knowledge in a way that the students easily grasp it. (The sequence in which material is presented to a learner is the teaching strategy that facilitates learning).

Conventional Teaching Method- the methods of instruction that tend heavily toward classroom lectures, and memorization of facts, equations, etc. Recitation usually consists of repeating without questioning what the instructor (or book) stated. Knowledge is periodically reinforced otherwise may be forgotten.

1.14 Summary

The purpose of this mixed methods research was to compare the performance and attitude of secondary school students in biology after being taught using computer-based collaborative concept mapping on the one hand and traditional methods of teaching on the other hand. The background of the study highlighted recent studies done in Kenyan secondary schools on the effects of concept mapping on students' motivation and performance in science subjects. These studies included Namasaka (2009) who investigated the effects of concept and vee mapping strategy on students' motivation and achievement in biology, and Kinya and Wachanga (2013) investigated the effects of experiential concept mapping on the academic achievement of students in chemistry. Barchok et al (2013) investigated the effects of collaborative concept mapping on students' attitudes towards chemistry. Wambugu *et al.,* (2013) researched experiential cooperative concept mapping on the academic achievement of students in physics. Githae et al (2015), investigated the effects of collaborative concept mapping on students' achievement in biology.

The factors influencing academic achievement have been extensive while the study variables that is the computer-based collaborative concept mapping and the academic achievement are elaborated for further review. The problem rests on the average performance in biology national exams as shown by the KNEC report over the years. The objectives of the study were to describe traditional methods of teaching and computer-based collaborative concept mapping as used in secondary school biology, to determine how CBCCM affects students' attitudes towards biology and to compare the effect of computer-based collaborative concept mapping and conventional methods on students' performance in biology.

The study hypotheses are postulated and so are the significance, justification and limitation of the study. The study is underpinned by constructivism and social cognitive theory which posits that learning is an active constructive as well as a social process and the learner is an information constructor. Terms used have also been defined. The next chapter focuses on the literature reviewed in the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The purpose of this mixed methods research was to compare the performance and attitude of secondary school students in Biology after being taught using computer-based collaborative concept mapping on the one hand and traditional methods of teaching on the other hand. The literature review gives an overview of traditional methods of teaching, concept mapping and related studies in concept mapping are also discussed. Attitudes and academic achievement are discussed and finally a summary of the chapter and the need for the current study.

2.2 Study concepts

2.2.1 Conventional Learning Approach

Learning is a complex and systematic process that involves the interplay between and interaction of cognitive, affective, and psychomotor domains (Joyce, Weil & Calhoun, 2004). During learning, learners seek to integrate new information with prior knowledge, organize new information, relate ideas, and regulate their understanding of the information which translates to higher academic performance (García *et al.,* 2016). Science education in secondary schools is supposed to be student-centred and result-oriented and this is only achieved when the students are willing and teachers are prepared to use the most appropriate learning techniques and resources in the classroom(Sugano & Nabua, 2020).

The roles of the teachers in the conventional teaching method are more of a content expert who imparts knowledge to the student while in non- conventional instructional approach, the teacher acts as a facilitator of the learning process (Blazar & Kraft, 2016). While the teachers' encouragement of questions and discussion is strongest associated with achievement (Schneider & Preckel, 2017). However, conventional teaching promotes rote memorization that does not develop or supports the development of students' problem-solving and critical-thinking skills (Maxwell *et al.,* 2015).

The traditional teaching method causes rote learning in science education with the teacher being in control of the learning environment. The powers and responsibilities of the teacher confer the instructor role of instructor and decision-maker, thus the teacher causes learning to occur. Education reforms have criticized the traditional teacher-centred methods and proposed that rote learning and memorization must be abandoned in favour of student-centred and task-based approaches to learning (Aktamiş, Hiğde & Özden, 2016).

Learning and learning outcomes are affected by several factors: learner, teacher, environment and resources. Learners factors include such as learner attitude and preparedness, teacher factors are teaching experience and teaching strategy employed while resources include classrooms, science laboratories and the availability of apparatus and presence of computers and computer laboratories. The teaching strategy employed is a critical factor whose choice is determined by other factors such as the content to be covered, resources available, the nature of the learners and the teacher's competence (Wachanga, 2005; Muni *et al.,* 2006).

According to Ayeni (2011), teaching is a process that involves bringing about desirable changes in learners to achieve specific outcomes. For the teaching method to be effective, Adunola (2011) maintains that teachers need to be conversant with numerous teaching strategies that take recognition of the magnitude of the complexity of the concepts to be covered. It seems that there is something in teaching that opens the gate to learning. Successful learning indeed depends on various factors that are not all teacher-related, but the methods that a teacher uses continue to play an important role in student learning and academic achievement.

Classrooms are more meaningful through the use of project-based learning arrangements, where groups of students work on complex authentic tasks over extended periods and structure problem-solving processes under supervision. The students' projects help students to see where and how the contents of their course can be useful. (Schneider & Preckel, 2017; Nicol & Macfarlane-Dick, 2006). Traditional teaching methods have over the years remained dominant where learning is teacher-centric and learners are passive thus teaching is viewed as a management procedure involving controlling the stimuli to which students are exposed and the rewards they receive for learning (Marcella et al, 2014).

The pedagogical approach adopted in traditional classes is a major influence on the student's cognitive achievements (La Velle *et al.,* 2003). On one part, conventional teaching methods provide opportunities for students to learn directly from subject experts but the conventional teaching methods that are currently being used often lack flexibility as they do not ensure consistency in teaching nor do they accommodate the diverse learning needs of the students (Bloomfield, Roberts & While, 2010). Teachers have emphasized the importance and necessity of simulated or authentic activities where students can work with real-world problems or develop a model (Hwang, Shi &

Chu, 2011). Students learning strategies are often content-dependent and therefore, the more that is demanded from students, the more likely they adopt a superficial learning style (Schittek *et al.,* 2001).

It is an oral method of presenting information and creating understanding in the learners. It, therefore, views learners as having minds similar to a clean slate; the teacher, therefore, aims at filling the slate. During the teaching-learning process, the teacher engages in giving information while learners listen and take down notes. This teaching method is very expository in nature. It is however useful when carefully planned and skilfully delivered in introducing new concepts, motivating learners, clarifying issues, providing consolidated research information, sharing personal experiences, covering a lot of material within a short time and summarising key points. Concerning teachers' and learners' participation, lectures can be divided into formal and informal lectures (Twoli, 2007).

A formal lecture is where the teacher's talk lasts for most of the entire lesson. The learners' questions and comments are limited or absent. During a formal lecture, the speaker's purpose is to inform, persuade, or entertain with little or no participation by the learners. Thus, formal lectures are ineffective in schools and should not be used (Marcella et al, 2014). The formal or informal lecture can take the form of an illustrated talk, a briefing, or a teaching lecture. In the illustrated talk, the teacher relies heavily on visual aids to convey ideas to the learners like in the use of graphics.

Teacher demonstration is another traditional method of teaching which is expository in nature. Demonstration involves the presentation of pre-arranged events for observation and learning purposes. It is a method where the learner observes the portrayal of a procedure, technique or operation. It involves showing and explaining, through accurate procedures and guidelines, how to do something or how something works. By seeing a task performed and associating it with its explanation, the learners become more conversant with the materials used, the procedures and the final products (Marcella et al, 2014).

Teacher demonstration is useful when time is limited and when learning ability is low such that the learners cannot follow instructions properly. It is also useful when there are limited resources, materials or apparatus such as instruments, models and chemicals. It can also be used when the teaching/learning resources are too expensive or too sophisticated for the learners to operate, or when the resources are likely to pose some danger to learners (Marcella *et al.,* 2014).

Teacher demonstration is advantageous because learners get confidence in the application of scientific principles as they observe them working and do not simply hear about them. It motivates the learners to further learning and experimentation. It also minimizes expenses concerning resources and time. It is also ideal when the number of equipment is less and learners are more. The results are usually more accurate considering that the demonstration is mostly monitored by the teacher who is expected to be knowledgeable (Marcella et al 2014). This method however has some disadvantages; for instance, learners are placed in a more passive role and may be denied the opportunity to practise some manipulative skills. Where the class size is large, it may require the time-consuming creation of groups. When the teacher lacks presentation skills, the method may not be effective.

Meaningful learning, therefore, is personal, and idiosyncratic and involves recognition of the links between concepts. According to Novak and Gowin (1984), "Both rote and meaningful learning may be achieved no matter what instructional strategy is used either reception learning or discovery learning may result in meaningful learning. Therefore, it is not necessarily how information is presented but how the new information is integrated into the old knowledge structure that is crucial for meaningful learning to occur.

Although modern methods of teaching are being advocated for, traditional methods of teaching are still being adhered to in schools. Moreover, teachers are in the mode of knowledge dispensers rather than facilitators and the learners are passive recipients of the information. The prevailing teaching practices in many schools do not actively involve students in the learning process and seem to deprive them of taking charge of their learning (Boujaode & Attieh, 2008). The method also puts more emphasis on examinations and results rather than the understanding of concepts. This results in improper alignment between objectives, activities and assessments (Nazzal, 2014).

For effective teaching to take place, the teacher must stimulate, encourage and maintain active participation of the students, through the selection of appropriate teaching methods. This would require a balance between what is taught and how it is taught. Thus, successful teaching in vocational education does not depend only on the teachers' mastery of the subject matter but also on the teaching method employed.

2.2.2 Computer-Aided Learning

Computer-based collaborative concept mapping is blended learning that incorporates three learning techniques. It implies that learning under this concept is made up of collaborative learning techniques, computer-aided learning and concept mapping. But all in all, learning requires appropriate learning supports and scaffolding to help learners generate structured knowledge and hold discussions based on what they are taught (Sung & Hwang, 2013).

The use of computers in teaching and learning is defined as Computer-Based Instruction (CBI) or computer-assisted learning (CAL) Computer-Aided Learning (CAL), or Computer-Aided Instruction (CAI) (Serin, 2011; Schittek *et al.,* 2001) and is part of a learning environment that expresses the effects in a social context with a rich, multimedia and multimodal learning environment (La Velle *et al.,* 2003). This technique heavily relies upon computer-assisted instruction (CAI) which involves the use of ICT components to strengthen the learning processes (Tekbiyik & Akdeniz, 2010). Owing to the popularity and advances in computer and network technologies, CAL/CAI learning approaches have attracted the attention of researchers (Hwang, Shi & Chu, 2011).

Several studies have highlighted the potential benefits of information and communication technologies (ICT) for improving educational outcomes (Sangrà & González-Sanmamed, 2010). The advances in the learning sciences indicate that acquiring and demonstrating new knowledge and skills occurs within an environment or pedagogical context, which includes learners with specific cognitive and emotional profiles and tools to promote and evaluate students’ learning (Shute & Rahimi, 2017).

Further, the cognitive tools embedded in ICT and the pedagogical content knowledge involved provide a powerful driver for the knowledge transformation that enables students to understand a new problem (La Velle *et al.,* 2003).

The pervasive advances in technologies have enabled various new learning approaches that situate students in environments and combine real-world and digital-world learning resources. This also allows collaborative and shared learning experiences during the learning process (Hwang, Shi & Chu, 2011). The ubiquitous application of Information and communication technology (ICT) has been at the centre of national education policies and all levels of education and is influenced by several trends namely: the futuristic preparation of students towards workplace setting; introducing efficiency and effectiveness into learning spheres and lastly as a reformation of the education sector (Kirschner & Erkens, 2006).

Scholars in the education sector have indicated that technologies should be used to not only support learning in instructing learners but also in aiding knowledge construction (Hwang, Hung, Chen & Liu, 2014). Using technologies in teaching induces a change in pedagogical practice (La Velle *et al.,* 2003; Serin, 2011) as the cognitive tools embedded in ICT and the pedagogical content knowledge provide a powerful driver for knowledge transformation (La Velle *et al.,* 2003). These technologies are referred to as context-*aware ubiquitous learning* which not only supports learners with an alternative way to deal with problems in the real world but also enables interactive and collaborative learning (Chu, Hwang & Tsai, 2010; Hwang, Kuo, Yin & Chuang, 2010). ICT components have become an integral part of our education system and influence the education system at different levels and each stage of education by enhancing the efficiency of the teaching-learning process, making students more attentive, confident and providing each student with an individualized learning environment to learn at one's own pace (Kumari, 2018). The successful use of ICT can produce a change in pedagogical practice (La Velle *et al.,* 2003) as learners acquire scientific concepts in an easy meaningful manner which enables them to make use of these concepts in their daily lives (Serin, 2011). The use of audio-visual devices and animations with instructional materials results in an enjoyable and productive learning process (Serin, 2011).

There is also individualized computer-based instruction, games, feedback, interactive quizzes, computer-based labs, simulations and robotics (Savelsbergh *et al.,* 2016), shortened learning and absorption time, and better outcomes in other aspects (Schittek *et al.,* 2001). CBI enables the students to learn by self-evaluating and reflecting on their learning process and provides them with immediate feedback and reinforcement by creating an exciting and interesting game-like atmosphere (Serin, 2011). CAL promotes learning by allowing learners to take absorb more responsibility in the choice, regulation and evaluation of learning activities at any time, place and means (Županec, Miljanović & Pribićević, 2013).

The use of computer-assisted learning techniques has several advantages that include: flexibility and the promotion of active learning, improvements in student motivation and satisfaction, cost efficiency and reductions in instructional time and consistency of educational delivery. Computer-assisted learning tends to individualize learning by decentralizing the teaching process and facilitating learner independence and direction (Bloomfield *et al.,* 2010). Computers facilitate interaction during the learning process on multiple levels. At one level, it involves the interaction of the students with the content and the learning material. On another level, computers host interaction of the students with the tutor, peer interaction or interaction virtual learning communities (Schittek *et al.,* 2001).

2.2.3 Collaborative learning

Many studies have elaborated on the benefit of collaborative learning in promoting peer interactions (Charitonos *et al.,* 2012). For instance, Ma *et al.,* (2020) acknowledged that learners in a collaborative environment can integrate multiple perspectives, and gain insights, interactions and feedback from one another while engaging in reflective thinking through peer discussion. Hong and Lin (2019) examined the students at the elementary level in learning energy-saving ideas and noted that collaborative knowledge construction activities were conducive to learners' collective knowledge formation and the development of innovative ability. Cheng & Chu (2019) noted that knowledge sharing predicts learning achievement.

The concept of collaborative knowledge construction involves the generation, sharing knowledge and personal knowledge, and correcting the public's cognitive process; thereby, learners create a common vision, negotiate, discuss, share understanding, build consensus, and ultimately create artefacts (Ma *et al.,* 2020). Chen *et al.,* (2017) pointed out that collaborative knowledge construction offers considerable benefits for teachers to obtain a deeper understanding of information and develop learning autonomy and teaching skills. In collaborative learning settings, group coordination must include communication, interaction, and exchange of thoughts and ideas (Gu & Cai, 2019).

In collaborative classrooms, students are expected to discuss topics with each other, help and evaluate each other's knowledge, and compensate for each other's deficiencies (Blazar & Kraft, 2017). Curricular structures that incorporate active learning are thought to improve learning and engagement, particularly when facilitated by peers. While collaborative problem-solving reinforces argumentation skills as students advance and rebut provisional solutions (Kudish *et al.,* 2016). Collaborative learning involves groups of learners working together, helping one another, and contributing towards the achievement of shared learning targets (Jones, Antonenko & Greenwood, 2012). Collaborative learning facilitates knowledge gains (Stahl, 2011) and promotes cognitive development (Gu & Cai, 2019). The collaboration phase of learning plays a critical role in aiding the students to proceed from the passive to the active state of thinking (Lazakidou & Retalis, 2010).

Collaborative learning enables students with various intellectual capabilities to work together towards a common goal (Wu, Hwang, Kuo & Huang, 2013). This is illustrated by the experimental study by Cheng (2009) who comparatively examined the creativity of business students using a web-based collaborative learning tool. The experimental group used a collaborative tool and the results showed that the students in the experimental group had significantly higher performance scores than those in the traditional lecturing group for business creativity

Collaborative learning fosters creativity and focuses through the social environment and management. Collaborative support fosters students' creativity and problem-solving through intensive interaction, reflection and participation, thus the success of one student aids in the success of other students as well (Wu *et al.,* 2013). As Gikandi, Morrow and Davis (2011) pointed out, the students in face-to-face classes have many opportunities to interact with their peers and their teacher as they seek and receive feedback.

2.2.4 Concept mapping

Past studies indicate that concept maps are effective tools that assist students to visualize or map knowledge and learning experiences (Hung *et al.,* 2014; Hwang *et al.,* 2011; Hwang *et al.,* 2013). Computer-supported collaborative learning is a newly developed concept map and computer-supported collaborative learning system that has been successfully applied in educational settings to improve group learning performance (Cheng & Chu, 2019). Concept maps as developed by Novak and Gowin (1984) are a type of knowledge visualization tool wherein the knowledge of an individual about a subject is represented by nodes, concepts, and possible links between nodes, indicative of the relationships between the concepts(Cheng & Chu, 2019).

A **concept** map is a graphical representation of the relationships between concepts in our cognitive structure (Martínez *et al.,* 2013). It contains nodes that are interlinked by labelled, directed arcs. When constructing a concept map, the focus is on the relationships between concepts. Concept maps take meaningful knowledge of a particular subject and present it in a schematic format (Harrison & Gibbons, 2013). Research has shown that providing a quantified root concept has a stronger effect on the resulting concept map than providing a corresponding focus question (Cañas, Novak & Reiska, 2012). Providing both a focus question and the root concept further increases the possibility of having a positive effect on the type and quality of the map constructed. Cross-links are relationships between concepts in different segments of the concept map (Martínez *et al.,* 2013).

Among the existing Mindtools, concept mapping is an effective tool for assisting students to represent knowledge and learning experiences (Chu, Hwang & Huang, 2010). A concept map engages learners in constructive higher-order critical learning (Hwang *et al.,* 2011) by acting as means for communicating information, organizing ideas and promoting problem-solving strategies and can act as an intermediate step in ontological learning for a particular domain to support the acquisition of domain knowledge (Qasim *et al.,* 2013). Concept maps have been used for improving learning outcomes and evaluation, aiding students' critical thinking abilities and students knowledge retention and cognitive skills. In addition, concept mapping helps reduce students' cognitive load (Abbas *et al.,* 2018), supports creative learning activities and enhances students' innovative performance (Wu *et al.,* 2013).

The graphical nature of concept maps permits a topological or structural analysis of the map. The hierarchical structure of knowledge in a particular domain usually leads to a hierarchical structure in concept maps, with more general concepts at the top and more specific concepts at the bottom. By counting structural characteristics such as the number of hierarchical levels, the number of crosslinks, the number of propositions, etc., many rubrics have been developed that assess a concept map based on its structure, often as part of a more comprehensive rubric (Cañas *et al.,* 2012).

Concept maps are more effective when they only depict central ideas and give no details. Student project tasks that are prepared carefully and supervised closely by a teacher are much more effective (Schneider & Preckel, 2017). Concept mapping is an effective tool for assisting students to represent knowledge and learning experiences (Chu, Hwang & Huang, 2010). Concept mapping was developed at Cornell University as a way of visually presenting the hierarchical arrangement of concepts as well as their relationships for representing conceptual knowledge structures (Sanchiz *et al.,* 2019; Hwang, Wu & Kuo, 2013). Concept maps have become widely accepted as an educational tool (Hwang *et al.,* 2013) and in several ways, including evaluation or assessment tools, cooperative/collaborative learning tools, and advanced organizer and visualization tools (Qasim *et al.,* 2013).

Concept maps function as an 'intellectual partner' with the learner in facilitating critical thinking and high-order learning (Kazantzis & Hadjileontiadou, 2021; Kirschner & Erkens, 2006; Kirschner & Wopereis, 2003; Chu *et al.,* 2009; Hwang *et al.,* 2011). The maps are cognition tools that stimulate the learner's cognitive ability and enable them to construct knowledge that reflects what they have learned and realized instead of merely memorizing or recalling (Chu *et al.,* 2009; Kirschner & Wopereis, 2003). Concept maps help students to develop new propositions that are naturally integrated into the student's cognitive structure and this leads to meaningful learning. Concept maps have demonstrated effectiveness as cognitive tools regardless of whether students construct them individually or collaboratively in groups, although appear to be more effective when applied in learning groups (Martínez *et al.,* 2013).

Concept mapping provides intellectual challenges and encouraging independent thought helps students think through new learning content, and elaborate on it (Schneider & Preckel, 2017). Concept maps are considered an effective way of assisting students to learn complicated learning concepts and constructs (Hwang *et al.,* 2014) and have been applied as a tool to help students visualize and organize existing or newly learned knowledge and serve a variety of educational applications, playing the role of a knowledge construction tool (Hwang *et al.,* 2011; Wu *et al.,* 2012; Zheng, Huang, Hwang, & Yang, 2015) or assessment tool (Wu *et al.,* 2012). Concept mapping employs concepts and propositions as central elements in structuring knowledge and creating meaning while translating complex concepts into visual representations (Cañas, Reiska, & Möllits, 2017).

A concept map provides a ubiquitous learning experience and serves as an extension of the mind as it can engage learners in constructive higher-order critical learning (Hwang *et al.,* 2011). They act as means for communicating information, organizing ideas and promoting problem-solving strategies and can act as an intermediate step in ontological learning for a particular domain to support the acquisition of domain knowledge (Qasim *et al.,* 2013). Concept maps have been used for improving learning outcomes and evaluation, aiding students' critical thinking abilities and students knowledge retention and cognitive skills. In addition, concept mapping helps reduce students' cognitive load (Abbas *et al.,* 2018).

Concept mapping engages students in meaningful learning, hence, improving comprehension and learning achievements (Amadieu, Tricot, & Mariné, 2010). In experimental studies, Hwang, Wu and Ke (2011) revealed that concept mapping has a significant influence on learning perceptions and attitudes towards science courses and students taught using concept mapping had higher cognitive scores than the control group (Kaddoura, Van-Dyke & Yang, 2016).

Concept mapping is integrated into a computer-supported collaborative learning system, which is developed to assist learners with group discussion, to enhance their knowledge representation and construction. An example is CmapTools which provides extensive support for collaborative work during concept map construction. Many of the CmapServers are “public”, allowing anybody (no authorization needed) to publish their collections of concept maps and resources (Cañas *et al.,* 2004a).

2.2.5 Concept Mapping Approach

Concept mapping was developed at Cornell University as a way of representing conceptual knowledge structures (Novak & Gowin, 1984) and is a graph containing nodes and meaningful connections to show the relationships among concepts (Chu, Hwang, Shi, Lee & Chien, 2009). Concept maps take meaningful knowledge of a particular subject and present it in a schematic format (Harrison & Gibbons, 2013) and represent the knowledge structure externalization, which aids learners in internally reconstructing learning concepts and is the most appropriate method of visually representing the conceptual structures. It is like a 'window to the mind' as it allows for self–reflection (Chu *et al.,* 2009).

Concept mapping is a useful tool for learning and instruction, constructing concept maps using pencil and paper has some obvious disadvantages which include the: It is inconvenient for a teacher to provide appropriate feedback to students during concept mapping; the construction of a concept map is complex and difficult for students, especially among novice students; concept maps constructed using pencil and paper are difficult to revise; the pencil and paper concept map is not an efficient tool for evaluation. (Chang et al, 2001). Because of these difficulties, researchers have built computer-based concept mapping systems to help students construct concept maps more easily (Chang, Sung, and Chen, 2001).

These mind maps help stimulate visual intelligence as it aids in the visualization of the interrelationship between the concepts/constructs (Wu, Hwang, Kuo & Huang, 2013). These mindtools are cognition tool that stimulates the learner's cognitive ability and enables them to construct knowledge that reflects what they have learned and realized instead of merely memorizing or recalling. Group concept mapping can be a brainstorming technique that is commonly used to achieve meaningful collaborative learning (Chu *et al.,* 2009). Critics have voiced concerns with the attitudinal–oriented approach saying that these approaches might come at a cost of achievement outcomes (Savelsbergh *et al.,* 2016).

Concept mapping tools are computer-based, visualizing tools for developing representations of semantic networks in memory. Several concept mapping computer software has been developed and many more are coming up as research on concept mapping continues. Programs such as CMapTools, SemNet, Learning Tool, Inspiration, Webster, Luckie Concept Connector, TPL-KATS, Knowledge Mapper Prototype System and many others. Chung, Baker and Cheak (2002) describe the most recent version of their knowledge mapping software, called the Knowledge Mapper Prototype system. Research suggests that users take some time to become proficient.

Concept mapping has been proven to provide meaningful learning in an educational setting by offering clear structure and detailed organization during the process by which students gain knowledge (Chabeli, 2010). Concept maps can be used to represent knowledge held by anyone from young children to research professors in any subject matter domain. Moreover, using concept maps help learners learn how to learn meaningfully, and help researchers design and interpret research more effectively (Novak, 2010). Concept mapping is an effective knowledge construction tool that helps learners organize important concepts related to a core issue and their inter-relationship (Hwang *et al.,* 2014).

Concept mapping uses many different graphic tools for organizing and representing knowledge. Concepts often are described in a few words and enclosed in circles or boxes with relationships between them sometimes indicated by connecting arrow lines linking two or more concepts (Cooper & Zimmerman, 2020). Each concept consists of a minimum number of words that are as concise as possible, and thus a network of interrelated concepts is generated. Concept mapping may use different types of shapes and graphic organizers (such as triangles, concentric circles, overlapping circles, and rectangles) to specify kinds or degrees of relationships among concepts to demonstrate how they relate to one another (Cañas, Reiska, & Möllits, 2017).

The development of a mind map entails the following steps: begin in the middle of the blank page by composing or drawing the concept; develop the related subtopics for this central concept, connecting all of them to the centre with a line; repeat the same process for the subtopics, generating lower-level subtopics while matching or connecting interrelated subtopic; use of colour, sketches and symbols; label the topic as short as possible, keeping all of them to an individual term, or to merely an image; and lastly, alter the text dimensions, colours and alignment as required(Wu *et al.,* 2013).

Concept mapping constitutes complete propositions developed from concept–relationship–concept triplets (Nesbit & Adesope, 2006). The nodes and meaningful connections show the relationships among concepts (Chu *et al.,* 2009) and represent the relationship between ideas or images or words in the same way that a road map represents the locations of roads and houses. It organizes information like an outline but is less linear and more spatial. In a concept map, connections are made between pieces of information in different areas (Sanchiz *et al.,* 2019).

Concept map has hierarchical tree-like structures (Chiou, 2008) which takes meaningful learning proceeds more easily as new concepts or concept meanings are subsumed under broader, more inclusive concepts (Novak & Gowin, 1984). The format of concept maps, specifically the use of brief labels and simple node-link-node syntax to represent propositions, maybe more easily comprehended and constructed by learners. The building of a concept map can support the elaboration of a relevant macro-structure of the learning content (Schroeder *et al.,* 2017). A concept map usually takes the form of a visual presentation that explains graphically key concepts that are related to specific topics and relationships among them.

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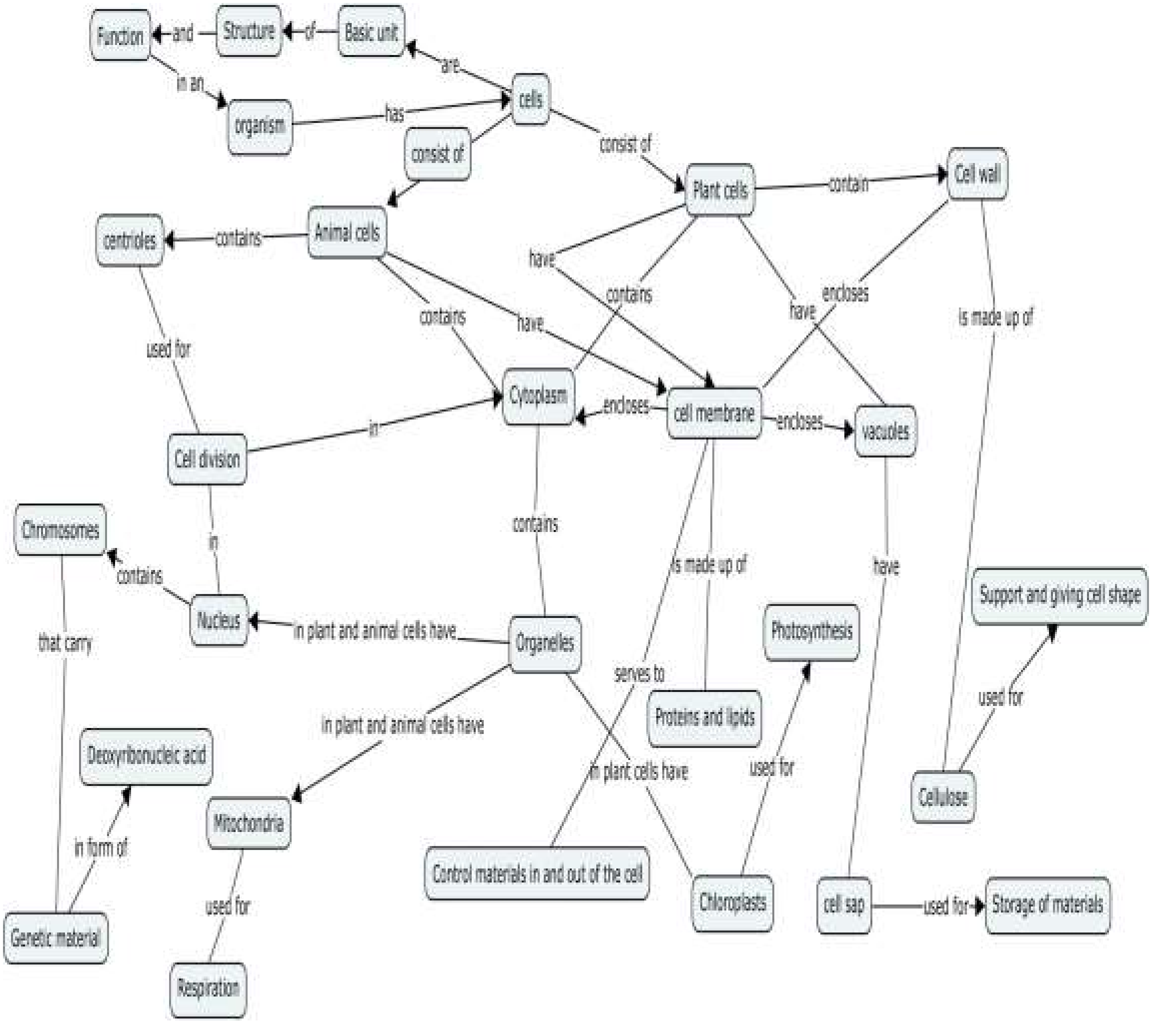


Figure 2.1: Concept map on cell structure and function

Novak (1998) described the various characteristics of a concept map, explaining that the nodes, which take the shape of a circle, square, or rectangle, represent c concepts. He defined a concept as "a perceived regularity (or pattern) in events or objects, or records of events or objects, designated by a label". When the nodes are joined together with appropriate one-way, two-way, or non-directional links or lines accompanied with linking words that explain the relationships among the nodes, the node-link network describes a proposition (Novak, 1998). Propositions consist of two or more concepts connected using linking words to form a meaningful statement (Novak & Canas, 2008).

Another characteristic feature of concept maps is cross-links. Cross-links are the lines depicting the relationships between concepts in different segments of the concept map (Novak & Canas, 2008). In essence, cross-links assist in demonstrating how two concepts or sub-concepts may be related to one another. Finally, an important feature of a concept map is its hierarchical structure. The hierarchical structure of a concept map places the most general, highly inclusive concepts at the top with the more specific, less generalized concepts arranged appropriately in a lower position (Novak, Gowin, & Johansen, 1983). Additionally, the concepts are organized into groupings, regions, or branches that specify a particular level of relationship or divergence.

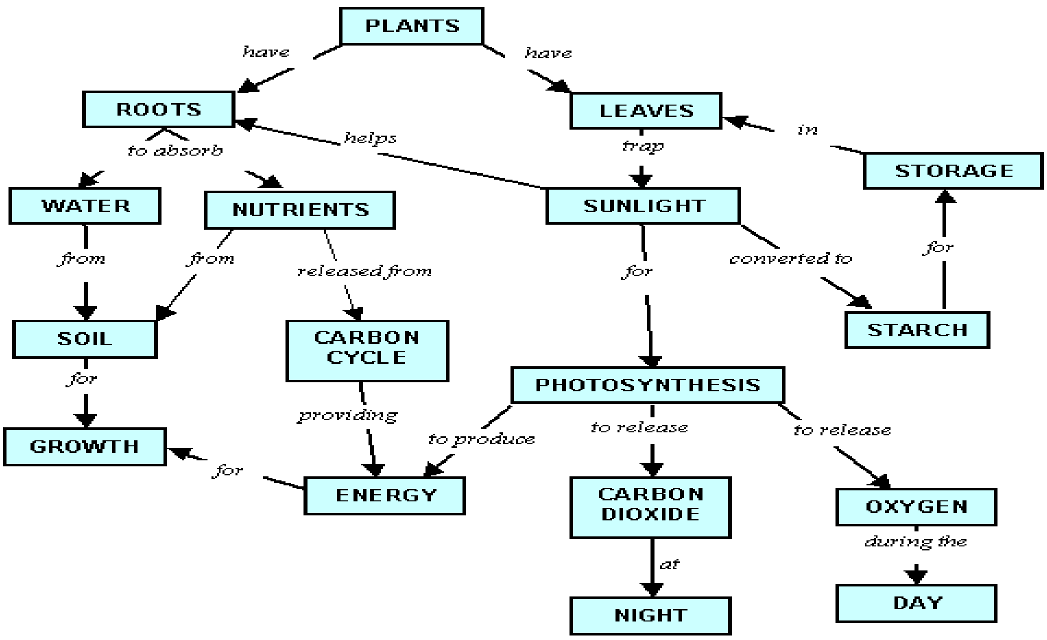


Figure 2.2: Concept map on the process of photosynthesis

Concept map Tools have been extended to aid the user in the construction of Concept Maps. A search feature (Carvalho, Hewett & Cañas, 2001) allows the user to locate resources (including Concept Maps) and Web pages that are related to a Map, facilitating the addition of explanatory resources to the Map (all Concepts map servers in the network are automatically indexed making the search feature very fast). A WordNet server allows users to navigate through definitions, synonyms, antonyms, etc. for any word in a Concept Map (Cañas, Lalinde-Pulido, Carvalho & Arguedas, 2003).

Research is being done on "suggester" additions to the software that takes advantage of the topology and semantics of Concept Maps to mine the Web and index servers to propose concepts (Cañas *et al.,* 2003), propositions, resources, other Concept Maps (Leake, Maguitman & Cañas, 2002), and topics for related Concept Maps (Leake *et al.,* 2003), that will help the user improve their Concept Map. A new recorder feature allows the recording and step-by-step playback of the whole Concept Map construction process which greatly facilitate the analysis of Concept Map building techniques and allow teachers and instructors to carefully re-examine the Map construction process of their students.

Through the storing of concept maps in CmapServers, CmapTools encourages collaboration among users constructing the maps. When maps are stored in a server on the Internet, users with appropriate permissions (Cañas *et al.,* 2003c) can edit shared concept maps at the same time (synchronously) or their convenience (asynchronously). The high degree of explicitness of concept maps makes them an ideal vehicle for the exchange of ideas or the collaborative construction of new knowledge. It has also been found that the obstacles deriving from personal insecurities and fear of embarrassment are largely circumvented since critical comments are directed at the concept map, not at the person(s) building the map.

The extensive support that CmapTools provides for the collaborative construction of concept maps by groups, whether they are at the same location or in distant locations, has encouraged the increasing use of collaboration during map building. In a variety of educational settings, concept mapping in small groups has served well in tasks such as understanding ideas in assimilation learning theory. Each student can construct the initial concept map individually, giving the teacher feedback on the level of understanding of every student. Within the option of individual construction of the map, the students can be allowed to collaborate through a knowledge soup (Cañas *et al.,* 2001), where students can share propositions but not see each other's maps. CmapTools has a *recorder* feature that allows the recording and playback of steps in map construction, including the identification of each contributor.

Using CmapTools, it is possible to use concept maps to access any material that can be presented digitally, including materials prepared by the mapmaker. In this way, concept maps can serve as indexing and navigational tools for complex domains of knowledge (Briggs *et al.,* 2004). By facilitating the linking between concept maps, learners can construct Knowledge Models (Cañas *et al.,* 2003; Cañas *et al.,* 2005), which are collections of concept maps with linked resources about a particular topic, demonstrating that their understanding of a domain is not limited to a single concept map. In the present study, all the activities that can be achieved through the use of concept mapping tools software were not explored because none of the schools in the county had internet connections.

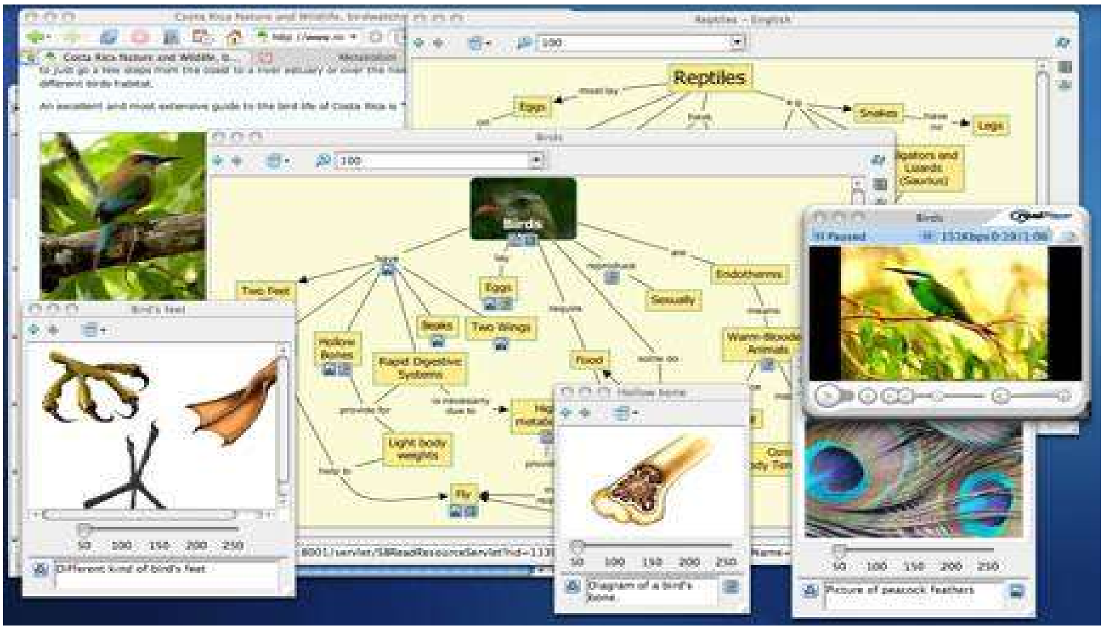


Figure 2.3: Concept map of birds

Icons under the concepts provide links to resources (e.g., images, pictures, web pages, videos, and other concept maps), some of which are shown in the figure

Source: Technical Report IHMC CmapTools 2006-01 Rev 01-2008

Concept maps benefit students in several ways which include: providing students with nonlinear visual ways to understand, produce, and represent knowledge; helping develop higher-order thinking skills including analytical skills; facilitating the recall and processing of information; helping students externalize their knowledge and show their understanding; make explicit structural forms of knowledge and relationships between concepts and therefore enhance students comprehension; they engage students in meaningful learning activities; they are effective organizational tools students can use to organize their knowledge; visual representations of knowledge is proved to both stimulate and increase brain activity boost social interaction, communication and collaborative teamwork; they can be used in different content areas and with students from different grades(Cañas *et al.,* 2003).

Some researchers however have found some limitations in concept mapping. The main disadvantages of concept mapping are that they require some expertise to learn; they can be idiosyncratic in terms of design (peculiar to a specific individual), and because of their complexity they may not always assist memorability with learners faced with designing concepts maps often feeling overwhelmed and de-motivated (Eppler 2006). Others have noted that the rigid rules used for identifying concepts and their multiple relationships do not make the process simple or easy to learn, and the linear nature of concept maps means that they are not adequate to capture more complex relationships between concepts.

There are four types of concept maps: teacher-generated, student-generated, concept-identifying, and proposition-identifying. Teacher-generated concept maps are created entirely by the teacher and given to the students as a study tool (Lim *et al.,* 2009). In contrast, student-generated concept maps are created entirely by the students (Harpaz, Balik, & Ehrenfeld, 2004; Novak & Gowin, 1984). Concept-identifying concept maps are partially completed concept maps that students complete by finding the correct concepts to place in the nodes (Wang & Dwyer, 2006). Similarly, proposition-identifying concept maps are also partially completed maps, however, rather than finding the correct concepts to place in the nodes, students complete them by providing linking word(s) between concepts to create propositions or node-link networks (Wang & Dwyer, 2006).

2.2.6 Collaborative Concept Mapping Tools

Through collaborative learning taking on a variety of forms and being practised by teachers of different disciplinary backgrounds and teaching traditions, the field is tied together by several important assumptions about learners and the learning process. The use of computer-assisted learning techniques has several advantages that include: flexibility and the promotion of active learning, improvements in student motivation and satisfaction, cost efficiency and reductions in instructional time and consistency of educational delivery. Computer-assisted learning tends to individualize learning by decentralizing the teaching process and facilitating learner independence and direction (Bloomfield, Roberts & While, 2010).

Weideman & Kritzinge (2003) suggest significant educational values of concept maps. They include increased efficiency of information retrieval, effective teaching via better course content communication and enhanced collaborative learning. The use of concept mapping enhances the development of positive attitudes towards learning and improves text comprehension. It increases students' understanding and also brings order to complex tasks. Christodoulou (2010) suggests that using concept mapping enables learners to present prior conceptions and identify their weak points. A learner can use concept mapping to extract relationships between key concepts because knowledge is broken down into simple and more easily understandable parts.

A concept map is a visual construction of a knowledge structure. It organizes and presents information easily using keywords. This promotes creative thinking hence self-directed learning. Concept mapping is an important pedagogical technique that provides an excellent means for a learner to externalize knowledge of a particular domain and to get a meaningful understanding of new information. Learning is a personal and unique experience that differs from individual to individual (Cicognani, 2000). It can be enhanced by concept mapping which is regarded as a powerful pedagogical process that fosters social creativity. Davidson (1998) indicated that when a learner is constructing a concept map, learning is enhanced and becomes even more effective when constructed collaboratively. Collaborative concept mapping benefits from interactions with others by allowing learners to blend their thoughts and experiences while trying to achieve an understanding of a common concept.

CBCCM is based on the influence of the computer-supported learning activity which produces a pedagogical change (La Velle *et al.,* 2003) thus learners acquire concepts in an easy and meaningful manner. Collaborative concept mapping is where students work together in a group to generate concept maps. In concept mapping, collaboration is achieved in various phases. For example, in a brainstorming session, all participants collectively agree on the focus question. They contribute to the creation of a list of keywords that later were used to give birth to the concept map (Cicognani, 2000). Collaboration is also achieved among the group through evaluation, questioning, discussion and debate with others. Collaborative concept mapping is a hybrid teaching/learning strategy involving an interaction between two or more individuals during concept mapping to create a shared understanding of a concept, discipline or area of practice that none had previously possessed or could have come to on their own (BouJaoude & Attieh, 2008).

Dosanjh (2011) measured the effects of concept mapping strategies on seventh-grade students' science achievement at an urban middle school in San Francisco, United States of America. However, the concept-identifying group performed highest on vocabulary and process items, those in student-generated concept mapping performed highest on identification items while the students in proposition-identifying concept mapping performed lowest on vocabulary and identification of items. Dosanjh's study was rigorous but done in general science using paper and pencil and so it was not known how concept mapping in biology using CMapTools would affect performance hence the need for the current study.

Sumeyye (2012) studied the effects of concept mapping on the attitude and academic success of eleventh graders in Turkey. The study was quasi-experimental and concept-identifying concept maps were used where the students were provided with partially completed concept maps that the students were required to complete by finding the correct concepts to place in the nodes. Sumeyye's study is similar to the current study because it investigated the effects of a concept mapping strategy in senior school biology.

Collaborative learning behaviours in a CMCLS environment can be improved by the incorporation of a function related to group awareness (Kwon, Liu, and Johnson, 2014). Group awareness in CMCLS has also been proven to enhance personal contributions and peer interactions (Lin & Tsai, 2016). The success of a computer-supported collaborative environment should include support functions designed to increase personal self-governance skills and learning strategies. The addition of group awareness functions to improve self-regulation within the group and team member awareness during the learning process would have a positive effect (Järvelä *et al.,* 2015).

Cheema and Mirza (2013) studied the effects of concept mapping on student academic achievement among seventh-graders in Pakistan. The study evaluated the interaction effects of gender on student academic achievement. The results indicated that the experimental group outperformed the control group and that males performed significantly better than females. This is likely to have caused fluctuation and inconsistency in student numbers although the researcher did not give the numbers of students at the start and the end of the study period.

Ajaja (2013) studied the effects of concept mapping as a study skill in achievement in biology in Nigeria. There was no significant difference in achievement between the experimental and control groups. Ajaja's study is similar to the current study because it investigated the effects of student-generated concept maps on biology achievement in senior school biology. Uchenna and Okafor (2012) examine the effects of concept mapping on the biology achievement of senior secondary school slow learners in Nigeria. The experimental group performed significantly better than the control group. Females also outperformed their male counterparts.

Appaw (2011) studied the use of concept mapping in enhancing the learning of cell theory by senior high school students in Ghana. The study comparatively evaluated the effects of concept mapping among high, average and low achievers male and female students. The results of this study showed that there was no significant difference in performance between the experimental and control groups. However, high-scoring females performed significantly better than their male counterparts in the post-test. There was no significant gender difference between average and low achievers.

One of the limitations of this study was the use of a small sample size. The other limitation of this study was having both experimental and control groups in one school without putting measures in place to counter the effects of interaction between the two groups hence it is possible that the interaction could have occurred and could have affected the results of the study. The nature of his study showed that there were two independent variables each occurring at two levels. Such a study would have required the use of factorial designs.

2.2.7 Learner Attitudes

Studies show that there is a significant drop in interest, motivation and attitudes towards science education which occur between elementary and secondary school (Potvin & Hasni, 2014a). Barmby, Kind and Jones (2008) reported that students' attitudes towards science in England declined as they progressed through secondary school and that the decline was more pronounced in female pupils. Studies have attributed the decline to the basic schooling systems which are not able to preserve the initial strength of students' attitudes toward science and technologies because the current school science may be considered “unattractive” by the students as it does not involve topics of interest or provide students with opportunities for creative expression (Christidou, 2011).

Several researchers have proposed that affective learning outcomes are more important to further learning activities than cognitive ones, but then empirical surveys have observed a weaker link between attitude and achievement (Maltese & Tai, 2011). Science teachers play a crucial role in the formation and reorganization of students' conceptions and attitudes towards science, hence, the teachers' views and attitudes towards science impact the students' attitudes. This is confirmed by previous studies which show that teachers with a positive view towards science tend to draw a comparative positive view among students (Christidou, 2011; Potvin & Hasni, 2014a). Further, positive attitudes towards science and technology serve as important learning goals in science education (Sjøberg & Schreiner, 2010). But affective outcomes are important, especially in the long run (Savelsbergh *et al.,* 2016).

Studies that have explored the influence of affective emotions have been conducted in young samples and described these components as an indeterminate set of predispositions such as persistence, emotion regulation, or attentiveness (García *et al.,* 2016). Many constructs have been developed and used to assess and describe the relationship that students develop with school science and technology subjects. The construct of attitude is the most commonly used, followed by interest, and finally motivation. These constructs all have in their definitions certain components that are exclusive to each (Potvin & Hasni, 2014b). Attitude can be defined as the feelings that an individual has about an object, based on his or her knowledge and belief about that object. This definition is made based on the model that attitudes include the three components of cognition, affect and behaviour (Barmby *et al.,* 2008)

Attitudes are formed by people as a result of some kind of learning experience if the experience is favourable a positive attitude is found and vice versa (Orunaboka, 2011). Attitude thus seems like a system of ideas with an emotional core or content. Some attitudes are based on people's own experience, knowledge and skills and some are gained from other sources. However, the attitude does not stay the same, it changes a couple of times and gradually (Olasheinde and Olatoye, 2014). Fasakin (2012) recognized attitude as a major factor in a subject choice. He also considered attitude as a mental and natural state of readiness, organized through experiences exerting a directive influence upon the individual's responses to all objects and situations with which it is related.

Every other student holds abilities but not every other student can develop them because the existing education system does not provide an effective learning environment to enable students to develop creativity. Therefore, the promotion of students' creative potential through creative thinking instruction is important in the current education system (Wu *et al.,* 2013). Student attitudes toward learning determine their ability and willingness to learn. If negative attitudes are not altered, a student is unlikely to continue his education beyond what is required. Changing students' negative attitudes towards learning is a process that involves determining the factors driving the attitude and using this information to bring about change.

2.2.8 Academic Achievement

Academic achievement is largely related to the individual characteristics of basic cognitive processes, i.e., information processing speed, visuospatial working memory, and number sense, as well as higher-order cognitive processes, such as primarily fluid intelligence (Tikhomirova, Malykh, & Malykh, 2020). In particular, the cognitive characteristics at each level of school education are strongly related to fluid intelligence and, to a lesser extent, to sense and working memory. Learning or achievement outcomes are also predicted by the students' approaches to learning (García *et al.,* 2016). Other factors include gender difference, teacher's education and teaching style, class environment, socioeconomic factors and family education background (Mushtaq & Khan, 2012).

The academic achievement reflects knowledge mastery and skill development and plays a pivotal role in determining students' career-seeking behaviour and future accomplishments. Even though schools facilitate equal classroom instruction for all students, a wide range of differences is observed in their performance outcomes because of several related factors (Richardson, Abraham & Bond, 2012).

MacCann *et al.,* (2020) also affirmed that student emotional intelligence is associated with academic performance. Kpolovie Joe and Okoto(2014) examined the influence of student interest and academic achievement using regression analysis. The results indicated that 21.60% of the variance in students' academic achievement is predicted by their interest and attitudes towards learning. Academic success is one of the most widely used constructs in educational research and assessment and it's often wrongly confused with the term academic achievement. . Secondary education plays a crucial role in laying the foundation for the further education of students (Kpolovie Joe & Okoto, 2014).

Academic achievement is the primary goal of schooling, and therefore schools are judged by students' performance rather than by what teachers do (Ardura & Galán, 2019). Academic success in school is a critical qualification for success later in life in most societies (Terzi & Kirilmazkaya, 2020). The student's academic achievement is capturing the attention of stakeholders in the education sector as it is a significant determinant of students' future specifically, and the future of a nation in general. Educational institutions strive to ensure the attainment of the academic calibre of students (Richardson, Abraham & Bond, 2012).

Academic achievement should be also analysed in a relation to a student's attitude towards learning and school, as it ensures internal motivation for providing better performance. The study by Fisher, Schult & Hell (2013) indicates that girls during adolescence are more motivated to learn compared with their peers' boys, which is also reflected in the results of their learning. Candeias, Rebelo & Oliveira (2010) note that girls seem to have more positive attitudes toward school, while boys are less motivated and have more negative attitudes toward school.

2.3 Empirical Literature

2.3.1 Students' attitude towards learning in secondary schools

The past literature examining students' attitudes shows linkages between interest and achievement and establishes that interest, motivation and attitudes toward science and technology tend to decline during the school years (Shute & Rahimi, 2017; Sjøberg & Schreiner, 2010). Zacharia and Barton (2004) suggested that attitudes are affected by students' interest levels in science, the curriculum and the learning climate. According to Salta and Tzougraki (2004) students' views about school science, such the biology's perceived difficulty are the important factors that shape learners' attitudes towards science education.

Lyons (2006) suggested that the way science is taught (transmissive pedagogy, teacher-centred) along with the overloaded science curriculum, and the irrelevant and boring science content influences learners' attitudes towards science education. In some cases, the attitudes are affected by the relevance attached by the learner to everyday life (Ainley & Ainley, 2011). It may also mean that the fragmentation of science education into strictly isolated and distinct disciplines presented in contexts may deter the student's interest by failing to provide a coherent picture of the discipline (Christidou, 2011) or that teachers are deficient in teaching skills (Schittek *et al.,* 2001).

Other reasons for the decline include the science curricula, school textbooks, teachers, and teaching techniques which negatively affect students' attitudes and interests (Christidou, 2011). Sometimes the decline relates to structural and infrastructural challenges facing the schools and these include the costs involved, time consumed and inaccurate data sets during the laboratory procedures in the school science centres. Other challenges arise from the practical work in science education which does not help learners develop procedural knowledge (Kumari, 2018). Furthermore, the teachers' views and attitudes towards science impact the students' respective views and attitudes towards science (Christidou, 2011).

Fischer, Schult & Hell (2013) examined the effect of students' gender using university students in Germany. The study revealed that achievement motivation, self-perceived academic achievement, and sex significantly contribute to final secondary school success above intelligence. The study also reported that female students tend to have significantly higher achievements than their male counterparts. Sakariyau, Taiwo & Ajagbe (2016) evaluated the students' attitudes towards science education in Nigeria. The results showed that the majority of the students had positive attitudes towards science and that there was no significant difference between male and female students.

A study by Christidou (2011) affirmed that students rapidly lose their interest in science and cease seeing it as a viable option for their future, or associating it with their success aspirations. This has seen the largest decline in attitudes towards learning science in schools (Barmby, Kind & Jones, 2008). The attitudinal aspect of learning tends to vary by topic and by gender, however, a similar general trend exists for mathematics and most of the sciences, with the decline occurring in most countries that have attained certain levels (Schreiner & Sjøberg, 2010).

Gender does not seem to affect students' overall views about biology (Soltani & Nasr, 2010). However, Simonneaux *et al.,* (2005) affirmed that more girls than boys considered science as difficult while Uşak *et al.,* (2009) suggest that biology is more popular among girls than boys. It seems that this may be true for science in general but biology in Greece is as popular among boys as among girls. Although Spall *et al.,* (2004) suggest that the older the students the less positive they become towards biology, this was not the truth in a sample from Greece, since no statistically significant differences were found between younger and older Greek secondary school students in their overall opinion about biology.

Potvin & Hasni (2014) reported that trends in international mathematics and science study (TIMSS) affirmed that a positive attitude towards science is commensurate with higher average student achievement. Positive attitudes towards science are important as learning goals in themselves Empirical evidence shows that student's perceptions appear to go hand-in-hand with interest, motivation and attitudes and performance and that the decline in interest, motivation and attitudes and science and technologies appears in the school years (Potvin & Hasni, 2014a). The study noted the decline was more pronounced in female pupils. The decline in attitudes could be related to the type of science courses taken by students in each grade; however other non-school factors have also been invoked. And as examined by Potvin & Hasni (2014) the decline in students' attitudes towards science subjects has been recorded in many countries and this has affected learning achievement (Christidou, 2011).

The foregoing discussion indicated that the students' attitudes toward science in developing countries tend to decline (Potvin & Hasni, 2014; Barmby, Kind & Jones, 2008). In other studies, boys tend to have higher positive attitudes towards science education than girls (Uşak *et al.,* 2009) while Spall *et al.,* (2004) indicated that older students are more inclined to science. However, critics have voiced concerns with the attitudinal–oriented approach saying that the emphasis on affective outcomes which include attitude, interest and motivation might come at a cost of achievement outcomes. But affective outcomes are important, especially in the long run (Savelsbergh *et al.,* 2016). The findings from these quasi-experimental studies show that they were done in a different context but with limitations. The limitations include the small sample size, the focus of the study and the pedagogic approaches and this confers the current study with an opportunity to examine how collaborative learning supported by concept mapping influences students' attitudes and performance in biology subjects in secondary schools in Uasin Gishu County, Kenya.

2.3.2 Effect of students' attitude on performance in secondary schools

Studies show that interest in school science education in school is associated with achievement and the intention to pursue studies or careers in science and technology subjects (Potvin & Hasni, 2014). The interest and attitudes in mathematics and science education influence the career choices made by students in high schools in STEM (science, technology, engineering, and mathematics) discipline and have more influence over the career choices than enrolment or achievement figures(Maltese & Tai, 2011). For instance, Barkatsas, Kasimatis & Gialamas (2009) investigated the influence of affective learner characteristics on the levels of mathematics achievement of high school students in Greece. The results showed that high affective learner characteristics were associated with high levels of achievement in mathematics and that boys expressed more positive views towards mathematics than girls.

Verešová and Malá (2016) evaluated the influence of students' attitudes on academic achievement. The results indicated that there were significant differences in the cognitive and behavioural components with the female students having significantly higher positive attitudes than their male counterparts. Further, the attitudes predicted academic achievement. Guy, Cornick and Beckford (2015) and Villavicencio and Bernardo (2013) reported that students' affective emotional characteristics significantly influence the student's learning and achievement in science subjects. Sometimes, the student's perception might be weakened or held back by their perception towards science education (Savelsbergh *et al.,* 2016). However, a significant decline in students' attitudes towards science subjects has been observed in several countries including the UK, where a study revealed that the learner's interest and attitude to science decline at the point of entry to high school (Potvin & Hasni, 2014b).

Kubiatko (2013) argues that if attitudes towards a subject and school are positive, also the achievement of students gets better. The achievement of a student could be defined as individual progress, and improvement in terms of acquired knowledge, skills and competencies. Many teachers, as is apparent from the study of Holúbková & Glasová (2011) associate academic achievement with a positive attitude of a student towards the school that may not be necessarily reflected in excellent achievements, although it will be reflected in producing the best individual performance concerning student's dispositions.

The discussion shows that students' attitudes impact academic achievement (Holúbková & Glasová, 2011; Guy *et al.,* 2015; Villavicencio & Bernardo, 2013). Attitudes towards science education have generally declined with entry into secondary and high schools (Potvin & Hasni, 2014b; Shute & Rahimi, 2017; Sjøberg & Schreiner, 2010) and the decline is greater in girls (Barmby, Kind & Jones, 2008; Uşak *et al.,* 2009). The findings from these quasi-experimental studies show that they were done in different contexts but with limitations. The limitation includes the focus of the study and the instructional design this confers the study with an opportunity to examine how collaborative learning with the aid of mindtools (concept mapping) influences students' attitudes and performance in biology subjects in secondary schools in Uasin Gishu County, Kenya.

2.3.3 Effect of collaborative learning approach and student attitudes towards learning

Past studies have critiqued the conventional approach to learning, for example, Savelsbergh *et al.,* (2016) reported that different teaching approaches have a significant effect on the general attitudes of the students towards science education. Zhang, Ding and Mazur (2017) examined the influence of various instructional designs on the attitudes and beliefs of university students undertaking science courses. The results indicate that the experimental groups instructed by peer and collaborative instructional designs exhibited a greater positive shift in attitudes and beliefs than the group instructed by the traditional approach. Further, there were gender differences with female science majors in the peer–instructed classes achieving a greater positive shift in attitudes and beliefs than did male students.

Muraya and Kimamo (2011) examined the effect of the cooperative learning approach on students' performance in biology in Kenya. The study used a cooperative learning approach in the experimental group while traditional teaching techniques in the control group. The findings revealed that the experimental group had significantly higher mean achievement scores when compared to the control group and that gender had no significant influence on achievement. Hong & Lin (2019) examined the impact of collaborative learning on the learner attitudes of fifth-grade students in Taiwan. The study revealed that a collaborative learning environment helped transform students into collaborative, autonomous and creative learners. An experiment examining collaborative learning in Mathematics education for fourth-grade students revealed that the experimental group using digital pens performed better than the control group using lectures (Huang *et al.,* 2017).

Alsalhi, Eltahir & Al-Qatawneh (2019) examined the effects of blended learning on ninth-grade students' attitudes and achievement in science. The study compared various methods used to teach science to ninth graders and the results showed that was a statistically significant difference between the experimental and the control groups, with the students in the blended learning exhibiting higher attitudes toward science when compared to students in the traditional learning technique. This result was replicated by Demirci (2017) who examined the influence of active versus traditional learning techniques on students' attitudes towards science education. The results showed that the experimental group taught using active learning had significantly higher attitudes towards science compared with the control group.

The studies reviewing the effect of the conventional approach to learning science education show that the traditional approach to learning is inferior in instigating learners' attitudinal changes (Alsalhi, Eltahir & Al-Qatawneh, 2019; Zhang, Ding and Mazur, 2017). Furthermore, the studies conclude that the traditional approach does not raise or change perceptual and attitudinal changes among students (Demirci, 2017; Savelsbergh *et al.,* 2016). The findings from these quasi-experimental studies show that they were done in different contexts but with limitations. The limitation includes the focus of the study and the pedagogic design and this confers the study with an opportunity to examine how collaborative learning with the aid of mindtools(concept mapping) influences students' attitudes and performance in biology subjects in secondary schools in Uasin Gishu County, Kenya.

2.3.4 Effects of collaborative learning methods on students' academic performance

Past research has critiqued the conventional approach to learning, for example, Schroeder *et al.,* (2007) reported that different teaching approaches have a significant effect on general attitudes with a differential effect on the student's achievement. Emaliana (2017) evaluated the students' attitudes and achievements based on student-centred and traditional teaching approaches. The experimental group was taught using a student-centred approach and the result showed that mean scores varied significantly with the students taught on the traditional teaching methods having lower attitudinal and achievement scores.

The meta-analytical study by Capar and Tarim (2015) examined the effect of the influence of cooperative learning techniques on the attitude and learning achievement of post-graduate students. The results indicated that the cooperative learning technique had significantly higher attitudinal scores than the traditional technique. Research on teaching and learning constantly endeavours to examine the extent to which different teaching methods enhance growth in student learning. Quite remarkably, regular poor academic performance by the majority of students is fundamentally linked to the application of ineffective teaching methods and thus they do not impact knowledge learners (Adunola, 2011).

The foregoing reviews indicate that the pedagogical approach adopted in traditional classes has a major influence on the cognitive achievements of the students (La Velle, McFarlane & Brawn, 2003). On one part, the conventional teaching methods provide opportunities for students to learn directly from subject experts but at the same time, they lack flexibility as they do not ensure consistency in teaching nor do they accommodate the diverse learning needs of the students (Bloomfield, Roberts & While, 2010). The studies show that the traditional learning approach does not generate or change learner attitudes (Capar & Tarim, 2015) and have lower achievement levels among students (Schroeder *et al.,* 2007; Adunola, 2011). The findings from the quasi-experimental designs (Schroeder *et al.,* 2007; Emaliana (2017) and the meta-analytical (Capar & Tarim, 2015) study show that they were done in different contexts but with limitations. The limitation includes the focus of the study and the pedagogic design and this confers the study with an opportunity to examine how collaborative learning with the aid of mindtools (concept mapping) influences students' attitudes and performance in biology subjects in secondary schools in Uasin Gishu County, Kenya.

2.3.5 Effect of computer-aided learning and student attitudes towards learning

Several authors have asserted that the communicative opportunities in computing technologies may promote positive attitudes towards a collaborative and constructive learning perspective (Sangrà & González-Sanmamed, 2010) while enhancing students' interests in learning strategies (Kajamies, Vauras & Kinnunen, 2010). Computer-assisted learning environments aid in learning and are motivational tools (Huang, Liu & Chang, 2012).

Several studies showed that CAI was more effective than the other methods in increasing students' interest in science lessons (Tekbiyik & Akdeniz, 2010). Linden, Banerjee and Duflo (2003) affirmed that good and well-designed educational software can sustain interest and curiosity even in an otherwise dull school environment. Usage of CAL changes students' attitudes and motivation for learning, for instance in biology lessons, students can use various technological tools, thus indicating clear evidence of increased enjoyment and interest (La Velle, McFarlane & Brawn, 2003). In the primary level of education, many pupils demonstrate a vivid interest in science and mathematics (Savelsbergh *et al.,* 2016) however, their attitudes declined in the middle grades (Potvin & Hasni, 2014a).

Empirical evidence suggests that interest, motivation and attitudes and performance including their associated perception usually appear to go hand-in-hand (Potvin & Hasni, 2014). CAL influences the attitudes of the students with students (Morgil *et al.,* 2005) and can sustain the interest and curiosity of students and lead to gains in students' performance(Mo *et al.,* 2015). This was validated by a study on the upper elementary school in Spain which indicated that positive attitudes explained 21.3% of the variance in mathematics achievement (García *et al.,* 2016). However, empirical evidence in Israel and the United States showed little consistent evidence as to whether the application of computer technology in school instruction has beneficial effects on math and reading test scores (Mo *et al.,* 2014).

The empirical evidence on the impact of computer-assisted learning (CAL) on learning outcomes is mixed (Mo *et al.,* 2015). Several educational innovations such as integrated ICT usage among others have been proposed, both in science and mathematics education to foster positive attitudes, but there is little systematic evidence about which educational approaches are effective to promote interest, attitude, and motivation (Fortus, 2014). CAL sustain the interest and curiosity of students (Mo *et al.,* 2014) and is connected to perception change which is linked to motivation to learn and practice learning science education (Kajamies, Vauras & Kinnunen, 2010). CAI as a technique is reported to be more effective in increasing students' interest in science lessons (Tekbiyik & Akdeniz, 2010).

Empirical support for the influence of CAL on changes in perception/interest/motivation/attitude has reported that integrated ICT usage has a modest positive effect on attitude/motivation/ interest (Potvin & Hasni, 2014). The arousal of interest and curiosity and changes in perceptions has been positively linked to attitudinal changes (Hwang, Shi & Chu, 2011; Mo *et al.,* 2005 *et al.,* 2014; Pilli & Aksu, 2013). Evidence also highlights the concurrent effect of the teacher's attitudes positively influencing students' attitudes towards science education (Christidou, 2011; Potvin & Hasni, 2014) and serves as important learning goals in science education

(Sjøberg & Schreiner, 2010). A positive attitude is also linked to increases in self-regulated learning (Guy, Cornick & Beckford, 2015).

CAL also simplifies pedagogy thus its effective usage as a meaningful learning technique has some positive effects on students (Hwang, Shi & Chu, 2011; Serin, 2011). in that students using CAL/CAI have better learning outcomes (Kumari, 2018; Morgil *et al.,* 2005; Tareef, 2014). CAL increases the overall learner's achievement level with a commensurate higher performance level than the traditional teaching method (Mo *et al.,* 2014; Potvin & Hasni, 2014; Županec, Miljanović & Pribićević, 2013). However, other studies indicate that the adoption and usage of computing technologies have varying outcomes because of the differences in education systems in countries (Mo *et al.,* 2015).

2.3.6 Effects of computer-aided learning on students' academic performance

A study by Shute and Rahimi (2017) indicated that the use of CAL in instruction generally enhances learning and other outcomes across a range of content areas such as biology, mathematics and programming. In a study, Huang, Liu & Chang (2012) established that CAL improved the mathematical problem–solving skills of low-achieving second-and third-graders. Chang, Sung & Lin (2006) established that the use of mathematical CAL was effective in improving the performance of students with lower problem-solving ability. The use of CAL improved the academic scores of the 4th-grade student in the Multiplication of Natural Numbers, Division of Natural Numbers, and Fractions (Pilli & Aksu, 2013). CAL increases students' achievement when the technique supplements normal conventional teaching methods and is more effective for underachievers (Serin, 2011). Linden, Banerjee & Duflo, (2003) found that the CAL program significantly improves math test scores, with most of the gains occurring in the second part of the year.

Empirical studies have reported high skill performance scores for students who use CAL as compared to conventional learning methods (Bloomfield, Roberts & While, 2010). In an experimental study using CAL, Morgil *et al.,* (2005) observed that the use of CAL in teaching chemistry subject lessons on acids and bases resulted in 52% improvements in post-instruction test results. The results were significant and indicated that the use of CAL tends to result in improved test scores when compared to conventional teaching strategies. A meta-analytical study that examined the overall effectiveness of the CAL reported that the average student's achievement in science learning for learners using CAL rose significantly. This indicates that CAL influences the student's achievement scores (Tekbiyik & Akdeniz, 2010). Mo *et al.,* (2015) reported that the CAL math programs improved student self-efficacy, which improved by 0.08 standard deviations

Several empirical studies have shown that students using CAL have better learning outcomes when compared to the conventional learning technique (Schittek *et al.,* 2001; Morgil *et al.,* 2005; Ecalle, Magnan & Calmus, 2009; Tareef, 2014; Kumari, 2018). Further support to the findings illustrates that computing technologies help lower achievers improve their achievement outcomes (Mo *et al.,* 2015) and increase learners' achievement levels with a commensurate higher performance than the conventional teaching method. Thus, the use of computers in biology teaching was much more efficient than traditional teaching in terms of quality, durability and applicability of knowledge (Županec, Miljanović & Pribićević, 2013). However, other studies indicate that the adoption and usage of computing technologies have varying outcomes because of the differences in education systems in countries (Mo *et al.,* 2015)

These findings suggest cognitive gain and knowledge retention and mastery of biology concepts imply that the study participants can learn the theoretical abstracts that may be taught later using CAL. The achievement score was relatively high with a mean of 42 may be attributable to the development of higher knowledge capabilities in all three cognitive domains of knowledge, comprehension and application. This finding is supported by Županec *et al.,* (2013) who indicated that pupils taught with the CAL program achieved significantly higher quantity and quality of knowledge in all three cognitive domains of knowing, applying, and reasoning than the pupils from the traditional conventional teaching method.

Further, the effectiveness of the CAL is also underpinned by its effectiveness and efficiencies in presenting information, testing and evaluating and providing feedback (Tareef, 2014). In essence, rote learning is minimized, thus encouraging meaningful learning to take place in a CAL learning environment, (Županec *et al.,* 2013). Thus, several studies have demonstrated that students using CAL needed a shorter time to reach the learning objectives and achieve better final results than students who did not have access to CAL (Schittek *et al.,* 2001). CAL has been proven to be more efficient than the traditional methods in increasing the academic achievement of learners in biology subject lessons: digestion and excretion Systems, floral Plants, and reproduction of plants and animals among others (Županec *et al.,* 2013).

2.3.7 Effects of concept mapping on student attitudes towards learner attitudes

Several studies have been done on the effects of concept maps on students' attitudes with varied findings. Several empirical studies have shown that the usage of concept maps as a meaningful learning technique as effectively promoted has some positive effects on students' attitudes (Hwang, Shi & Chu, 2011). In Taiwan, Hwang *et al.,* (2014) examined the concept mapping tools using over 1,500 students. The results showed that students in the experimental group had higher interest with commensurate improvements in learning achievements than conventional learning. Results based on the use of collaborative mind tools in learning natural science in an elementary school in China indicated that the experimental group had enhanced learning motivation when compared to the control group (Hwang, Shi & Chu, 2011).

A qualitative study carried out on university students revealed that concept mapping improves the affective, psychomotor and cognitive domains of learning thus enhancing learning abilities (Ullah, Mughal & Nudrat, 2021). Chen, Liang, Lee and Liao(2011) carried out an experimental study on nursing students to gauge their critical thinking skills. The results showed that the experimental group had significantly higher adjusted mean scores on inference and overall critical thinking compared with the control group. Kaddoura, VanDyke, Cheng & Shea-Foisy(2016) used concept mapping to examine the development of critical skills among nursing students. The study revealed that the use of concept mapping fostered the growth of clinical judgment skills in nursing students.

Mahasneh(2017) examined the learning attitudes and achievements of university students studying education. The results indicated that there was a statistically significant difference in attitudes and achievement scores with the experimental group having higher attitudes compared to the control group. Youssef & Mansour (2012) examined the effect of concept mapping on nursing students in Iran. The results showed that students in the concept mapping class improved their learning achievement more than students in the traditional expository teaching class. A meta-analytical study indicated that the use of the concept mapping technique was associated with increased knowledge retention (Nesbit & Adesope, 2006). The study examined past empirical studies from Grade 4 to university level in different disciplines and showed that the effect size varied distinctively depending on the application of the concept mapping and the type of comparison treatment.

The reviews on the concept mapping on learner attitudes show that concept mapping at an individual level(Hwang *et al.,* 2014) and collective level(Youssef & Mansour, 2012; Hwang, Shi & Chu, 2011) has a positive effect on learner attitudes(Nesbit & Adesope, 2006). The studies range from elementary school (Hwang, Shi & Chu, 011), secondary school (Hwang *et al.,* 2014), university-level (Mahasneh, 2017; Youssef & Mansour, 2012) and were quasi-experimental, qualitative (Ullah, Mughal & Nudrat, 2021) and meta-analytical (Nesbit & Adesope, 2006) and all indicated the positive effect on the learner attitudes. The findings from these quasi-experimental studies show that they were done in different contexts and used varied approaches but with limitations. The limitation includes the focus of the study and the pedagogic design and this confers the study with an opportunity to examine how collaborative learning with the aid of mindtools(concept mapping) influences students' attitudes and performance in biology subjects in secondary schools in Uasin Gishu County, Kenya.

2.3.8 Effects of concept mapping on student's academic performance

Research on using concept mapping as a learning strategy to learn science content is broad and diverse. Many studies have been done globally, continentally and nationally in biology, chemistry and physics. Wu, Hwang, Kuo & Huang, (2013) examined the impact of map-based collaborative learning techniques using undergraduate students in Taiwan. One experimental group used embedded mobile-based mind tools while the other used computer-based collaborative learning tools. The results show that there were differences in the creative performance with the experimental group having significantly enhanced students' innovative performance in a project-based learning task.

Kaddoura, Van Dyke & Yang, (2016) examined the impact of concept mapping on the development of critical thinking among nursing students. The experimental group was taught with the aid of concept mapping and the results showed that there were significant differences in the mean scores of the nursing students. The experimental group had a higher mean score than the control group. Martínez, Pérez, Suero & Pardo (2013) evaluated the effectiveness of concept mapping on university students learning physics. The result revealed that there were significant differences between the two groups with the experimental group having on average higher academic scores of more than 19 percentage points than the control group taught using the conventional approach.

In Turkey, Sumeye (2012) investigated the effect of concept mapping on student achievement and attitude while teaching the urinary system and found that the experimental group performed significantly better than their control counterparts.

Similar results were obtained by Cheema and Mirza (2013), of Pakistan who investigated the effects of concept mapping on the academic achievement of seventh-grade students in the subject of general science. In the same study, however, male students performed better than females. Chiou(2008) examined the effect of concept mapping on attitudes and learning achievement of university students taking accounting courses In Taiwan. The results showed that the experimental group which used concept mapping had a significantly higher learning achievement than the group taught by the conventional method. Further, the students on the concept mapping strategy had more favourable attitudes than the control group.

Orora *et al.,* (2014) investigated the use of a cooperative e-learning teaching strategy (CEL) on learners' creativity in biology in Nakuru County and found that CEL enhances the learners' creativity in biology compared to conventional teaching methods. For example, the effect of collaborative concept mapping on student achievement in biology (Githae et al, 2015), found that the experimental group performed significantly higher than the control group on the topic of gaseous exchange in plants and animals; effect of Collaborative Concept Mapping on student motivation in biology (Oraro & Wachanga, 2007), effect of Collaborative Concept Mapping (CCM) teaching strategy on students' attitudes towards chemistry learning (Barchok, & Too, 2013), and found no significant difference between experimental and control groups in the topic of the mole concept; effect of Collaborative Concept Mapping on student achievement in chemistry (Kinya & Wachanga, 2013), the effect of experiential Collaborative Concept Mapping on student motivation in physics (Wambugu *et al.,* 2013).

The reviews on the concept mapping on the performance show that the concept mapping has a positive effect on critical thinking(Wu, Hwang, Kuo & Huang, 2013; Kaddoura, Van Dyke & Yang, 2016) and academic achievement (Martínez, Pérez, Suero & Pardo, 2013; Sumeye, 2012). The studies range from elementary school level (Cheema & Mirza, 2013), high school level (Githae et al, 2015; Oraro & Wachanga, 2007; Barchok, & Too, 2013; Kinya & Wachanga, 2013) and university level (Wu, Hwang, Kuo & Huang, 2013; Kaddoura, Van Dyke & Yang, 2016) and were quasi-experimental and all reported the positive effect on the academic achievement. The findings from these quasi-experimental studies show that they were done in different contexts and used varied approaches but with limitations. The limitation includes the focus of the study and the pedagogic design and this confers the study with an opportunity to examine how collaborative learning with the aid of mindtools(concept mapping) influences students' attitudes and performance in biology subjects in secondary schools in Uasin Gishu County, Kenya.

2.3.9 Effects of computer-supported collaborative learning on student's academic performance

Research on using computer-supported collaborative learning as a learning strategy has been explored by several authors. Cheng and Chu (2019) examined the use of CMCLS by university students and the results showed that a consensus map-embedded collaborative learning system (CMCLS) had a significant impact on the learning achievement of the students. The experimental group had significantly higher learning attitudes and achievements. Liu, Chen & Chang (2010) examined the effect of a computer-assisted concept mapping learning strategy on the learning achievement of students enrolled in an English proficiency course. The results showed that the student in the experimental group had significant improvements in their reading ability when compared to the control group.

Sung & Hwang (2013) examined the use of the mindtool-integrated collaborative educational game in learning science among students in an elementary school. The results indicated that the experimental group improved the learning outcomes of the students in addition to improving their learning attitudes and motivation. Cheng & Chu, (2019) evaluated the use of CMCLS on undergraduate students learning computer science and the results showed that the experimental group using CMCLS had significantly higher learning achievement than the students in the control group using the conventional approach.

Wambugu, Changeiywo & Ndiritu(2011) evaluated the effect of the Experiential Cooperative Concept Mapping Instructional Approach (ECCA) on students' achievement in Physics in Kenya. The experimental groups were taught using the ECCA approach while the control group was taught using the conventional approach. The results indicated that students taught ECCA had significantly higher achievement scores than the control group and that gender had no significant influence on the scores.

The reviews on the computer-supported collaborative performance show that concept mapping reports a positive effect on learning achievement (Liu, Chen & Chang, 2010; Sung & Hwang, 2013; Cheng & Chu, 2019). The studies were quasi-experimental and all reported a positive effect on academic achievement. The findings from these quasi-experimental studies show that they were done in different contexts and used varied approaches but with limitations. The limitation includes the focus of the study and the pedagogic design and this confers the study with an opportunity to examine how collaborative learning with the aid of mindtools(concept mapping) influences students' attitudes and performance in biology subjects in secondary schools in Uasin Gishu County, Kenya.

2.4 Summary

The review of the concept mapping literature highlights the importance of the need for additional research. The research has demonstrated that concept mapping strategies can effectively enhance meaningful learning. Furthermore, the research conducted in science classes revealed that concept mapping strategies may increase science academic performance and improve learners' attitudes towards science subjects; however, the results are inconsistent. Globally, a lot of studies have been conducted in both primary and secondary schools. Most of the concept mapping studies have been conducted on academic performance while a few studies have been done on attitude hence more studies on attitude are necessary.

Based on pre-existing literature on the studies conducted in Kenya, the studies used Solomon-Four Non-equivalent control group design and used paper and pencil concept maps. None of these studies sought to establish how collaborative concept mapping which uses concept mapping tools (CmapTools) software can affect student performance and attitude in Biology subjects in a secondary school setting. Given that the world is embracing information technology, the study explored the possibility of using ICT as an aid in collaborative concept mapping to foster meaningful learning and creativity in Biology instruction. In this study, the collaborative mind mapping approach is used to support learning activities. The experiment was conducted to evaluate the effectiveness of the proposed approach on different computer platforms.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter outlines the research design and methodology employed to achieve the study objectives stated. This section also presents a detailed description of the philosophical underpinning of the research, the research strategy (method), the study area; the target and accessible population, sampling design, instrumentation, data collection and analysis procedures.

3.2 Research Philosophy

Research philosophy contains important assumptions about how the world is viewed (Saunders, Lewis & Thornhill, 2009) and provides the backdrop from which specific methodological decisions in research are made. The philosophy shapes the researcher's knowledge by directing the research process and by selecting the specific methods to be used, and the strategies to be used to obtain, analyze and interpret information. The philosophy was underpinned by the pragmatism foundation (Depoy & Gitlin, 2011).

Pragmatism advances the knowledge foundation by defining the world through the ideas and the unique interpretation of symbols occurring through the lenses by which each individual knows the universe and takes a pluralistic perspective which has gained acceptance more recently than logical positivist approaches. Pragmatism is suited because; first, the study utilized mixed methods with both qualitative and quantitative designs (Depoy & Gitlin, 2011) and the choice of approach is linked directly to the purpose of and the nature of the research questions posed (Cresswell, 2012).

Pragmatism has been advocated by several researchers (Johnson & Onwuegbuzie, 2004; Maxcy, 2003; Morgan, 2007). The rationale can be established by considering the objectives of the study. In this study, the following objectives were investigated; i) to compare the effect of computer-based collaborative concept mapping and conventional methods on student's performance in Biology, ii) to determine the effect of CBCCM on student's attitudes towards biology, iii) to compare the gender differences in students' attitudes towards Biology when taught using CBCCM technique and iv) to compare the gender differences in students' performance in Biology when taught using CBCCM technique and conventional methods.

Objectives two and three are both quantitative and qualitative because the student questionnaire had both closed and open-ended questions. Objectives one and four were quantitative. Due to the foregoing objectives, this study, therefore, took a mixed-methods approach. Pragmatists agree that research always occurs in social, historical, political, and other contexts. In this way, mixed methods studies may include a postmodern turn, a theoretical lens that is reflective of social justice and political aims. Pragmatists have believed in an external world independent of the mind as well as that lodged in the mind. Thus, for the mixed methods researcher, pragmatism opens the door to multiple methods, different worldviews, and different assumptions, as well as different forms of data collection and analysis.

3.3 Research Design

Research designs are plans and procedures that span the decisions from broad assumptions to detailed methods of data collection and analysis (Cresswell, 2012). This study adopted a mixed methods research (MMR) using the triangulation design where both quantitative and qualitative data were collected simultaneously. As a method, triangulation, by combining methods in a research study, ensure that fundamental biases arising from the use of a single method are overcome. Triangulation is also an effort to help explore and explain complex human behaviour using a variety of methods to offer a more balanced explanation to readers. It is a procedure that enables the validation of data and can be used in both quantitative and qualitative studies. It is premised on the use of both qualitative and quantitative approaches concurrently to provide a better understanding of research problems than either research alone.

3.3.1 Survey on Attitudes

In seeking to assess any of the affective outcomes in science education in the basic education system, there is the need to capture both transient and permanent aspects of the affective outcomes at any one moment as they form the core affective emotion in different contexts and curricula. The use of conventional constructs or fine-grained frameworks may suffice but the simpler and more effective way is to generate simple and easy-to-understand constructs.

Based on the foregoing literature, a baseline student attitudinal test was purposefully developed and consisted of questions on an agreement continuum ('Strongly disagree' 'Strongly agree'). This test consisted of questions with a five-point Likert-type scale that evaluated the students based on the statement's levels of agreement/disagreement (strongly agree, agree, indecisive, disagree, and strongly disagree). There was one open-ended question where the students were to express their views regarding Biology and concept mapping.

3.3.2 Quasi-experimental Design

A quasi-experimental research design known as the Solomon Four Non-Equivalent Control Group design was employed. Creswell and Clark (2011) argue that integrating methodological approaches strengthens the overall research design, as the strengths of one approach offset the weaknesses of the other and can provide more comprehensive evidence than one-method studies. Therefore intact streams in the selected schools were randomly placed into experimental and control groups. This is because the school authorities do not normally allow classes to be dismantled so that they can be re-constituted for research. Experimental designs enable the researcher to study cause-and-effect relationships between the independent variable (IV) and the dependent variable (DV). In this study, the I.V that was manipulated was the computer-based collaborative concept mapping. The researcher sought to investigate its influence on the outcome of the DVs which were the learner performance in the Biology achievement test and learners' attitude towards Biology.

The design is as follows: -

Group 1 (E1)	O1	X	O2
Group 2 (C1)	O3	__	O4
Group 3 (E2)	__	X	O5
Group 4 (C2)	__	__	O6

Where:

E represent the experimental groups

C represent the control groups

O1 and O3 are observations of pre-tests

O2, O4, O5, & O6 are observations of post-test

X is the treatment (computer-based CCM)

__ represents no treatment/no pre-test

-------- indicates non-equivalent groups

Group 1 is the experimental group that received the pre-test (O1), the treatment (X) and the post-test (O2). Group 2 is the true control group that received a pre-test (O3) followed by the control condition and finally a post-test (O4). Group 3 is the experimental group that received the treatment (X) and post-test (O5) only but did not receive a pre-test while Group IV is the control group that received post-tests (O6) only. Groups 2 and 4 did not receive the treatment.

This design has four groups. Two of the groups receive the treatment and two do not. Further, two of the groups receive a pretest and two do not. One way to view this is as a 2x2 (Treatment Group X Measurement Group) factorial design. Within each treatment condition, there is a group that is pretested and one that is not. By explicitly including testing as a factor in the design, it is possible to assess experimentally whether a testing threat is operating.

The design controls all major threats to internal validity associated with the interaction of selection and history, selection and instrumentation, and selection and maturation (Cook and Campbell, 1979). The conditions under which the instruments were administered were kept as similar as possible in all schools to control for interaction between selection and instrumentation. The schools were assigned randomly to control and treatment groups to control for interaction between selection and maturation.

Schools were used as sampling units and a list of county secondary schools in Uasin-Gishu County was used as a sampling frame. A stratified sampling technique was used to group the schools into two categories, those with computers and those without computers and to select eight schools that have computers and a computer laboratory. The study involved extra-county secondary schools only to ensure that the respondents of the study have comparable academic abilities. This is because the selection of students joining secondary schools is based on their overall performance at the Kenya Certificate of Primary Education (KCPE) examination that is usually administered at the end of standard eight in the primary school cycle.

3.3.3 Study Procedures

The quantitative and qualitative data was collected through the use of an attitudinal test (SAT) was given to both groups one and two to gauge their attitudes towards Biology at the pre-test and another SAT was given to groups one and three to gauge their attitudes towards Biology and CBCCM at the post-test periods. The researcher with the help of the assistants helped administer a Biology Attitudinal Test and collected all the questionnaires and analysed for the differences in the students' attitudes before randomly assigning the schools into either experimental or control groups.

Questionnaires facilitate the easy and quick derivation of information within a short time and give the respondents adequate time to provide well-thought-out responses to the questionnaire items. Borg and Gall (1979) emphasize that whereas open-ended questions give the respondents freedom of response, the closed-ended type facilitates consistency of certain data across the respondents. There were two questionnaires for students, one for the pre-test administered to groups one and two and the other for the post-test administered to groups one and three. The questionnaire items were selected by the researcher from instruments that have been previously used by other researchers in past research studies. Modifications were done where necessary and the items were put together in a questionnaire.

The student questionnaire had three sections. The first section consisted of six closed-ended questions in a semantic differential scale having five-point scales. The second section consisted of twenty closed-ended questions on a Likert scale having five-point response scales ranging from strongly disagree to strongly agree. In each item, the response was rated with strongly disagree rated as point one and the rating increased to a maximum of five points for strongly agree. The third section comprised open-ended questions where the students were required to freely express their opinion about computer-based collaborative concept mapping in about ten sentences.

The Biology achievement test consisting of questions on the topic of respiration was administered. These questions were drawn from KNEC past papers one and two. There were nine questions and each question had marks ranging from three to eight and had a maximum score of fifty marks. The test was administered to all the groups. The Post-test was used to test whether there were significant differences in performance between experimental and control groups and whether there were gender differences in performance after the treatment and hence determine the effects of computer-based collaborative concept mapping teaching strategy on the learners' performance in Biology. The table of specifications for the BAT post-test is given in Appendix III

The experimental design which took the form of the Solomon IV non-equivalent group was used with a focus on comparing the collaborative learning approach which was aided by concept mapping and the traditional learning approach. The study was designed to facilitate the acquisition of concepts of respiration and comparisons were made based on its effects.

Conventional module: The control group (n = 178) were taught in a normal classroom setting by the subject teacher. This process involved the preparation of a lesson plan using the standard teaching pack consisting of a secondary school Biology curriculum, a set of secondary school biology, shorthand notes, chalks and aboard. The shorthand notes detailing respiration were drawn from various textbooks; secondary school

Biology book two by the Kenya literature bureau, longhorn biology book two and principles of biology volume two. All the illustrations of the concepts were done on the board and in the books.

Any questions about the subject matter during the session were dealt with by the research assistants and the researcher who was also a science teacher. The whole concept of respiration was taught in four weeks following the laid down school timetable. Ideally, the Biology lesson is always allocated four lessons per week, each taking up forty minutes. In total, the whole concept was covered in six hundred and forty minutes. The evaluation questions at the end of each lesson were prepared using the same textbooks. The researcher tried as much as possible to operate within the time allocated.

Concept mapping: The experimental group (n = 167) underwent training where they were taught using computer-based concept maps for the first five days over a period of one week. The training covered concepts on cell structure and function. This is because there is some correlation between these concepts and those in the topic of respiration. First, the participants in the group were inducted into the use of computing technology and after which they were expected to complete the study following the instruction of the researcher. The lesson was developed in line with the objectives outlined in the Kenya Institute of Curriculum Development (KICD) syllabus. The content for the lesson included CMapTools which were downloaded freely from http://cmap.ihmc.us and loaded into all the personal computers in the computer laboratory. Construction of concept maps was done in the evening after the normal classes had been attended

Each lesson lasted for one hour over three days for a period of four weeks The topic was broken into six sub-topics which were the definition and significance of respiration, types of respiration, phases of aerobic respiration, oxygen debt, the economic importance of anaerobic respiration and respiratory quotient (RQ) and its significance. With the aid of the software, the students began by placing the general idea (respiration) at the top of the map. In the experimental group, the researcher and her assistants first explained why concept mapping is a useful tool for learning and how concept mapping can be used to show relationships among concepts, and then spent hours training students to draw concept maps following the procedures.

The students then work down the list and added more concepts as needed, each time placing the selected two, three, or four sub-concepts to place under each general concept. No more than three or four concepts were placed under any other concept. Having listed all the concepts in a hierarchy, the next step was to connect the concepts by lines. The lines were labelled with one or a few linking words which defined the relationship between the two concepts so that it reads as a valid statement or proposition. The hierarchically linking together a large number of related ideas illustrated the structure of meaning for the given subject domain.

The students would then restructure their map, in several ways which included adding, subtracting, or changing superordinate concepts. The students seemed to enjoy this part and they would do this reworking several times in turns until they came up with a refined map. This process went on indefinitely as an individual or as the group gained new knowledge or new insights. This was evident because while the groups were working on the fourth or fifth map, some groups would be seen going back to restructure the first or any other previously constructed map. This was always done just before the beginning of a new map or immediately after completing the new map for that particular day.

Learners were first required to identify the focus question and the parking lot. The focus question addresses the problem, issues, or knowledge domain an individual or a group wishes to map. A parking lot refers to a list of concepts waiting to be added to a concept map. The learners then brainstormed a set of concepts that are pertinent to the question and listed them down on paper. Concept labels should be a single word, or at most two or three words. This list of concepts now made the parking lot of each group. Listing of these concepts however was not done haphazardly. Certain concepts need to be identified for each sub-topic. For example, in the first sub-topic, the focus question was: define respiration and state its significance. The concepts to be included were; respiration, cells, food, energy, muscle contraction, conduct nerve impulses, tissue repair, growth, organ function, mitochondria, cristae and enzymes.

Using the concept mapping software, the students then produced a list of concepts on their computers. The broadest most general and the most inclusive idea was placed at the top of the map. Taking the case of the first sub-topic, the most general and inclusive idea was respiration. The students then worked down the list and added more concepts as needed, each time placing the most inclusive and most general concept(s) at the top. Usually, there would be only one, two, or three most general concepts at the top of the map. After placing the most general and most inclusive concepts at the top, the students then selected two, three, or four sub-concepts to place under each general concept. No more than three or four concepts should be placed under any other concept.

Having listed all the concepts in a hierarchy, the next step was to connect the concepts by lines. The lines were labelled with one or a few linking words. These linking words should always define the relationship between the two concepts so that it reads as valid statements or propositions. The connection creates meaning. When you hierarchically link together a large number of related ideas, you can see the structure of meaning for a given subject domain.

Concepts in a map are usually interconnected and so after linking the concepts, the students would then look for cross-links between concepts in different sections of the map and label these lines. Cross links can often help to see new creative relationships in the knowledge domain. Specific examples of concepts were attached to the concept labels if they were available depending on the type of map constructed. Each group would then print their map and hand it over to the teacher for scoring.

The collaboration involved students discussing and agreeing on the concepts, links and cross-links and even examples where available. This is time-consuming and therefore constructing one map would take two or three days depending on the complexity of the map. Here is an example of the first concept map on the definition and significance of respiration

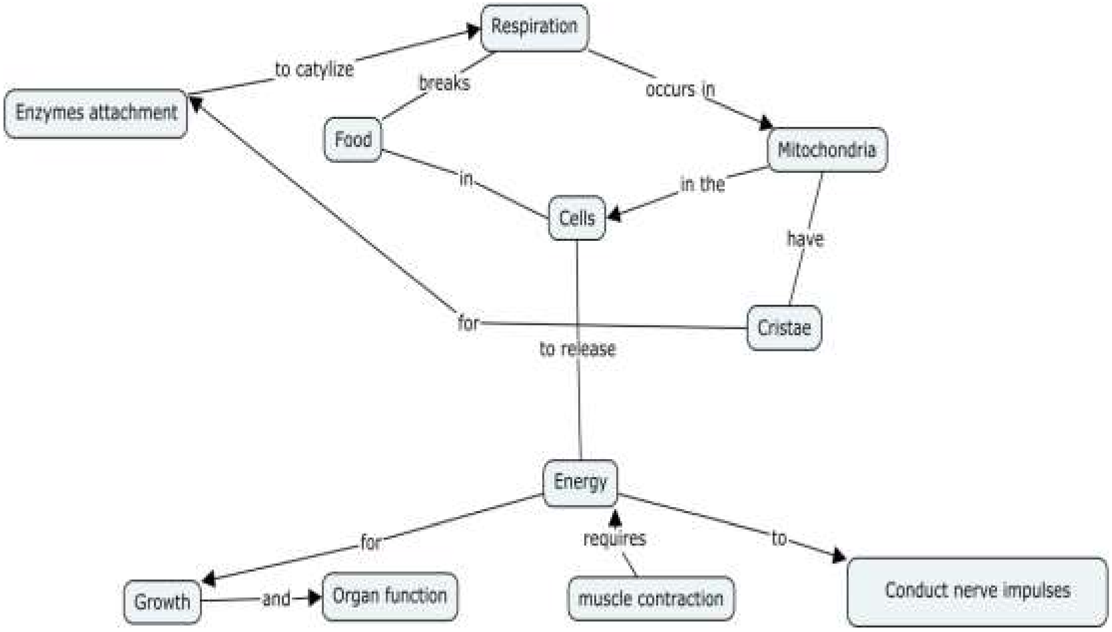
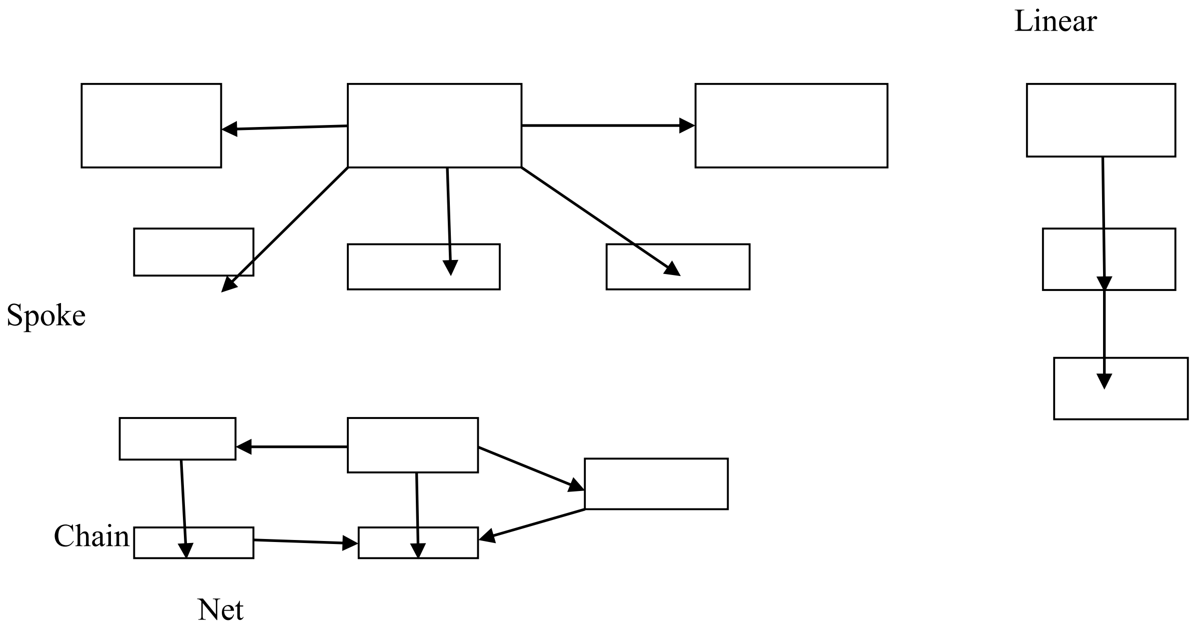


Figure 3.1. Concept map on the definition and significance of respiration

Once the experimental period had ended, the researcher carried out a post-test Biology test for all the groups before administering an attitudinal test on concept mapping to the experimental group as envisioned by the Solomon IV group design. The results from all the pre-test and post-test attitudinal scores and the pre-test and post-test Biology were collected, collated and entered into a Microsoft Excel spreadsheet in preparation for analysis.

4.2.3 The complexity of the maps

Map complexity is easy to determine and is quite informative hence the teacher should begin by evaluating this feature. This can be as simple as observing whether the maps are complex networks, or if they are simple structures. Experts and highly proficient students tend to create highly interconnected maps, whereas novices tend to create simple structures that are linear, circular, a hub with spokes, or a tree with few branches.



Spoke – a radial structure in which all the related aspects of the topic are linked directly to the core concept, but are not directly linked to each other. Chain – a linear sequence of understanding in which each concept is only linked to those immediately above and below. Though a logical sequence exists from beginning to end, the implied hierarchical nature of many of the links is not valid. Net – a highly integrated and hierarchical network demonstrating a deep understanding of the topic

If a pupil holds a spoke structure, then the addition of new knowledge will not cause any disturbance to the existing framework. It can simply be added in with a link to the core concept but without any links to associated concepts. The result would be that the knowledge can be assimilated quickly, but only be accessed by reference to the core concept and not by reference to one or other of the associated concepts. For the pupil with a chain structure, the addition of new knowledge will be easy if there is an obvious break-in (or premature end to) the sequence but may be problematic if a workable sequence is already in place as the additional concept may appear spurious.

Alternatively, the addition of a concept near the beginning of the sequence may be so disruptive to the knowledge structure lower down that incorporation of the new knowledge is rejected. Additionally, understanding a concept in the middle of the sequence may be difficult without travelling from the beginning. For the student with a net framework, access to a particular concept may be achieved by several routes, making the knowledge more flexible. However, this requires an understanding of the associated concepts beyond their link with the core concept and so implies a wider understanding.

The most important reason for the widespread use of mapping tools is that through research, they have been proven to be beneficial to student learning. Knowledge mapping allows meaningful learning to occur**.** Hay et al. usefully distinguish between ‘‘non-learning’’, ‘‘rote learning’’ and ‘‘meaningful learning’’ (Hay *et al.,* 2008).

They found that measurable improvements in meaningful learning occur using concept mapping under test conditions with control groups. They found that non-learning occurs when no detectable change in knowledge occurs before and after the presentation of new material. Rote learning occurs when new information is added (or rejected) in a student's knowledge store, but there is no new integration made between the new or substituted information. Students accept and reject information but do not think about it or relate it to other knowledge they possess. Meaningful learning, by contrast, occurs when new perspectives are integrated into the knowledge structure and prior concepts of the student. Hay *et al.,*(2008) found that concept mapping can significantly add to the quality of teaching as it promotes meaningful learning.

Concept mapping allows the presentation of new material to build on existing knowledge. Having a source of prior knowledge that is well structured and retrievable allows students to "scaffold" new learning. This enables meaningful learning to occur. Structured diagrams incorporating prose—such as mapping devices—can represent new information better than traditional discursive prose on its own (Gelder, 2007). This, in turn, allows efficient learning and integration with information stored in memory. There are two reasons why this occurs: map-making improves the usability of information and also complements what the brain can do imperfectly. In essence, both improve student learning.

3.4 Research Variables

A variable is the characteristic or attribute of an individual, group, educational system, or environment that is of interest in a research study (Katrina, 2012). Variables can be defined as any aspect of a theory that can vary or change as part of the interaction within the theory. In other words, variables are anything that can affect or change the results of a study. Every study has variables as these are needed to understand differences.

3.4.1 Dependent Variable

The dependent variable refers to that factor that is observed and measured to determine the effect of the independent variable. In a research study, the dependent variable defines a principal focus of research interest. It is the consequent variable that is usually affected by one or more independent variables that are either manipulated by the researcher or observed by the researcher and regarded as antecedent conditions that determine the value of the dependent variable (Jaeger, 1990). Student's performance in the Biology achievement test and the student's attitude towards Biology constituted the dependent variables.

3.4.2 Independent Variable

An Independent (Experimental, Manipulated, Treatment, Grouping) *Variable* refers to a factor that is measured, manipulated, or selected by the experimenter to determine its relationship to an observed phenomenon. In the study, the independent variables are antecedent conditions that are presumed to affect a dependent variable and are either manipulated by the researcher or observed by the researcher so that their values can be related to the dependent variable. In this study, one independent variable was investigated and this was a teaching strategy known as computer-based collaborative concept mapping.

3.4.3 Extraneous Variables

These are the variables that if not controlled, may compete with the independent variable in explaining the outcome of the dependent variable. One way to control an extraneous variable that might influence the results is to make it a constant (keep everyone in the study alike on that characteristic). These extraneous variables were teacher factors which included experience and training and student factors which included gender, age and type of school.

Teacher factors were controlled by involving trained teachers who have at least three years of teaching experience. Student factors were controlled in the following ways; gender was controlled by using both boys and girls schools, age was controlled by using form two students most of whom are aged between fifteen to sixteen years and the category of school was controlled by using extra-county schools only since they have the same entry behaviour.

3.5 Study Area

The study was conducted in Uasin-Gishu County which borders Baringo and Elgeyo-Marakwet Counties to the East, Kericho and Nandi Counties to the South, Trans_Nzoia County to the West and Kakamega to the South – West. The study location was chosen because of its relevance to the region and the concentration of over 150 schools in the county.

3.6 Target Population

Creswell (2005) defines the target population as a group of available individuals from the population that have some common characteristics that the researcher can identify and study. The target population for the study was 149 secondary schools in Uasin Gishu County. The school's classification is as follows; 14 girls' schools, 8 boys' schools and 127 mixed schools. Classified by hierarchical tier system, there is 1 National, 13 Extra counties, 13 County and 122 Sub-county schools respectively. In this study, the target population was all form two secondary school students in Uasin-Gishu County because the topic of respiration is taught in the form two biology syllabus. Moreover, school authorities can easily allow a form two class to be used in a research study hence the population is easily accessible compared to form three and form four who need time to prepare for national examinations and any interruptions on the set programs for these two classes may not be easily allowed.

3.7 Sample and Sampling Procedures

A sample is a subgroup of a large population that the researcher plans to study to make generalizations about the target population (Creswell, 2005). Multi-stage sampling was used and in the first stage, the study used stratified random sampling to cluster the schools according to the categories of national, extra-county, county and sub-county schools. Second, the researcher used purposive sampling and selected only extra-county schools to participate in the study because most of them have well-equipped learning facilities and the majority are likely to have computers. Thus, the list of extra-county schools in Uasin-Gishu County served as the sampling frame in appendix v. At the third stage, the chosen schools were further split into the category of single-sex schools which either had computers or not. Lastly, the researcher used random sampling to select four boys' schools and four girls’ schools which formed the sample size. The individual schools as a unit for a sample unit as it was composed of individual learners in a classroom because classes operate as intact groups. Therefore, two schools that is one boys’ school and one girls’ school formed one group of either experimental or control group.

Under the Solomon IV non-equivalent group design, two were experimental and two were controlled. Therefore, there were two treatment groups each having one girls' school and one boys' school and two control groups each constituting one boys' school and also one girls' school. Simple random sampling was used to select the schools into control and experimental groups. All the schools had more than one stream in each class and therefore simple random sampling was also used to select one form two-stream in each school into either an experimental or control group. The number of students in the experimental or control groups varied depending on school enrolment. A total of three hundred and forty-five students took part in the study where one hundred and sixty-seven were in the experimental group, while one hundred and seventy-eight formed the control group. The teachers who teach the selected classes took part in the study because in most schools each stream is taught by a particular teacher and where team teaching is done, different topics are handled by different teachers.

3.8 Research Instruments

This study adopted a mixed methods research (MMR) where both quantitative and qualitative data were collected simultaneously using an experimental approach. This study used two sets of research instruments for data collection; the biology achievement test (BAT) for the pre-test and the post-test administered to participants. The student attitude questionnaires used both closed and open-ended questions and were administered to students during pre-test and post-test periods. Likert scale types of questions were used for ratings because these questions consist of numbers and descriptions, which are used to rate or rank the subjective and intangible components of research (Mugenda & Mugenda, 1999). The numerical scale also helps to minimize subjectivity and makes it possible to use quantitative analysis.

The Biology achievement test (BAT) was used to measure objective four. The biology achievement test comprised items drawn from past KNEC examinations. The instruments were developed by the researcher. The questionnaire had both closed and open-ended questions.

BAT- Pre-test

Data were collected to check whether the participants had similar characteristics in terms of their level of performance before the treatment was administered. Sixteen questions were drawn from KNEC past papers on all form one topics and the first two forms two topics are transport in plants and animals and gaseous exchange in plants and animals. The questions were drawn from biology paper one and paper two and had marks ranging from two to eight. The Biology achievement test had a maximum score of fifty marks. A questionnaire was also administered to ascertain the attitude of students towards Biology. The pre-test was administered to two groups these are experimental group one (group one) and control group one (group two). The questions were on comprehension, application, analysis and synthesis. The table of specifications for the pre-test is given in appendix I

3.9 Pre-test Evaluation of Attitudes and Scores

3.9.1 Pre-test Evaluation of Attitudes

Before participating in the learning activity, the students in experimental group one and control group two took a pre-test to evaluate their attitudes towards biology. The results of independent t-tests in Table 3.1 demonstrated that there was no significant level of difference in the pre-test attitudes of the two groups ($t = -0.820$, $p > 0.05$), indicating that the prior attitudes towards biology for the two groups were equivalent before the learning activity. The mean values and standard deviations of the pre-test scores were 2.9591 and 0.25037 for the control group, and 2.9236 and 0.31799 for the experimental group. In addition, the analysis of the homogeneity of the within-class regression coefficient with $F = 3.574$ ($p > 0.05$), implied that the homogeneity test was not met.

Consequently, it is concluded that the two groups had equivalent prior attitudes before the experiment.

Table 3.1: Group Differences in Pre-Test Attitudes

Group	n	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
One(Experimental)	91	2.9236	.02625	.25037	-.12100	.04996
Two(Control)	82	2.9591	.03512	.31799	-.12213	.05109

Levene's test for equality in variances		F = 3.574	p-value = 0.060
Equal variances assumed		Equal variances not assumed	
Degrees of freedom = 171		Degrees of freedom = 153.626	
t = -.820	p = .413	t = -.810	p = .419

3.9.2 Pre-test Evaluation of Attitudes

Before participating in the learning activity, the students in experimental group one and control group two took a pre-test for evaluating their basic knowledge about content in form one and two concepts other than the topic of respiration. The results of independent t-tests in Table 3.2 demonstrated that there was no significant level of difference in the pre-test attitudes of the two groups ($t = -1.463$, $p > 0.05$), indicating that the prior Biology score in Biology for the two groups was equivalent before the learning activity. The means and standard deviations of the pre-test scores were 18.50 and 4.33 for the experimental group, and 19.50 and 4.54 for the control group. In addition, the analysis of the homogeneity of the within-class regression coefficient with $F = 1.035$ ($p > 0.05$), implied that the homogeneity test was not met. Consequently, it is concluded that the two groups had equivalent prior scores before the experiment.

Table 3.2: Group Differences in Pre-Test Score

Group	n	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
One(Experimental)	88	18.5000	.46226	4.33643	-2.36443	.35177
Two(Control)	79	19.5063	.51175	4.54852	-2.36819	.35553

Levene's test for equality in variances		F = 1.035	p-value = .311
Equal variances assumed		Equal variances not assumed	
Degrees of freedom = 165		Degrees of freedom = 161.074	
t = -1.463	p = .145	t = -1.459	p = .146

3.10 Validity and Reliability of Research Instruments

3.10.1 Pilot Study

A pilot or a feasibility study test logistics and gathers information before a larger study to improve the quality and efficiency of the questionnaire. A pilot study can reveal deficiencies in the design of a proposed experiment or procedure. These can then be addressed before time and resources are expended on large-scale studies (Lancaster, Dodd & Williamson, 2004).

The researcher identified an extra-county school in Elgeyo-Marakwet County for piloting. The school had similar characteristics as the sampled schools. A pre-test was administered to the students then computer-based collaborative concept mapping was introduced to them followed by a post-test.

3.10.2 Validity of Research Instrument

Validity addresses the critical issue of the relationship between a concept and its measurement (Depoy & Gitlin, 2011), the issue of the authenticity of the cause-and-effect relationships (internal validity), and the generalizability of the results to the external environment (external validity) (Sekaran & Bougie, 2010). Validity tests are grouped under three broad headings; content validity, criterion-related validity, and construct validity. The validation of a scale is an ongoing process with each form (content, criterion, and construct) building on the other and occurring progressively or sequentially (Depoy & Gitlin, 2011).

Face validity determines that the measure appears to be assessing the intended construct under study. Although it is not a very scientific type of validity, it may be an essential component in enlisting the motivation of respondents. Content validity is the extent to which a measure assesses the construct of interest. Like face validity, content validity is not usually assessed quantitatively. Instead, it is assessed by carefully checking the measurement method against the conceptual definition of the construct. Content validity is obtained through the specification of the domain of the concept through a literature search and; the construction of indicators from past studies and the submission of the constructed items or draft for review by a panel of experts (Depoy & Gitlin, 2011).

Criterion validity is the extent to which people's scores on a measure are correlated with other variables (known as criteria) that one would expect them to be correlated with. When the criterion is measured at the same time as the construct, criterion validity is referred to as concurrent validity; however, when the criterion is measured in the future (after the construct has been measured), it is referred to as predictive validity (because scores on the measure have "predicted" a future outcome). Criteria can also include other new measures positively correlated with existing measures of the same constructs. Convergent validity occurs when measures of constructs that are expected to correlate do so.

Construct validity occurs when the theoretical constructs of cause and effect accurately represent the real-world situations they are intended to model. This is related to how well the experiment is operationalized. A good experiment turns the theoretical constructs into actual things you can measure. Construct validity is thus an assessment of the quality of an instrument or experimental design.

Guidance was sought from the university supervisors to form the face and content validity for the questionnaire. For the BAT, content validity was enhanced by making references from recommended form two textbooks and drawing questions from KNEC past papers. Reference was also made to the laid down objectives in the secondary school biology syllabus for the topics under study. Biology KNEC examiners were also consulted to assess the relevance of the test. Construct validity ensured that the question items measure the construct it purports to measure in both the BAT and the questionnaire. BAT was expected to meet the criterion-related validity because the questions are drawn from KNEC past papers which are standard examinations. The BAT and the questionnaire items were constructed in a way that they assess what they intended to assess to motivate the teachers and the students who took part in the study. The schools were randomly assigned to experimental and control groups to obtain high control of internal and external validity.

3.10.3 Reliability of the Research Instrument

Reliability is an indication of the stability and consistency with which the instrument measures the concept and helps to assess the goodness of a measure (Sekaran & Bougie, 2010). Reliability is a measure of the degree to which a research instrument yields consistent results after repeated trials (Mugenda and Mugenda,1999). Cronbach's alpha reliability index was determined for both pre-test and post-test questionnaires. A reliability coefficient of 0.9 for the pre-test and 0.8 for the post-test was obtained as shown in table 3.3 and 3.4 respectively.

Table 3.3: Reliability Coefficients for the Pre-test Attitudes

	Total Correlation	Cronbach's Alpha if Item is Deleted
Biology is interesting	0.6584	0.9079
Biology is not interesting	0.6914	0.9068
Always under strain in biology class	0.5299	0.9105
Biology is fascinating and fun	0.5220	0.9106
Biology makes me feel secure and stimulated	0.3728	0.9143
Biology makes me feel uncomfortable, restless and impatient	0.5916	0.9089
I have positive feelings towards biology	0.7728	0.9050
I have negative feelings towards biology	0.7019	0.9066
Biology feels me with enthusiasm	0.1424	0.9198
Biology gives me a feeling of dislike	0.6296	0.9082
I approach biology with hesitation	0.2586	0.9171
I like biology	0.6773	0.9068
I don’t like biology at all	0.6211	0.9082
Always enjoyed studying biology	0.6535	0.9073
Given a chance, i would drop biology	0.6439	0.9075
Makes me nervous to think about doing a biology experiment	0.3371	0.9155
Always look forward to biology experiments	0.6942	0.9064
Feels at ease with biology i like it very much	0.5495	0.9099
Feel a definite positive reaction to biology it is enjoyable	0.7119	0.9060
Biology is awful i hate it	0.6724	0.9073
Average		0.9138

Table 3.3 shows the statistical values for Cronbach's Alpha coefficient which ranged above 0.90 and were above the threshold of 0.7, indicating that the study instrument had an acceptable level of measurement and scale.

Table 3.4: Reliability Coefficients for the Post-test Attitudes

	Total Correlation	Cronbach's α if Item Deleted
Biology maps construction is interesting	0.3858	0.8304
Concept maps are a waste of time	0.3173	0.8330
Concept maps have helped me understand biology more than before	0.3766	0.8306
Concept maps make me confused	0.3356	0.8323
Concept maps have made me like biology	0.6032	0.8192
Concept maps have made me dislike biology	0.3041	0.8334
Concept maps have made me creative	0.3613	0.8314
I Prefer concept maps to assignments	0.2792	0.8378
Rather do biology revision than construct concept maps	0.4287	0.8285
Concept maps construction helps in the demonstration of what learnt	0.3479	0.8317
Concept maps don't make sense	0.5438	0.8238
Concept maps have made me learn more easier	0.6374	0.8198
Concept maps have made me enjoy biology	0.5401	0.8227
Concept maps construction makes me nervous and irritable	0.4943	0.8253
Construct maps help me remember what was taught	0.4503	0.8274
Prefer reading biology to concept maps	0.3107	0.8355
Always looking forward to biology lessons after the concept maps introduction	0.4433	0.8274
Concept maps have made biology unpleasant	0.3871	0.8300
Concept maps construction with peers makes biology fascinating	0.3900	0.8300
Concept maps have helped me develop a positive feeling toward biology	0.4602	0.8281
Average		0.8361

Table 3.4 shows the statistical values for Cronbach's Alpha coefficient which ranged above 0.80 and were above the threshold of 0.7, indicating that the study instrument had an acceptable level of measurement and scale.

3.11 Data collection procedures

The researcher applied for a research permit from the National Commission on Science, Technology and Innovation (NACOSTI) courtesy of the Department of Curriculum Instruction and Educational Media in the School of Education at Moi University before embarking on the field. After receiving the permit, the researcher sought permission from the county commissioner, and the county director of education in Uasin-Gishu County before visiting the selected schools. The letter of permission from the county director of education was presented to the principals of the schools where data was collected so that the researcher could be permitted to carry out the research. In the experimental schools, the researcher trained the biology teachers on the construction and use of concept maps. These teachers acted as research assistants and they would in turn train their students on the construction and use of computer-based concept maps.

There were four treatment groups in four different schools, two boys' schools and two girls' schools. A research assistant was trained in each school bringing the number of research assistants to four. It was not possible to bring together all four research assistants for training therefore the research assistants were trained separately in their schools. The training took four days, one day for each research assistant. The training was done in the school computer laboratory because that is where the students were going to be taught. The training began with an introduction to concept mapping where the researcher explained to the research assistants what concept maps are.

During the introduction, the researcher showed two examples of concept maps drawn on paper and explained the vocabulary associated with the concept maps. The first concept map gave a general overview of what is contained in a concept map. For example, the concepts, nodes, and cross-links were identified on the map. In addition, the researcher highlighted the hierarchical structure of the concept map. The second map was on cell structure and function and concepts, nodes, and cross-links were identified on the map. This was followed by the installation of CMapTools software into one computer in the computer laboratory. The research assistants were then shown how to create and link concepts in a hierarchical order following the list of steps shown in appendix VI. Several concept maps were constructed in various biology topics and each time concepts, nodes, and cross-links were identified on the map. By the end of the day, the research assistants felt confident enough to undertake the study and guide the students using the same maps and the same guidelines in appendix VI. The research assistants were left with an expert concept map on the topic of respiration (Appendix VII) and a scoring rubric (Appendix VIII) which was to be used to correct learners' concept maps and to give feedback during the actual treatment period.

Training of students was done a day after the pre-test and it took five days one hour each day. Day one was the introduction to concept mapping where the research assistant explained to the students what concept maps are and showed them a generalized map showing the components of a concept map. This was the same concept map that was used to train the research assistants. Concepts, nodes, and cross-links were identified on the map. A projector was used so that the whole class could see the map and its components on the whiteboard. The class was then divided into groups of four or five students depending on the number of computers available and the class size.

Each group was then given a guide showing the steps followed when constructing a concept map and each step was clarified.

During the second day, learners worked in their groups. Some of them did not know how to use a computer and the research assistant showed them how to hold a mouse, double click to create a box, drag and drop, link one box to another using an arrow, delete, cut, copy and paste. To make it easy for learners to proceed more easily, a student who was computer literate was placed in each group to help the other members of the group in case of any difficulty.

During the third day, the students practised the construction of maps on cell structures. The research assistant went around the groups checking what the students were constructing and also ensuring that each student was participating in the exercise. Feedback was given and the expected concept map was projected on the board.

On the fourth day, the students constructed maps of the functions of cell structures. Again learners' work was checked and feedback was given at the end of the lesson on the expected concept map.

On the fifth day, learners constructed a generalized concept map of cell structure and function. This was done by bringing together the maps drawn on days three and four. Learners were given feedback on the expected concept map and that marked the end of the training session. The topic of cell structure and function was chosen for training because it has concepts that are linked to the topic of respiration which the learners were going to be taught and expected to construct concept maps during the actual treatment period

Three days after completion of the training, both the experimental and the control groups began the topic on respiration. Both groups were taught using the methods agreed which were lecture, teacher demonstration, laboratory experiments and question and answer. The topic was broken into six sub-topics which were the definition and significance of respiration, types of respiration, phases of aerobic respiration, oxygen debt, the economic importance of anaerobic respiration and respiratory quotient (RQ) and its significance.

After each sub-topic, learners in the control group would answer questions from a textbook while those in the experimental groups would construct a concept map. In the control groups, the teachers would either mark or correct the assignments or the students would discuss the answers in groups and each group would present answers to a particular question to the class. Any corrections would be made in class by the teacher.

The students in the experimental group constructed concept maps based on what they had understood about each sub-topic. The maps would be scored by the research assistants using the scoring rubric provided by the researcher. To make scoring easier, each group printed a hard copy of their map and the research assistant would score them manually. Correction and feedback would be given to the class before the next sub-topic was taught. This continued throughout the treatment period which took four weeks. From the maps constructed by the students, the teacher would be able to find out what the students had understood or the misconceptions they may have had. One day after the end of the study period, both the experimental and control groups took a post-test. The post-test was administered by the researcher.

3.12 Data scoring procedures

Questionnaires had a Likert scale with five options (Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D), and Strongly Disagree (SD) used to score the questionnaire items. The items on the questionnaire were positively and negatively worded to minimize participant-satisfying responses. Positively worded items (e.g. "Students are more enthusiastic about the subjects for whom they use concept mapping") were scored as follows:

Table 3.5: Scores for the Likert scale

Response Intensity	Symbol	Score
Strongly Agree	SA	5
Agree	A	4
Neutral	N	3
Disagree	D	2
Strongly Disagree	SD	1

Negatively worded items (Concept mapping hinder students’ ability with learning tasks”) were scored as follows:

The Likert scale was used to score the questionnaire items because it looks interesting to respondents and people often enjoy completing a scale of this type (Muijs, 2004). Again, the Likert scale is easier to construct, and interpret and also provides the opportunity to compute frequencies and percentages as well as statistics such as the mean and standard deviation of scores. This, in turn, allows for a more sophisticated statistical analysis such as Analysis of Variance (ANOVA), T-test and MANOVA.

Variable scores were obtained by averaging the numeric values of the responses for the related items on the variable. A mean score near 5 was considered a very high level of support, therefore 4 and 5 were considered very high-level support. A score between 1 and 2 was regarded as a low level of support. A mean score of 3.0 represents a neutral or ambivalent position. This value representing a neutral position was used in this study to indicate a position in that respondents neither agree nor disagree with a statement. A mean value below 3.0 gives a general picture of disagreement while a mean value above 3.0 gives a general picture of agreement with a statement.

However, it must be noted that a mean value above or below 3 does not imply that all respondents agreed or disagreed with a statement, but the majority were. Agreement or disagreement to a statement was therefore considered on a majority basis. The percentages of the participant's responses to the Likert scale items were also used to indicate the extent to which participants agreed or disagreed with the items. The percentage responses on a five-point Likert scale were presented in a frequency distribution table (Table 4.3 and 4.5)

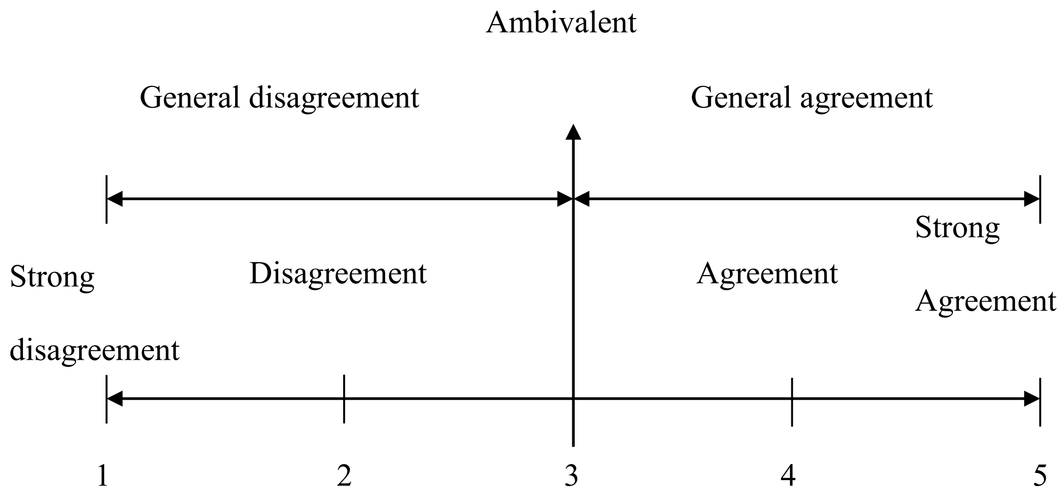


Figure 3.2: Categories of student responses

Since the responses on the Likert scale were further grouped under three categories of general disagreement, neutral/ambivalent and general agreement, the responses were then presented on a chi-square contingency table (Table 4.4 and 4.6).

The test items on the biology achievement test were marked by the researcher alone to ensure uniformity. The scores for each group were recorded on a separate sheet indicating whether it was an experimental or control group. The results were then analysed using both descriptive and inferential statistics.

Measuring the quality of concept maps generated by the students was not one of the objectives of this study. However, to guide students to construct correct concept maps and gain meaningful knowledge from them, their concept maps were scored during the treatment period. Generally speaking, there are three major approaches (Ruiz-Primo & Schavelson, 1996) for the scoring of concept mapping in science. The first one is scoring a student's map component, like concepts, propositions, hierarchy, cross-links and examples in Novak and Gowin (1984) scheme. The second approach is using a criterion map and comparing students' maps with the criterion map which in this case is the expert concept map. The third approach combines both the component of a generated map and a criterion map. This study combined the first and the second approaches. Scoring as per the first approach was done according to the scoring system in table 3.6. Scoring as per the second approach compared the student-generated concept map with the expert concept map shown in Appendix IX.

Table 3.6: Scoring System for Student-generated Concept Maps

Component	Description	Score
Concept	The logic of each concept	2-points for a logical concept 0-point for a non-logical concept
Relationship among concepts	The rationale of the links	1-point for a correct relationship 0-point for the wrong relationship
Arrows	The correct labelling of arrows	1-point for the correct arrow 0-point for the wrong arrow
Linking phrase	The accuracy of linking phrases	1-point for a correct linking phrase 0-point for a wrong linking phrase

3.12 Data Analysis Procedures

Data analysis is the categorization, manipulation and summarization of data to answer the study objectives. The qualitative data obtained from the discourse analysis of concept mapping and open-ended questions in the questionnaires was sorted out and organized. Some excerpts giving the students' and teachers' opinions and feelings towards concept mapping were presented in summaries. The quantitative data from the biology test and the closed-ended questions from the questionnaires were coded and entered into the computer for analysis using SPSS before being analysed using both descriptive and inferential statistics.

Descriptive statistics enable the researcher to meaningfully describe a distribution of measurement (Mugenda & Mugenda, 1999). The descriptive analysis involved the use of frequency tables, pie charts, means and standard deviations were used to summarise raw data into information. Inferential statistics took the form of a t-test, analysis of variance(ANOVA) and multivariate analysis of variance(MANOVA) which were used to test the hypotheses at α=0.05 level of significance. T-test was used to compare the pre-test mean scores for the two groups to find out whether there was any significant difference. ANOVA was used to compare the means of post-test for all four groups. This statistical technique is used to compare the means of more than two groups and to show the variation that may exist within the sample or between the samples.

ANOVA was used to determine whether the difference in the means of the groups is significant at α=0.05. MANOVA was used to determine the impact of the extraneous variables on the dependent variable.

Table 3.7: Measurement level and Statistical Tools

OBJECTIVE	SCALE	DATA/TOOL	STATISTIC
1. T To evaluate the gender differences in students' attitudes towards Biology between control and experimental groups.	Ratio	Quantitative (BAT)	t-test ANOVA MANOVA
2. To determine the effect of CBCCM on the students' attitudes towards Biology.	Interval	Quantitative and qualitative (SAQ)	t-test
3. To examine the gender differences in students' academic achievement in Biology between control and experimental groups.	Interval	Quantitative and qualitative (SAQ)	t-test
4. To compare the effect of computer-based collaborative concept mapping and conventional methods on students' academic achievement in Biology.	Interval	Quantitative (BAT)	t-test ANOVA MANOVA

3.13 Ethical considerations

Ethics are norms or standards that distinguish between right and wrong. There are seven ethical considerations in research. These are plagiarism, fabrication and falsification, non-publication of data, faulty data-gathering procedures, poor data storage and retention, misleading authorship and sneaky publication practices. Five ethical issues were observed in this research study. Plagiarism was avoided by acknowledging all sources of information. There was no fabrication or falsification in this research study. Data collection and analysis were presented as obtained without changing anything to suit this research study. Faulty data gathering was avoided by conducting proper training of research assistants. Research tools were piloted to ensure their reliability and validity in collecting the intended data. Hard copies of data collected from questionnaires and tests have been properly stored in a file for reference or verification whenever required. The research was carried out after the research permit and necessary approval had been granted.

3.14 Summary

This chapter has outlined the philosophical underpinning of the research which is pragmatism and the research design which is quasi-experimental involving Solomon IV non-equivalent control group design. Sample and sampling procedures have been described showing how students were placed into experimental and control groups. In this case, multi-stage sampling and simple random sampling were used. The research instruments used which are the Biology achievement test (BAT) and student attitude questionnaire (SAQ) have been stated and described. The nature of the treatment (use of computer-based collaborative concept mapping) and how it was administered have been discussed. The procedure for data collection and analysis has also been discussed but the actual data presentation analysis and interpretation were done in chapter four.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.1 Introduction

The chapter presents information concerning the nature of the study and participants which include the study area, and the demographic characteristics of the statistics relating to the study. It also presents the objectives of the study and explains how each objective was achieved and the results obtained in each case. Descriptive statistics were used to summarize the results obtained under each objective. Results on inferential statistics used to test the null hypotheses are also presented.

4.1.1 Traditional teaching technique

The traditional methods described here are textbook assignments. The groups under study were taught using similar methods which comprised both traditional and modern methods. These were lectures, teacher demonstrations, laboratory experiments, question-and-answer methods and group discussions. Lectures and teacher demonstrations are expository while laboratory experiments, question and answer and group discussion are heuristics in nature. After being taught the experimental group would construct computer-based concept maps while the control group would answer textbook assignments.

After each sub-topic, learners in the control group would answer questions from a textbook. In the control groups, the teachers would either mark or correct the assignments or the students would discuss the answers in groups and each group would present answers to a particular question to the class. Any corrections would be made in class by the teacher. This continued throughout the time when the topic of respiration was being taught.

In a traditional classroom, students consider what they have learned by responding to the following prompt at the end of the lesson: things they learned from the lesson; things they want to know more about; and questions they have. The prompt stimulates student reflection on the lesson and helps to process the learning.

4.1.2 Concept mapping technique

Concept mapping is the process of organizing concepts and relationships between them hierarchically from more inclusive concepts to more specific, less inclusive concepts (Novak & Gowin, 1984). Concept mapping is used to develop logical thinking and study skills by revealing connections and helping students see how individual ideas form a larger whole. It organizes knowledge in an understandable visual way and connects prior knowledge with new concepts by utilizing a visual structure for planning and thinking (Christodoulou, 2010). Christodoulou further argues that the human mind can organize knowledge in an orderly fashion.

Knowledge is organized upon an existing framework or the learner's prior knowledge. When new ideas are presented to a learner, a framework of prior knowledge is constructed for the new ideas to attach to. The concept map is a relatively new way to visualize complex subject matter. Novak discovered that representing thoughts visually often helped students to effectively associate ideas without being inconvenienced by writing them down in lengthy formats. His students, Novak found, could represent newly learned information by first defining a concept, adding related topics, and linking similar ideas. Such an arrangement helped to organize research information and formulate educational theses.

Concept mapping replaces the traditional textbook assignments which dominate our educational systems; and provides a conduit for better learning, wider discussions, and more positive advancements within those environments. Teachers use concept maps to better assess knowledge gained by their students. Traditional testing, such as with essays, multiple-choice, and fill-in-the-blank questions, is a valuable way to test students but it has served to promote memorization of content. One of the powerful uses of concept maps is not only as a learning tool but also as an evaluation tool, thus encouraging students to use meaningful-mode learning patterns (Mintzes *et al.,* 2000; Novak, 1990; Novak & Gowin, 1984). Concept maps are also effective in identifying both valid and invalid ideas held by students. Computer-based concept maps were constructed using the CMapTools software.

4.2 Respondent’s Socio-Demographic Characteristics

The research instrument required that the researcher indicates the social and demographic characteristics of the study participants and these characteristics are listed in Table 4.1.

Table 4.1: Socio-Demographic Characteristics

Variable	Categories	N	%
Gender	Male (Boys)	163	47.2
	Female (Girls)	182	52.8
	Total	**345**	**100.0**
Test grouping	Control	178	51.6
	Experimental	167	48.4
	Total	**345**	**100.0**
Student group	One	91	26.38
	Two	82	23.8
	Three	78	22.6
	Four	94	27.2
	Total	**345**	**100.0**
Test	Pre-test	173	50.1
	Post-test	345	100.0

Source: Field Data (2018)

The distribution in Table 4.1 shows that a total of 345 students participated in the study. One hundred and sixty-seven(167) students participated in the experiment while the remaining 178 formed the control group. The study comprised four groups, two experimental groups and two control groups.

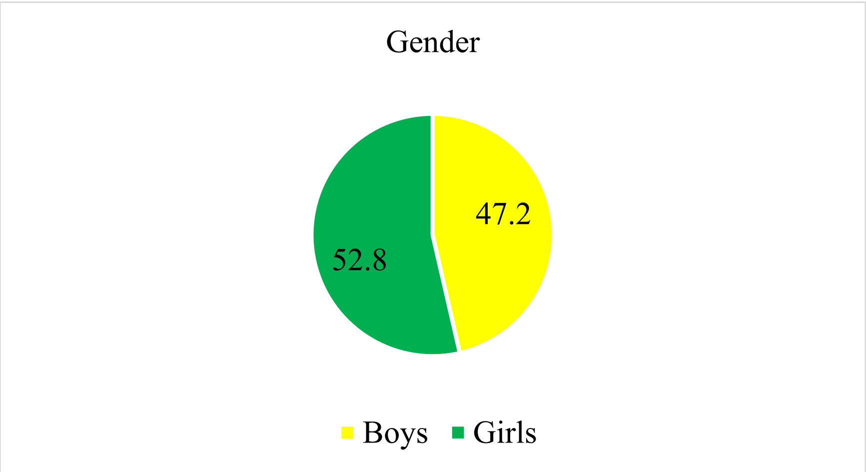


Figure 4.1: Sex of the students

Figure 4.1 shows the percentage of students who participated in the study with girls outnumbering boys by more than 5%.

4.2.1 Testing for Normality

Before carrying out any further analysis, the study tested the characteristics of a normal distribution from the sample. The test that data was drawn from a normally distributed population was based on the Shapiro-Wilk Test and graphical analysis. When the Shapiro-Wilk Test is applied, the rejection of the null hypothesis as shown by insignificant p-values(p>0.05) indicates the data drawn from a normally distributed population cannot be rejected.

Table 4.2 Shapiro Wilk test

Variable	Obs	W	V	z	Prob>z
CBCCMS	167	0.99664	0.393	-2.115	0.98280

The statistics from Table 4.2 which tested for any departure in normality indicated that all the W values were significantly closer to 1 and the test of significance of the W having p-values > 0.05. The indications are that data was drawn from a normally distributed population and this allows the study findings to be generalized over large populations.

The second test for normality was carried out through the analysis of normality probability distribution plots (Figure 4.1) which compared the cumulative distribution of actual data values for the study with the cumulative distribution of normally distributed data. Usually, the normally distributed data forms a straight diagonal line and a comparison is made between the plotted data values with the diagonal. The decision criterion is that the line representing the actual data distribution must closely follow the diagonal line of the normally distributed data (Hair *et al.,* 2010).

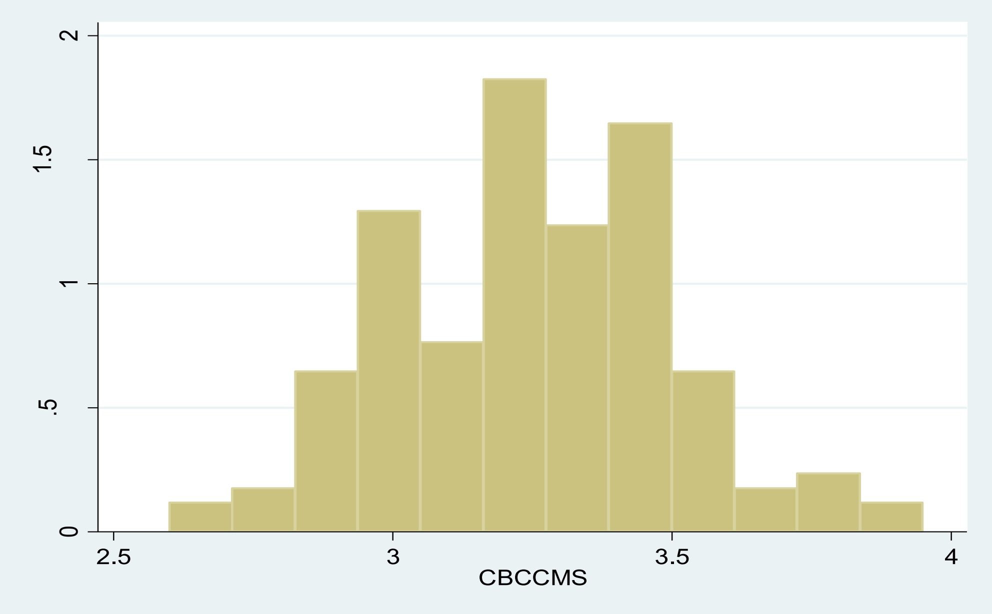


Figure 4.2: Histogram plot on CBCCM Indicators

Figure 4.2 shows that the histogram is bell-shaped hence it can be inferred that the sample was drawn from a normally distributed population.

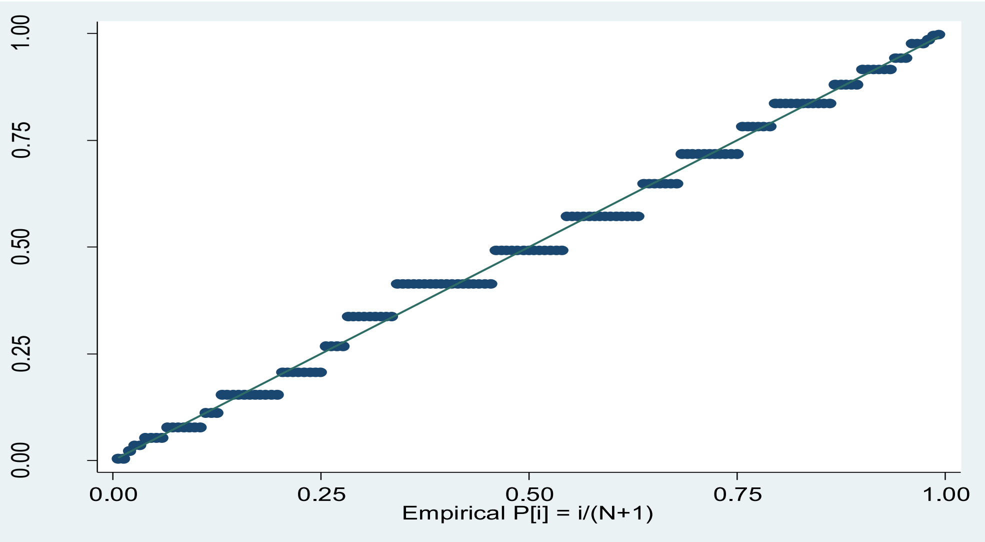


Figure 4.3: Normal probability plot on CBCCM indicators

As shown in figure 4.3, the data appear to portray a normal distribution since the data points for the study variables were closely shadowing the straight diagonal line of the normal distribution. The tests carried out for normality indicated that the sample is normally distributed hence parametric tests were used to test the hypotheses at a 0.05 level of significance.

4.3 Descriptive Statistics

Before embarking on the study, the researcher investigated the attitude of students towards Biology as a subject in secondary schools. This was achieved through the administration of questionnaires to groups one (experimental) and two (control) which had both closed and open-ended questions. The closed-ended questions were rated on a Likert scale.

4.3.1 Descriptive statistics on attitudes of students towards Biology

The study examined the attitudes about Biology and the responses from student questionnaires were summarized using frequency distribution tables and chi-square contingency tables

Table 4.3: Pre- Experimental Attitudes towards Biology

Variable		SD	D	UN	A	SA	Tot.	Mean	SD
Biology is interesting	F	8	5	5	51	109	178	4.393	1.004
	%	4.5	2.8	2.8	28.7	61.2	100.0		
Biology is not interesting	F	111	41	9	13	4	178	1.640	1.022
	%	62.4	23.0	5.1	7.3	2.2	100.0		
Always under strain in biology class	F	77	58	10	20	13	178	2.067	1.265
	%	43.3	32.6	5.6	11.2	7.3	100.0		
Biology is fascinating and fun	F	15	19	8	64	72	178	3.893	1.278
	%	8.4	10.7	4.5	36.0	40.4	100.0		
Biology makes me feel secured and stimulated	F	22	16	23	70	47	178	3.584	1.305
	%	12.4	9.0	12.9	39.3	26.4	100.0		
Biology makes me feel uncomfortable, restless and impatient	F	123	34	9	8	4	178	1.517	0.946
	%	69.1	19.1	5.1	4.5	2.2	100.0		
Good feelings towards biology	F	5	11	10	47	105	178	4.325	1.023
	%	2.8	6.2	5.6	26.4	59.0	100.0		
Bad feelings towards biology	F	120	39	4	9	6	178	1.551	1.003
	%	67.4	21.9	2.2	5.1	3.4	100.0		
Biology feels me with enthusiasm	F	26	31	38	50	33	178	3.185	1.325
	%	14.6	17.4	21.3	28.1	18.5	100.0		
Biology gives me a feeling of dislike	F	98	55	8	12	5	178	1.713	1.021
	%	55.1	30.9	4.5	6.7	2.8	100.0		
I approach biology with hesitation	F	58	44	27	33	16	178	2.466	1.349
	%	32.6	24.7	15.2	18.5	9.0	100.0		
I really like biology	F	13	8	8	45	104	178	4.230	1.192
	%	7.3	4.5	4.5	25.3	58.4	100.0		
I don’t like biology at all	F	126	31	6	7	8	178	1.539	1.047
	%	70.8	17.4	3.4	3.9	4.5	100.0		
Always enjoyed studying biology	F	12	14	9	54	89	178	4.090	1.213
	%	6.7	7.9	5.1	30.3	50.0	100.0		
Given a chance, I would drop biology	F	99	36	13	10	20	178	1.966	1.369
	%	55.6	20.2	7.3	5.6	11.2	100.0		
Makes me nervous to think about doing a biology experiment	F	67	50	17	24	20	178	2.326	1.388
	%	37.6	28.1	9.6	13.5	11.2	100.0		
Always look forward to biology experiments	F	18	9	12	62	77	178	3.961	1.273
	%	10.1	5.1	6.7	34.8	43.3	100.0		
Feels at ease with biology I like it very much	F	18	10	6	56	88	178	4.045	1.2924
	%	10.1	5.6	3.4	31.5	49.4	100.0		
Have a positive reaction to biology its enjoyable	F	14	12	8	52	92	178	4.101	1.2401
	%	7.9	6.7	4.5	29.2	51.7	100.0		
Biology is awful I hate it	F	139	19	10	5	5	178	1.416	.93045
	%	78.1	10.7	5.6	2.8	2.8	100.0		

Source: Field Data (2022)

Table 4.3 shows the attitude of students towards Biology which was rated on a Likert scale before the experiment was initiated. The percentages of the participant's responses were used to indicate the extent to which participants agreed or disagreed with the items while a mean value of around 3 does not imply that all respondents agreed or disagreed with a statement. Based on the percentage distribution majority of the students had a positive attitude towards the subject. The positive statements had means of between three and four while the negative statements had means of between one and two. This is an indication that the student's attitude towards Biology before the introduction to CBCCM was generally positive.

4.3.2 Qualitative Analysis of student's attitude

Student's responses to open-ended questions were categorised into themes as follows:

Theme one;

Most of the students liked Biology because it is a career subject. Most of them aspired to become doctors, nurses and dentists. Some wanted to work in food production industries while a small percentage loved Biology because they wanted to become teachers of Biology

Theme two;

Another group of students liked Biology because they found it easy to understand its concepts and score higher marks in examinations compared to Physics and Chemistry

Theme three;

A few students disliked Biology and had varied reasons for their negative attitude towards the subject. Some claimed that they were put off by Biology practical lessons, especially where animal specimens were used for example fish and visceral organs like the intestines because such specimen stink and make them uncomfortable during the lesson. Some did not like Biology because they had performed dismally in examinations. They attributed their dismal performance to too strict marking rules employed by the teachers.

The responses on the Likert scale were further grouped under three categories of general disagreement, neutral/ambivalent and general agreement, and the responses were then presented on a chi-square contingency table

Table 4.4: Gender Differences in Attitudes towards Biology

Variable	Categories	Gender of students		Total	χ^2	p
		Boy	Girl			
Biology is interesting	Disagree	9(75.0%)	3(25.0%)	12(6.7%)	5.455	.065
	Neutral	3(75.0%)	1(25.0%)	4(2.2%)		
	Agree	72(44.4%)	90(55.6%)	162(91.0%)		
	Total	84(47.2%)	94(52.8%)	178(100.0%)		
Biology is not interesting	Disagree	65 (42.5%)	88(57.5%)	153(86.0%)	10.54	.005
	Neutral	5(62.5%)	3(37.5%)	8(4.5%)		
	Agree	14(82.4%)	3(17.6%)	17(9.6%)		
	Total	84(47.2%)	94(52.8%)	178(100.0%)		
Biology is fascinating and fun	Disagree	60(42.6%)	81(57.4%)	141(79.2%)	8.718	.013
	Neutral	19(59.4%)	13(40.6%)	32(18.0%)		
	Agree	5(100.0%)	0(0.0%)	5(2.8%)		
	Total	84(47.2%)	94(52.8%)	178(100.0%)		
Always under strain in biology class	Disagree	20(58.8%)	14(41.2%)	34(19.1%)	2.446	.294
	Neutral	3(37.5%)	5(62.5%)	8(4.5%)		
	Agree	61(44.9%)	75(55.1%)	136(76.4%)		
	Total	84(47.2%)	94(52.8%)	178(100.0%)		
Biology makes me feel secured and stimulated	Disagree	21(55.3%)	17(44.7%)	38(21.3%)	1.351	.509
	Neutral	11(47.8%)	12(52.2%)	23(12.9%)		
	Agree	52(44.4%)	65(55.6%)	117(65.7%)		
	Total	84(47.2%)	94(52.8%)	178(100.0%)		
Biology makes me feel uncomfortable, restless and impatient	Disagree	70(44.6%)	87(55.4%)	157(88.2%)	6.745	.034
	Neutral	4(44.4%)	5(55.6%)	9(5.1%)		
	Agree	10(83.3%)	2(16.7%)	12(6.7%)		
	Total	84(47.2%)	94(52.8%)	178(100.0%)		
Good feelings towards biology	Disagree	12(75.0%)	4(25.0%)	16(9.0%)	8.248	.016
	Neutral	7(70.0%)	3(30.0%)	10(5.6%)		
	Agree	65(42.8%)	87(57.2%)	152(85.4%)		
	Total	84(47.2%)	94(52.8%)	178(100.0%)		
Bad feelings towards biology	Disagree	70(44.0%)	89(56.0%)	159(89.3%)	5.994	.050
	Neutral	3(75.0%)	1(25.0%)	4(2.2%)		
	Agree	11(73.3%)	4(26.7%)	15(8.4%)		
	Total	84(47.2%)	94(52.8%)	178(100.0%)		
Biology feels me with enthusiasm	Disagree	24(42.1%)	33(57.9%)	57(32.2%)	1.887	.389
	Neutral	16(42.1%)	22(57.9%)	38(21.5%)		
	Agree	43(52.4%)	39(47.6%)	82(46.3%)		

	Total	84(47.2%)	94(52.8%)	178(100.0%)		
Biology gives me a feeling of dislike	Disagree	65(42.5%)	88(57.5%)	153(86.0%)	9.691	.008
	Neutral	6(75.0%)	2(25.0%)	8(4.5%)		
	Agree	13(76.5%)	4(23.5%)	17(9.6%)		
	Total	84(47.2%)	94(52.8%)	178(100.0%)		
I approach biology with hesitation	Disagree	41(40.2%)	61(59.8%)	102(57.3%)	8.906	.012
	Neutral	11(40.7%)	16(59.3%)	27(15.2%)		
	Agree	32(65.3%)	17(34.7%)	49(27.5%)		
	Total	84(47.2%)	94(52.8%)	178(100.0%)		
I really like biology	Disagree	15(71.4%)	6()28.6%	21(11.8%)	8.874	.012
	Neutral	6(75.0%)	2(25.0%)	8(4.5%)		
	Agree	63(42.3%)	86(57.7%)	149(83.7%)		
	Total	84(47.2%)	94(52.8%)	178(100.0%)		
I don’t like biology at all	Disagree	69()43.9%	88()56.1%	157(88.2%)	5.689	.058
	Neutral	4(66.7%)	2(33.3%)	6(3.4%)		
	Agree	11(73.3%)	4(26.7%)	15(8.4%)		
	Total	84(47.2%)	94(52.8%)	178(100.0%)		
Always enjoyed studying biology	Disagree	16(61.5%)	10(38.5%)	26(14.6%)	2.964	.227
	Neutral	5(55.6%)	4(44.4%)	9(5.1%)		
	Agree	63(44.1%)	80(55.9%)	143(80.3%)		
	Total	84(47.2%)	94(52.8%)	178(100.0%)		
Given a chance, I would drop biology	Disagree	54(40.0%)	81(60.0%)	135(75.8%)	18.924	.000
	Neutral	5(38.5%)	8(61.5%)	13(7.3%)		
	Agree	25(83.3%)	5(16.7%)	30(16.9%)		
	Total	84(47.2%)	94(52.8%)	178(100.0%)		
Makes me nervous to think about doing a biology experiment	Disagree	57(48.7%)	60(51.3%)	117(65.7%)	.393	.821
	Neutral	8(47.1%)	9(52.9%)	17(9.6%)		
	Agree	19(43.2%)	25(56.8%)	44()24.7%		
	Total	84(47.2%)	94(52.8%)	178(100.0%)		
Always look forward to biology experiments	Disagree	18(66.7%)	9()33.3%	27(15.2%)	4.866	.088
	Neutral	5 (41.7%)	7(58.3%)	12(6.7%)		
	Agree	61(43.9%)	78(56.1%)	139(78.1%)		
	Total	84(47.2%)	94(52.8%)	178(100.0%)		
Feels at ease with biology I like it very much	Disagree	16(61.5%)	10(38.5%)	26(14.6%)	5.618	.060
	Neutral	6(75.0%)	2(25.0%)	8(4.5%)		
	Agree	62(43.1%)	82(56.9%)	144(80.9%)		
	Total	84(47.2%)	94(52.8%)	178(100.0%)		
Feel a definite positive reaction to biology its enjoyable	Disagree	16(61.5%)	10(38.5%)	26(14.6%)	5.618	.060
	Neutral	6(75.0%)	2(25.0%)	8(4.5%)		
	Agree	62(43.1%)	82(56.9%)	144(80.9%)		
	Total	84(47.2%)	94(52.8%)	178(100.0%)		
Biology is awful i hate it	Disagree	69(43.7%)	89(56.3%)	158(88.8%)	7.193	.027
	Neutral	7(70.0%)	3(30.0%)	10(5.6%)		
	Agree	8(80.0%)	2(20.0%)	10(5.6%)		
	Total	84(47.2%)	94(52.8%)	178(100.0%)		

Source: Field Data (2022)

The distribution in Table 4.4 concerns the gender differences in attitudes towards Biology before the experiment. The study used both affirmative and negative statements and the p-values for the χ^2 statistic show that there were no distinct differences in terms of the gender of the participants. In total, three affirmative statements (Biology is fascinating and fun; Good feelings towards biology; I really like biology) had $p < 0.5$ implying that there were differences in attitude based on the sexes of the students. Boys tended to have more positive attitudes than girls in this instance. On the converse, six negated statements(Biology is not interesting; Biology makes me feel uncomfortable, restless and impatient; Biology gives me a feeling of dislike; I approach biology with hesitation; Given a chance I would drop biology; Biology is awful i hate it) had $p < 0.05$ implying that there were statistically significant differences between the sexes of the student. This implication is that the girls were more likely to have negative attitudes toward Biology. In all remaining statements, there were no statistically significant differences ($P > 0.05$) which implies that there were statistically significant differences in the attitude towards Biology.

4.3.3 Descriptive statistics on attitudes of students towards CBCCM

The study examined the attitudes about CBCCM and the responses from student questionnaires were summarized using frequency distribution tables and chi-square contingency tables. This was achieved through teaching the experimental group of students (group one and group three) using CBCCM, followed by the administration of questionnaires. Responses from student questionnaires were summarized using frequency distribution tables and chi-square contingency tables.

Table 4.5: Post- Experimental Attitudes towards CBCCM and Biology

Variable		SD	D	UN	A	SA	Tot.	Mean	SD
Biology maps construction is interesting	F	4	4	5	68	86	167	4.365	0.853
	%	2.4	2.4	3.0	40.7	51.5	100.0		
Concept maps are a waste of time	F	100	45	10	7	5	167	1.634	0.984
	%	59.9	26.9	6.0	4.2	3.0	100.0		
Concept maps have helped me understand biology more than before	F	11	4	13	56	83	167	4.173	1.114
	%	6.6	2.4	7.8	33.5	49.7	100.0		
Concept maps make me confused	F	90	52	11	6	8	167	1.742	1.058
	%	53.9	31.1	6.6	3.6	4.8	100.0		
Concept maps have made me like biology	F	12	12	16	61	66	167	3.940	1.196
	%	7.2	7.2	9.6	36.5	39.5	100.0		
Concept maps have made me dislike biology	F	102	47	7	7	4	167	1.586	0.933
	%	61.1	28.1	4.2	4.2	2.4	100.0		
Concept maps have made me creative	F	12	5	8	58	84	167	4.179	1.137
	%	7.2	3.0	4.8	34.7	50.3	100.0		
I Prefer concept maps to assignments	F	25	12	30	36	64	167	3.610	1.435
	%	15.0	7.2	18.0	21.6	38.3	100.0		
I would rather do biology revision than construct concept maps	F	37	46	41	17	26	167	2.694	1.343
	%	22.2	27.5	24.6	10.2	15.6	100.0		
Concept maps construction helps in the demonstration of what learnt	F	3	4	8	52	100	167	4.449	0.841
	%	1.8	2.4	4.8	31.1	59.9	100.0		
Concept maps don't make sense	F	120	32	6	2	7	167	1.467	0.949
	%	71.9	19.2	3.6	1.2	4.2	100.0		
Concept maps have made me learn more easier	F	5	5	14	51	92	167	4.317	0.964
	%	3.0	3.0	8.4	30.5	55.1	100.0		
Concept maps have made me enjoy biology	F	15	5	14	67	66	167	3.9820	1.189
	%	9.0	3.0	8.4	40.1	39.5	100.0		
Concept maps construction makes me nervous and irritable during Biology lessons	F	81	54	18	6	8	167	1.8383	1.072
	%	48.5	32.3	10.8	3.6	4.8	100.0		
Construct maps help me remember what was taught	F	9	3	9	65	81	167	4.2335	1.024
	%	5.4	1.8	5.4	38.9	48.5	100.0		
Prefer reading biology to concept maps	F	42	36	33	30	26	167	2.773	1.408
	%	25.1	21.6	19.8	18.0	15.6	100.0		
Always looking forward to biology lessons after the concept maps introduction	F	16	6	18	72	55	167	3.862	1.197
	%	9.6	3.6	10.8	43.1	32.9	100.0		
Concept maps have made biology unpleasant	F	101	41	10	10	5	167	1.6647	1.033
	%	60.5	24.6	6.0	6.0	3.0	100.0		
Concept maps construction with peers makes biology fascinating	F	12	4	6	50	95	167	4.269	1.133
	%	7.2	2.4	3.6	29.9	56.9	100.0		
Concept maps have developed a positive feeling toward biology	F	2	2	12	53	98	167	4.455	0.782
	%	1.2	1.2	7.2	31.7	58.7	100.0		

Source: Field Data (2022)

Table 4.5 shows that the students had mixed feelings towards Biology and CBCCM but the majority seemed to have a positive attitude towards the subject. The positive statements had means of between three and four while the negative statements had means of between one and two. This is an indication that the student's attitude towards Biology after introduction to CBCCM was generally positive.

Table 4.5 shows the attitude of students towards Biology and CBCCM which were rated on a Likert scale after the experiment. The percentages of the participant's responses were used to indicate the extent to which participants agreed or disagreed with the items while a mean value of around 3 does not imply that all respondents agreed or disagreed with a statement. Based on the percentage distribution, it can be inferred that the majority of the students had a positive attitude towards biology and CBCCM. The positive statements had means of between three and four while the negative statements had means of between one and two. This is an indication that the student's attitudes towards Biology and CBCCM were generally positive.

4.3.4 Qualitative analysis of students' attitudes towards CBCCM

The students' responses to open-ended questions were placed into themes as follows;

Theme one:

Most students enjoyed using concept mapping because it broke the monotony of everyday talk, chalk and board study. Most of them showed interest and willingness to stay in the computer laboratory longer than they would stay in a classroom. Most of them were willing to forego other activities that were done after classes so that they could construct concept maps.

Theme two:

Most students alluded to the fact that they had enjoyed learning Biology as they constructed concept maps because they did not have to cram lengthy sentences. Some even went ahead to construct concept maps in other topics as a way of revision. Working in groups enhanced class cooperation and helped them acquire knowledge

Theme three:

A small group of students was not fascinated by concept maps, especially at the beginning of the study. Those who were not computer literate were discouraged. They were restless and agitated and did not want to spend any extra time in the computer laboratory. However, after constant reassurance from the researcher and with continued practice, they started enjoying the exercise.

Another small group felt that the construction of concept maps was good but unnecessarily time-consuming and they would rather answer questions from textbooks or past examination papers to help them in quick revision.

These excerpts show that students generally had a positive attitude towards CBCCM. Those who were negative seemed to have encountered some technicalities.

The responses on the Likert scale were further grouped under three categories of general disagreement, neutral/ambivalent and general agreement, and the responses were then presented on a chi-square contingency table.

Table 4.6: Gender Differences in Attitudes towards biology and CBCCM

Variable	Categories	Gender of students		Total	χ^2	p
		Boy	Girl			
Biology maps construction is interesting	Disagree	5(62.5%)	3(37.5%)	8(4.8%)	.867[a]	.648
	Neutral	2(40.0%)	3(60.0%)	5(3.0%)		
	Agree	72(46.8%)	82(53.2%)	154(92.2%)		
	Total	79(47.3%)	88(52.7%)	167(100.0%)		
Concept maps are a waste of time	Disagree	67(46.5%)	77(53.5%)	144(86.2%)	.636[a]	.728
	Neutral	5(45.5%)	6(54.5%)	11(6.6%)		
	Agree	7(58.3%)	5(41.7%)	12(7.2%)		
	Total	79(47.3%)	88(52.7%)	167(100.0%)		
Concept maps have helped me understand biology more than before	Disagree	8(61.5%)	5(38.5%)	13(7.8%)	1.487[a]	.475
	Neutral	7(53.8%)	6(46.2%)	13(7.8%)		
	Agree	64(45.4%)	77(46.2%)	141(84.4%)		
	Total	79(47.3%)	88(52.7%)	167(100.0%)		
Concept maps make me confused	Disagree	64(44.4%)	80(55.6%)	144(86.2%)	3.595[a]	.166
	Neutral	7(70.0%)	3(30.0%)	10(6.0%)		
	Agree	8(61.5%)	5(38.5%)	13(7.8%)		
	Total	79(47.3%)	88(52.7%)	167(100.0%)		
Concept maps have made me like biology	Disagree	10(43.5%)	13(56.5%)	23(13.8%)	1.593[a]	.451
	Neutral	11(61.1%)	7(38.9%)	18(10.8%)		
	Agree	58(46.0%)	68(54.0%)	126(75.4%)		
	Total	79(47.3%)	88(52.7%)	167(100.0%)		
Concept maps have made me dislike biology	Disagree	69(46.6%)	79(53.4%)	148(88.6%)	.334[a]	.846
	Neutral	4(57.1%)	3(42.9%)	7(4.2%)		
	Agree	6(50.0%)	6(50.0%)	12(7.2%)		
	Total	79(47.3%)	88(52.7%)	167(100.0%)		
Concept maps have made me creative	Disagree	7(43.8%)	9(56.3%)	16(9.6%)	1.473[a]	.479
	Neutral	6(66.7%)	3(33.3%)	9(5.4%)		
	Agree	66(46.5%)	76(53.5%)	142(85.0%)		
	Total	79(47.3%)	88(52.7%)	167(100.0%)		
I Prefer concept maps to assignments	Disagree	17(47.2%)	19(52.8%)	36(21.6%)	.426[a]	.808
	Neutral	14(42.4%)	19(57.6%)	33(19.8%)		
	Agree	48(49.0%)	50(51.0%)	98(58.7%)		
	Total	79(47.3%)	88(52.7%)	167(100.0%)		
Rather do biology revision than construct concept maps	Disagree	37(44.0%)	47(56.0%)	84(50.3%)	.827[a]	.661
	Neutral	22(52.4%)	20(47.6%)	42(25.1%)		
	Agree	20(48.8%)	21(51.2%)	41(24.6%)		
	Total	79(47.3%)	88(52.7%)	167(100.0%)		
Concept maps construction helps in the demonstration of what learnt	Disagree	6(66.7%)	3(33.3%)	9(5.4%)	2.344[a]	.310
	Neutral	2(28.6%)	5(71.4%)	7(4.2%)		
	Agree	71(47.0%)	80(53.0%)	151(90.4%)		
	Total	79(47.3%)	88(52.7%)	167(100.0%)		
Concept maps don’t make sense	Disagree	75(49.0%)	78(51.0%)	153(91.6%)	2.748[a]	.253
	Neutral	1(16.7%)	5(83.3%)	6(3.6%)		
	Agree	3(37.5%)	5(62.5%)	8(4.8%)		
	Total	79(47.3%)	88(52.7%)	167(100.0%)		
Concept maps have made learning easier	Disagree	2(22.2%)	7(77.8%)	9(5.4%)	5.575[a]	.062
	Neutral	10(71.4%)	4(28.6%)	14(8.4%)		
	Agree	67(46.5%)	77(53.5%)	144(86.2%)		
	Total	79(47.3%)	88(52.7%)	167(100.0%)		
Concept maps have made me enjoy biology	Disagree	10(55.6%)	8(44.4%)	18(10.8%)	.635[a]	.728
	Neutral	7(50.0%)	7(50.0%)	14(8.4%)		
	Agree	62(45.9%)	73(54.1%)	135(80.8%)		
	Total	79(47.3%)	88(52.7%)	167(100.0%)		

Concept maps construction makes me nervous and irritable	Disagree	62(46.6%)	71(53.4%)	133(79.6%)	.249[a]	.883
	Neutral	11(52.4%)	10(47.6%)	21(12.6%)		
	Agree	6(46.2%)	7(53.8%)	13(7.8%)		
	Total	79(47.3%)	88(52.7%)	167(100.0%)		
Construct maps help me remember what was taught	Disagree	5(50.0%)	5(50.0%)	10(6.0%)	.760[a]	.684
	Neutral	3(33.3%)	6(66.7%)	9(5.4%)		
	Agree	71(48.0%)	77(52.0%)	148(88.6%)		
	Total	79(47.3%)	88(52.7%)	167(100.0%)		
Prefer reading biology to concept maps	Disagree	37(46.8%)	42(53.2%)	79(47.3%)	.967[a]	.617
	Neutral	14(41.2%)	20(58.8%)	34(20.4%)		
	Agree	28(51.9%)	26(48.1%)	54(32.3%)		
	Total	79(47.3%)	88(52.7%)	167(100.0%)		
Always looking forward to biology lessons after the concept maps introduction	Disagree	8(36.4%)	14(63.6%)	22(13.2%)	1.226[a]	.542
	Neutral	9(50.0%)	9(50.0%)	18(10.8%)		
	Agree	62(48.8%)	65(51.2%)	127(76.0%)		
	Total	79(47.3%)	88(52.7%)	167(100.0%)		
Concept maps have made biology unpleasant	Disagree	70(49.0%)	73(51.0%)	143(85.6%)	2.429[a]	.297
	Neutral	2(22.2%)	7(77.8%)	9(5.4%)		
	Agree	7(46.7%)	8(53.3%)	15(9.0%)		
	Total	79(47.3%)	88(52.7%)	167(100.0%)		
Concept maps construction with peers makes biology fascinating	Disagree	11(57.9%)	8(42.1%)	19(11.4%)	4.471[a]	.107
	Neutral	5(83.3%)	1(16.7%)	6(3.6%)		
	Agree	63(44.4%)	79(55.6%)	142(85.0%)		
	Total	79(47.3%)	88(52.7%)	167(100.0%)		
Concept maps have developed a positive feeling toward biology	Disagree	1(25.0%)	3(75.0%)	4(2.4%)	3.408[a]	.182
	Neutral	9(69.2%)	4(30.8%)	13(7.8%)		
	Agree	69(46.0%)	81(54.0%)	150(89.8%)		
	Total	79(47.3%)	88(52.7%)	167(100.0%)		

The distribution in Table 4.6 concerns the gender differences in attitudes towards Biology and CBCCM after the experiment. The study used both affirmative and negative statements and the p-values for the χ^2 statistic show that there were no distinct differences in attitudes towards biology and CBCCM in terms of the gender of the participants.

4.3.5 Descriptive Statistics on Test-score

The biology achievement test (BAT pre-test) was administered to both experimental group one (group one) and control group one (group two) before the start of the study period and another BAT was administered as a post-test to all four groups at the end of the study period.

Table 4.7: Descriptive Statistics on Pre-test Score

Statistics	Control group	Experimental group
	Control group two	Experimental group one
Mean	19.506	18.500
SD	4.54852	4.33643

The statistics in Table 4.7 shows the test scores for Biology before the experiment. There was a slight difference between the test score with the control group having a higher test score.

Table 4.8: Descriptive Statistics on Post-test Score

Statistics	**Control groups**		**Experimental groups**	
	Control group two	Control group four	Experimental group one	Experimental group three
Mean	18.6667	19.9255	18.7595	22.3182
SD	3.47568	3.79371	5.01335	4.52971

The results in table 4.8 show that experimental group three posted the highest mean of 22.3 while the other three groups had a more or less equal mean of between 18.6 and 19.9

4.4 Hypothesis Testing

The statistical hypothesis is an assumption about a population that may or may not be true. Hypothesis testing is a set of formal procedures for testing whether the statistical assumption holds. The study used Solomon Four Non- equivalent design and used the following inferential statistics (t-test, ANOVA and MANOVA) to test the null hypotheses at a 0.05 level of confidence.

4.4.1 Hypothesis One

The null hypothesis was stated as follows: there is no significant gender difference in students' attitudes towards Biology between control and experimental groups. The hypothesis testing took the following; group differences in pre-test and post–attitudes in experimental and control groups using the t-test analysis as illustrated in Tables 4.9, and 4.10.

4.4.1.1 Differences in pre-test attitudes towards Biology

The results of independent t-tests in Table 4.9 demonstrated that there was no significant level of difference in the post-test attitudes of the two groups ($t = 0.105$, $p > 0.05$), indicating that the scores in attitudes for the two groups were equivalent after the experiment. The mean values and standard deviations of the post-test attitudes in experimental groups were 3.2575 and 0.26662 for group one, and 3.2532 and 0.2359 for group three. In addition, the analysis of the homogeneity of the within-class regression coefficient with $F = 0.210$ ($p > 0.05$), implied that the homogeneity test was not met. Consequently, it is concluded that the two groups had equivalent test attitudes after the experiment.

Table 4.9: Group Differences in Pre-Test Attitudes

Group	n	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
One(Experimental)	91	2.9236	.02625	.25037	-.12100	.04996
Two(Control)	82	2.9591	.03512	.31799	-.12213	.05109

Levene's test for equality in variances		F = 3.574	p-value = 0.060
Equal variances assumed		Equal variances not assumed	
Degrees of freedom = 171		Degrees of freedom = 153.626	
t = -.820	p = .413	t = -.810	p = .419

The results of independent t-tests in Table 4.12 demonstrated that there was no significant level of difference in the pre-test attitudes of the two groups ($t = -0.810$, $p > 0.05$), indicating that the scores in attitudes for the two groups were equivalent before the experiment.

4.4.1.2 Differences in post-test Attitudes towards Biology in experimental groups

The results of independent t-tests in Table 4.10 demonstrated that there was no significant level of difference in the post-test attitudes of the two groups ($t = 0.105$, $p > 0.05$), indicating that the scores in attitudes for the two groups were equivalent after the experiment. The mean values and standard deviations of the post-test attitudes in experimental groups were 3.2575 and 0.26662 for group one, and 3.2532 and 0.2359 for group three. In addition, the analysis of the homogeneity of the within-class regression coefficient with $F = 0.210$ ($p > 0.05$), implied that the homogeneity test was not met. Consequently, it is concluded that the two groups had equivalent test attitudes after the experiment.

Table 4.10: Differences in post-test Attitudes towards Biology

Group	n	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
One	73	3.2575	.03121	.26662	-.07652	.08517
Three	78	3.2532	.02672	.23595	-.07687	.08553

Levene's test for equality in variances		F = 0.210	p-value = 0.647
Equal variances assumed		Equal variances not assumed	
Degrees of freedom = 149		Degrees of freedom = 143.925	
t = 0.106	p = 0.916	t = 0.105	p = 0.916

The statistics suggest that the attitudinal component of the two groups before and after being exposed to CBCCM was similar hence no chance of attitudinal effects between the groups influencing the scores. The results show that students maintained a positive attitude towards Biology regardless of the teaching strategy employed.

The statistical results show that there were no significant differences in the post-test attitudes of the two groups (experimental one and control two) indicating that the prior attitudes towards Biology for the two groups were equivalent before the experiment. After the experiment, there was no significant level of difference in the post-test attitudes in the experimental groups indicating that the scores in the Biology test for the two groups were equivalent after the experiment. Further, the findings show that the students held a positive attitude towards concept mapping as illustrated by higher attitudinal scores for the post-test. The attitudinal mean towards Biology and concept mapping improved from 2.9236 in the pre-test to 3.2575 in the post-test.

Based on the results, the study rejected the null hypothesis that there is no significant difference in students' attitudes towards Biology between control and experimental groups and conclude that there were significant differences between experimental and control groups. Based on this finding, the study did not reject the H_{01} and concluded that CBCCM has no significant effect on students' attitudes towards biology.

The findings conform to those of previous studies that indicated that the learner exhibits a certain attitude towards science by reacting according to their understanding rather than to its actual state. As the findings by Chao *et al.,* (2015) indicated that students who had a more positive attitude towards science tended to have higher achievement scores. Students' attitude goes a long way to determining what a student can achieve. A positive attitude is like a mirror that reflects what the student is about to do and therefore energizes the student to accomplish it (Nja *et al.,* 2022).

Extant literature has shown examined this association between interest and attitudes toward science and technology tends to decline during the school years (Sjøberg & Schreiner, 2010). Both Guy, Cornick and Beckford (2015) and Villavicencio and Bernardo (2013 reported that students' affective characteristics significantly influence the student's learning and achievement in science subjects. Sometimes, the student's perception might be weakened or held back by their perception towards the school science (Savelsbergh *et al.,* 2016). However, a significant decline in students' attitudes towards science subjects has been recorded at the point of entry to high school (Potvin & Hasni, 2014).

This drop in interest, motivation and attitudes occurs between elementary and secondary school (Potvin & Hasni, 2014) and as reported by Barmby, Kind and Jones (2008), the variances in secondary students’ attitudes in England indicate that student's attitudes towards science declined as they progressed through secondary school and that the decline was more pronounced in female pupils. Studies have attributed the decline to the basic schooling systems which are not able to preserve the initial strength of students' attitudes toward science and technologies because the current school science may be considered "unattractive" by the students as it does not involve topics of interest or provide students with opportunities for creative expression (Christidou, 2011).

Sometimes the decline relates to structural and infrastructural challenges facing the schools and these include the costs involved, time consumed and inaccurate data sets during the laboratory procedures in the school science centres. Other challenges arise from the practical work in science education which does not help learners develop procedural knowledge (La Velle, McFarlane & Brawn, 2003). It may also mean that the fragmentation of science education into strictly isolated and distinct disciplines presented in contexts may deter the student's interest by failing to provide a coherent picture of the discipline (Christidou, 2011) or that teachers are deficient in teaching skills (Schittek *et al.,* 2001).

4.4.2 Hypothesis Two

The null hypothesis was stated as follows: there is no significant difference in students' academic attitude towards Biology between control and experimental groups. The hypothesis testing took the following; gender differences in pre-test and post–attitudes in experimental and control groups using the t-test analysis as illustrated in Tables 4.11, and 4.12.

4.4.2.1 Gender Differences in Pre-Test Attitudes

The results of independent t-tests in Table 4.11 demonstrated that there were no significant differences in the pre-test attitudes of the two groups ($t = -0.0820$, $p > 0.05$), indicating that the prior attitudes towards biology for the two groups were equivalent before the experiment. The mean values and standard deviations of the pre-test attitudes were 2.9424 and 0.29571 for the male students, and 2.9388 and 0.2756 for the female students. In addition, the analysis of the homogeneity of the within-class regression coefficient with $F = 0.325$ ($p > 0.05$), implied that the homogeneity test was not met. Consequently, it is concluded that the two groups had equivalent attitudes before the learning activity.

Table 4.11: Gender Differences in Pre-Test Attitudes

Group	n	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
Male	79	2.9424	.03327	.29571	-.08228	.08943
Female	94	2.9388	.02843	.27564	-.08284	.09000

Levene’s test for equality in variances		F = 0.325	p-value = 0.570
Equal variances assumed		Equal variances not assumed	
Degrees of freedom = 171		Degrees of freedom = 161.348	
t = 0.082	p = 0.935	t = 0.082	p = 0.935

This indicates that attitudinal components displayed towards biology by both sexes during the pre-test were not different from one another suggesting both girls and boys had more or less similar attitudes, thereby excluding the attitudinal component as a cause of variances in performance.

4.4.2.2 Gender Differences in Post-Test Attitudes

The results of independent t-tests in Table 4.12 demonstrated that there were no significant differences in the post-test attitudes of the two groups ($t = -0.073$, $p > 0.05$), indicating that the post-test attitudes towards biology for the two groups were equivalent after the experiment. The mean values and standard deviations of the pre-test attitudes were 3.2528 and 0.23572 for the male students, and 3.2557 and 0.2522 for the female students. In addition, the analysis of the homogeneity of the within-class regression coefficient with $F = 0.276$ ($p > 0.05$), implied that the homogeneity test was not met. Consequently, it is concluded that the two groups had equivalent post-test attitudes after the learning activity.

Table 4.12: Gender Differences in Post-Test Attitudes

Group	n	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
Male	71	3.2528	.02797	.23572	-.08007	.07434
Female	88	3.2557	.02689	.25228	-.07953	.07380

Levene's test for equality in variances		F = 0.276	p-value = 0.600
Equal variances assumed		Equal variances not assumed	
Degrees of freedom = 157		Degrees of freedom = 153.610	
t = -0.073	p = 0.942	t = -0.074	p = 0.941

This indicates that attitudinal components displayed towards Biology by both sexes during the post-test were not significantly different from one another suggesting that both girls and boys had more or less similar attitudes after the experiment thereby excluding the attitudinal component as a cause of variances in performance between the two genders. However, there was an improvement in the mean from 2.9 in the pre-test to 3.2 in the post-test.

The statistical results show that there were no significant differences in the post-test attitudes of the two groups (male and female) indicating that the prior attitudes towards Biology for the two groups were equivalent before the experiment. After the experiment, there was no significant level of difference in the post-test attitudes in the two groups (male and female) indicating that the scores in the Biology test for the two groups were equivalent after the experiment. Further, the findings show that the students held a positive attitude towards concept mapping as illustrated by higher attitudinal scores for the post-test. The attitudinal mean towards Biology and concept mapping improved from 2.9424 in the pre-test to 3.2528 in the post-test for boys and 2.9388 in the pre-test to 3.2557 in the post-test for girls.

Based on the results, the study rejected the H_{02} that there is no significant difference in students' attitude towards Biology between control and experimental groups and conclude that there were significant differences between experimental and control groups. Several empirical studies have reported the positive effect of computer-supported collaborative learning (CSCL) on students' attitudes and achievement at the university level (Cheng & Chu, 2019; Liu, Chen & Chang, 2010) and the elementary school level (Sung & Hwang, 2013).

Learners' attitude towards the technological medium of instruction is linked with intellectual achievement as well as learners' attitude towards science. The expressive affinity to the technological medium of instruction also explains the attitudinal component of the learner (Nja *et al.,* 2022). The application of concept mapping technologies in learning activities has the potential to inspire students' extrinsic motivation and possibly enhance learning outcomes (Hwang *et al.,* 2014). For instance, Hwang, Wu and Ke (2011) revealed that concept mapping not only enhances learning attitudes but also improves the learning outcomes for the students.

Marcela and Mala (2016) observed that learners' attitudes were an important determinant that predicted academic achievement in science education. Thus, a positive attitude gives rise to positive results while a negative attitude turns out to be a negative result. Learners' attitude towards the technological medium of instruction is linked with intellectual achievement as well as learners' attitude towards science. The expressive affinity to the technological medium of instruction also explains the attitudinal component of the learner (Nja *et al.,* 2022). Attitudes are also relevant to the cognitive domain as the outcomes of attitudes towards learning are critical (Kumari & Saraladevi, 2014).

Active learning brings about a significantly better gain of scientific conceptions. Students who were taught in an active classroom setting developed more positive attitudes toward science lessons when compared with those taught with the traditional method (Nja *et al.,* 2022). Furthermore, an active learning approach enhances the learning achievement of students in science. It also revealed that active learning promoted student motivation which resulted in improved academic performance. This aspect occurs through the experience during the learning process as compared to the passive learning environment (Momani *et al.,* 2016).

Collaborative learning significantly impacts students’ attitudes and achievement by transforming learning activity through peerage (Hong & Lin, 2019; Zhang, Ding & Mazur, 2017) knowledge construction (Ma *et al.,* 2020; Huang *et al.,* 2017) and learner scaffolding through the cooperative learning activity (Alsalhi, Eltahir & Al-Qatawneh, 2019; Demirci, 2017; Sung & Hwang, 2013). The collaborative learning approach supports creative learning activities and enhances students' innovative performance (Wu *et al.,* 2013). Collaborative learning facilitates knowledge gains (Stahl, 2011), and promotes cognitive development (Gu & Cai, 2019) and creativity (DelgadoTéllez & Pérez Raposo, 2011).

The use of technological aids helped increase students' interest in the topic and thus indirectly increase the knowledge base (Herrero & Quiroga, 2020). Educational technology is most effective when it complements classroom interaction (Schneider, 2012). Therefore, it can be argued that the student's academic achievement in the groups where the inquiry-based learning method is employed is much higher than in the groups where the traditional learning method is employed (Aktamiş, Hiğde & Özden, 2016). Strong moderator effects are found for almost all instructional methods, indicating that how a method is implemented in detail strongly affects achievement (Schneider & Preckel, 2017).

The use of interactive mediums such as audio-visual devices and animations with instructional materials results in an enjoyable and productive learning process (Serin, 2011 Morgil *et al.,* 2005). Further, individualized computer-based instruction, games, feedback, interactive quizzes, computer-based labs, simulations and robotics (Savelsbergh *et al.,* 2016), shortened learning and absorption time, and better outcomes in other aspects (Schittek *et al.,* 2001). Teachers foster meaningful learning by visualizing abstract relations between constructs in concept maps (Schneider & Preckel, 2017). Clear learning goals and success criteria are strongly associated with achievement (clarity of course objectives and requirements) (Schneider & Preckel, 2017).

4.4.3 Hypothesis Three

The null hypothesis was stated as follows: there is no significant gender difference in students' academic performance in Biology between control and experimental groups. The hypothesis testing took the following; group differences in pre-test and post–attitudes in experimental and control groups using the t-test analysis as illustrated in Table 4.13, 4.14 and 4.15.

4.4.3.1 Gender Differences in post-test scores in control groups

The results of independent t-tests in Table 4.13 demonstrated that there were no significant levels of difference in the post-test scores of the two groups ($t = -1.591$, $p > 0.05$), indicating that the scores in the biology test for the two groups were equivalent after the experiment. The mean values and standard deviations of the post-test scores were 17.8929 and 6.062 for the male students, and 19.4894 and 7.3173 for the female students. In addition, the analysis of homogeneity of the within-class regression coefficient with $F = 2.626$ ($p < 0.05$), implied that the homogeneity test was not met. Consequently, it is concluded that the two groups had equivalent test scores after the experiment.

Table 4.13: Gender Differences in post-test scores in control groups

Group	n	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
Male	84	17.8929	.66141	6.06196	-3.5979	0.4049
Female	94	19.4894	.75472	7.31730	-3.5771	0.3841

Levene's test for equality in variances		F = 2.626	p-value = 0.107
Equal variances assumed		Equal variances not assumed	
Degrees of freedom = 176		Degrees of freedom = 175.028	
t = -1.574	p = .117	t = -1.591	p = .113

The statistics indicate that there were no significant differences in performance in Biology between the boys and the girls in the control groups two and four. These results indicate that the conventional methods of teaching used did not favour one gender over the other. Based on the Solomon Four non-equivalent group, the test score of these groups should not differ from each other and this validates the effects of the intervention or the method.

4.4.3.2 Gender Differences in post-test scores

The results of independent t-tests in Table 4.14 demonstrated that there were significant differences in the post-test scores of the two groups ($t = -5.114$, $p < 0.05$), indicating that the scores in the biology test for the two groups were non-equivalent after the experiment. The mean values and standard deviations of the post-test scores were 18.712 and 4.323 for the male students, and 21.082 and 4.324 for the female students. In addition, the analysis of the homogeneity of the within-class regression coefficient with $F = 0.148$ ($p > 0.05$), implied that the homogeneity test was not met. Consequently, it is concluded that the two groups had non -equivalent test scores after the experiment.

Table 4.14 Group Differences in post-test scores

Group	n	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
Male	163	18.7117	.33500	4.27702	-3.28321	-1.4583
Female	182	21.0824	.32050	4.32375	-3.28269	-1.4588

Levene's test for equality in variances		F = 0.148	p-value = 0.700
Equal variances assumed		Equal variances not assumed	
Degrees of freedom = 343		Degrees of freedom = 339.619	
t = -5.110	p = 0.000	t = -5.114	p = 0.000

The statistics indicate that there were significant differences in the biology test score between the genders after the experiment. The test score for girls was significantly higher compared to those exhibited by the boys. The findings show that the girls outperformed the boys in both the pre-test and post-test scores. Biology seems to be a favourite science subject of girls irrespective of the teaching strategy employed.

4.4.3.3 Gender Differences in post-test scores in experimental groups

The results of independent t-tests in Table 4.15 demonstrated that there was a significant difference in the post-test scores of the two experimental groups ($t = -3.842$, $p < 0.05$), indicating that the scores in the biology test for the two groups were non-equivalent after the experiment. The mean values and standard deviations of the post-test scores were 17.253 and 5.546 for the male students, and 20.857 and 6.541 for the female students. In addition, the analysis of the homogeneity of the within-class regression coefficient with $F = 4.233$ ($p < 0.05$), implied that the homogeneity test was met. Consequently, it is concluded that the two groups had non -equivalent test scores after the experiment.

Table 4.15: Group Differences in post-test scores in experimental groups

Group	n	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
Male	79	17.2532	.62395	5.54577	-5.45566	-1.7523
Female	91	20.8571	.68573	6.54144	-5.43428	-1.7737

Levene's test for equality in variances		F = 4.233	p-value = 0.041
Equal variances assumed		Equal variances not assumed	
Degrees of freedom = 168		Degrees of freedom = 167.913	
t = -3.842	p = 0.000	t =-3.887	p = 0.000

The statistics indicate that there were significant differences in test scores in Biology between the boys and the girls after the treatment in experimental groups one and three. The statistical results show that there were no significant differences in the post-test scores of the two control groups indicating that the scores in the biology test for the two groups were equivalent after the experiment. Further, there were significant differences in the post-test scores of the two groups (male and female) indicating that the scores in the biology test for the two groups were non-equivalent after the experiment.

Moreso, there was a significant difference in the post-test scores of the two experimental groups (male and female) indicating that the scores in the biology test for the two groups were non-equivalent after the experiment. The overall mean post-test scores for the male (18.7117) and female(21.0824) are significantly different from each other and there were significant differences between the experimental groups with male students having a lower mean score of 17.2532 when compared to the mean score of female students of 20.8571.

Based on the results, the study rejected the null hypothesis that there is no significant gender difference in students' academic performance in Biology between control and experimental groups and conclude that there were significant differences in academic performance between experimental and control groups. Based on this finding, the study rejected the H_{03} and concluded that CBCCM has a significant effect on students' academic performance in biology. The test scores indicate that girls outperformed boys after being exposed to CBCCM.

The differences in the test scores are supported by earlier studies (Namasaka *et al.,* 2009; Adiyah, 2011; Uchenna & Okafor 2012). The empirical literature that supports the differences in the academic scores includes Županec, Miljanović and Pribićević (2013) who reported that the use of computers in teaching biology in school was much more efficient than traditional teaching in terms of quality, durability and applicability of knowledge. Shute & Rahimi (2017) also affirmed the environment or pedagogical context influences the learners with specific cognitive and emotional profiles and tools and thus promotes the acquisition and demonstration of new knowledge and skills. Generally, several studies have reported the positive impact of computer-supported learning on students' achievement in science education (Shute & Rahimi, 2017; Huang, Liu & Chang, 2012; Chang, Sung & Lin, 2006; Serin, 2011; Linden, Banerjee & Duflo,2003; Pilli & Aksu, 2013).

Studies have shown individual differences in the application of learning strategies between male and female students (Ruffing *et al.,* 2015). Ardura and Galán (2019) observed gender effects on academic achievement as girls showed higher levels of achievement in sciences. According to Cheng and Chu (2019), CSCLS helps in knowledge construction and improves both individual and group performance. The effect of computer-supported collaborative learning is explained by the effects of three activities; computer-aided learning, cooperative learning activities and the use of mind tools such as concept mapping.

Empirical evidence shows that gender differences in the attitudes towards science, technology, engineering, and mathematics (STEM) discipline appear at the high school level (Cheryan *et al.,* 2017). The gender gaps in science, technology, engineering, and math (STEM) tend to extend to higher education levels however, the disparities are not equal in all STEM majors (Cimpian, Kim, & McDermott, 2020). For instance, there is a lower representation of women in computer science, engineering, and physics compared with biology, chemistry, and mathematics holds for all racial groups((Cheryan *et al.,* 2017). In the US, the male-to-female ratio among U.S. college majors in biology, chemistry, mathematics, and many other STEM fields is now about 1-to-1 while it is about 4-to-1 in physics, engineering, and computer science (PECS). (Cimpian, Kim, & McDermott, 2020).

Covill and Cook2019) noted that the effect of the CBCCM may be attributable to the student satisfaction with the instructional methodology which may be related to student intrinsic motivation to complete the pre-class work. Jacobse and Harskamp (2012) reported a statistically significant positive high effect on the use of instructional intervention on students' academic achievement in mathematics, while Sugano and Nabua (2020) observed a significant effect of teaching strategies on student achievement in science. The incorporation of active-learning interventions in a variety of science, technology, engineering, and mathematics (STEM) fields increases student grades and decreases the failure rate (Kudish *et al.,* 2016).

The use of technological aids brings more efficient learning than the traditional ways of teaching as it helps students to prepare for the lesson, contributing positively to learning, enhancing retention, increasing success, promoting participation in class activities and being an enjoyable way of teaching/learning (Karadag & Keskin, 2017). It is also beneficial to students as it enhances retention, makes learning easier, promotes regular study habits, improves comprehension skills and helps develop computer skills Theoretical evidence demonstrates the linkages exist between domain-general executive functions and achievement in science education. The contribution of domain-general skills, in particular executive functions, is the set of processes that control and guide an individual's information processing, to achievement (Cragg *et al.,* 2017).

The use of computer-assisted learning techniques has several advantages that include: flexibility and the promotion of active learning, improvements in student motivation and satisfaction and consistency of educational delivery (Bloomfield, Roberts & While, 2010). In technology-assisted classrooms, the techniques based on collaborative work ensure that learners are actively learning (Ayaz & Sekerci, 2015). Small-group collaborative learning is more beneficial when face–to–face interaction occurs when compared to work with technology (Schneider & Preckel, 2017).

On average, small-group learning goes along with higher achievement than individual learning or whole-group learning (Schneider & Preckel, 2017). Small-group learning is more effective when each learner has individual responsibilities within his or her group, and when the learners can only solve the task through cooperation. Making new content more meaningful through explicit association with the student's lives, experiences, and aims, helps students perceive the relevance of the new content, integrate it with prior knowledge in their long-term memory, and memorise it (Schneider, 2012).

Blended learning, that is, a mix of online and classroom learning, is more effective than classroom teaching alone (Schneider & Preckel, 2017). These findings with the following studies (Hwang, Wu and Ke, 2011; Amadieu *et al.,* 2010; Cañas *et al.,* 2012; Hwang *et al.,* 2014; Barchok & Too, 2013; Hwang, Shi & Chu, 2011; Ullah, Mughal & Nudrat, 2021; Mahasneh, 2017). Computer-supported learning activity transforms positively knowledge learning environment which has rich, multimedia and multimodal learning environment (La Velle *et al.,* 2003; Tekbiyik & Akdeniz, 2010). The use of models also ensures that learners can visualize the concepts much easier than they do in real-life situations (La Velle *et al.,* 2003).

4.4.1 Hypothesis Four

The null hypothesis was stated as follows: there is no significant difference in students' academic performance in Biology between the control and experimental groups. The hypothesis testing took the following; group differences in pre-test scores, post-test scores, and post-test scores in experimental and control groups using the t-test analysis as illustrated in Table 4.16, 4.17, 4.18 and 4.19.

4.4.1.1 Group Differences in pre-test score

The results of independent t-tests in Table 4.16 demonstrated that there were no significant differences in the pre-test scores of the two groups ($t = -1.459$, $p > 0.05$), indicating that the prior scores in the Biology test for the two groups were equivalent before the experiment. The mean values and standard deviations of the pre-test scores were 18.500 and 4.336 for the experimental group one, and 19.506 and 4.548 for the control group one. In addition, the analysis of the homogeneity of the within-class regression coefficient with F = 1.035 (p > 0.05), implied that the homogeneity test was not met. Consequently, it is concluded that the two groups had equivalent test scores before the experiment.

Table 4.16: Group Differences in Pre-Test Scores

Group	n	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
Experimental group one	88	18.500	.46226	4.33643	-2.3644	.3517
Control group two	79	19.506	.51175	4.54852	-2.3681	.3555

Levene's test for equality in variances		F = 1.035	p-value = 0.311
Equal variances assumed		Equal variances not assumed	
Degrees of freedom = 165		Degrees of freedom = 161.074	
t = -1.463	p = 0.145	t = -1.459	p = 0.146

This suggests that the intellectual and mental capabilities of the students in the two groups were equivalent before the treatment and this alleviated the non-equivalence between the groups during the experiment and help explain any statistical difference after the experiment.

4.4.1.2 Group Differences in post-test scores

The results of independent t-tests in Table 4.17 demonstrated that there were significant differences in the post-test scores of the two groups (t = -2.740, p < 0.05), indicating that the scores in the Biology test for the two groups were non-equivalent after the experiment. The mean values and standard deviations of the post-test scores were 19.331 and 3.6910 for the control group, and 20.635 and 5.073 for the experimental group. In addition, the analysis of homogeneity of the within-class regression coefficient with F = 10.140 ($p < 0.05$), implies that the homogeneity test was met. Consequently, it is concluded that the two groups had non -equivalent test scores after the experiment.

Table 4.17: Group Differences in Post-test Scores

Group	n	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
Control	178	19.3315	.27666	3.69107	-2.2387	-.36786
Experimental	167	20.6347	.39259	5.07339	-2.2484	-.35816

Levene's test for equality in variances		F = 10.140	p-value = 0.002
Equal variances assumed		Equal variances not assumed	
Degrees of freedom = 343		Degrees of freedom = 301.967	
t = -2.740	p = 0.006	t = -2.714	p = 0.007

The statistics suggest that the experimental group performed significantly better than the control group, an indicator that computer-based collaborative concept mapping is a better teaching strategy than conventional methods of teaching. Therefore the null hypothesis that there is no significant effect of CBCCM and conventional methods on the academic performance of students in Biology is rejected. The result concludes that the application of CBCCM as a complementary teaching strategy has a significant impact on the intellectual and mental capabilities of the students who were exposed to it.

4.4.1.3 Group Differences in post-test scores in experimental groups

The results of independent t-tests in Table 4.18 demonstrated that there was a significant level of difference in the post-test scores in the experimental ($t = -4.819$, $p < 0.05$), indicating that the scores in the Biology test for the two groups were non-equivalent after the experiment. The mean values and standard deviations of the post-test scores were 18.759 and 5.013 for group one, and 22.318 and 4.529 for group three. In addition, the analysis of homogeneity of the within-class regression coefficient with $F = 1.142$ ($p > 0.05$), implied that the homogeneity test was not met. Consequently, it is concluded that the two groups had non -equivalent test scores after the experiment.

Table 4.18: Group Differences in post-test scores in experimental groups

Group	n	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
One	79	18.7595	.56405	5.01335	-5.0167	-2.1006
Three	88	22.3182	.48287	4.52971	-5.0251	-2.0921

Levene's test for equality in variances		F = 1.142	p-value = 0.287
Equal variances assumed		Equal variances not assumed	
Degrees of freedom = 165		Degrees of freedom = 158.094	
t = -4.819	p = 0.000	t = -4.793	p = 0.000

The statistics indicate that there were significant differences in Biology performance between student groups one and three after the treatment. The performance exhibited by group three was significantly higher than the performance of group one which was pre-tested. This result could be due to priming or learning effects. Priming occurs when the pre-test helps the subject predict what to expect in the post-test. Learning occurs when the pre-test acts as a practice, such that the subject increases their skill at doing this type of test. It is an indication that priming and learning effects did not influence the outcome of the post-test.

4.4.1.4 Group Differences in post-test scores in control groups

The results of independent t-tests in Table 4.19 demonstrated that there was a significant level of difference in the post-test scores of the two groups ($t = -2.310$, $p < 0.05$), indicating that the scores in the Biology test for the two groups were non-equivalent after the experiment. The mean values and standard deviations of the post-test scores were 18.667 and 3.476 for group two and 19.925 and 3.794 for group four. In addition, the analysis of the homogeneity of the within-class regression coefficient with $F = 0.078$ ($p > 0.05$), implied that the homogeneity test was not met. Consequently, it is concluded that the two groups had non -equivalent test scores after the experiment.

Table 4.19: Group Differences in Post-test scores

Group	n	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
Two	84	18.6667	.37923	3.47568	-2.3396	-0.1782
Four	94	19.9255	.39129	3.79371	-2.3343	-0.1835

Levene's test for equality in variances		F = 0.078	p-value = 0.780
Equal variances assumed		Equal variances not assumed	
Degrees of freedom = 176		Degrees of freedom = 175.885	
t = -2.299	p = 0.023	t = -2.310	p = 0.022

The statistics indicate that there were significant differences in Biology performance between students in groups two and four after the treatment. The performance exhibited by the control group four which was not pre-tested was significantly higher than the performance of group two which was pre-tested; This result shows that the priming or learning effects did not influence the outcome of the post-test.

4.4.1.4 Categorical Differences in post-test scores in experimental groups

Further analysis was carried out using the ANOVA to determine whether there were any significant differences between the groups. Where there are significant differences between the group means, post hoc tests are used to determine the differences between groups and seek to control the experiment-wise error rate (usually alpha = 0.05) in the same manner that the one-way ANOVA. Post hoc tests are termed posteriori tests; that is, performed after the event (the event, in this case, being a study).

Table 4.19: Categorical Differences in Biology post-test score

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	600.821	3	200.274	4.836	.003
Within Groups	14120.541	341	41.409		
Total	14721.362	344			

Tukey HSD

Group	N	Subset for alpha = 0.05: 1	2
Two	84	18.6667	
One	79	18.7595	
Four	94	19.9255	19.9255
Three	88		22.3184
Sig.		.105	.640

The statistics in table 4.19 shows that, F (3,344) = 4.836, p = 0.003 ($p < 0.05$) indicate that there were significant differences in biology post-test scores between the different groups. Tukey's post hoc indicate the presence of two performance bands in the test score with group three (experimental group two) and four (control group two) having the highest score at 22.3184 and 19.9255 respectively which was significantly different from groups two (control group one) and one (experimental group one) which had more or less similar score band of 18.6667 and 18.7595 respectively. This aspect could be attributable to the learning environment and teaching methodology.

4.4.1.5 Test for interaction effects of extraneous variables

Further analysis of post-test scores was done using multivariate analysis of variance (MANOVA) to determine the environmental or extraneous effects on the test score. In this study, the effects of two extraneous variables, gender of the student and category of school were analysed to determine the extent to which they affected the outcome of this study. It is usually difficult to control the extraneous variables but randomly assigning schools into experimental and control groups was done. Although this does not decrease the error amount that occurs because of the extraneous variables, it will at least equalize the error between the groups under study (Gaffney, 2019).

Table 4.20: Test for interaction effects in post-test scores

Source		Statistic	df	F(df1,	df2)	= F	p-value	
Model	W	0.9209	6	6.0	338.0	4.84	0.0001	e
	P	0.0791		6.0	338.0	4.84	0.0001	e
	L	0.0859		6.0	338.0	4.84	0.0001	e
	R	0.0859		6.0	338.0	4.84	0.0001	e
Residual			338					
Sex	W	0.9660	1	1.0	338.0	11.88	0.0006	e
	P	0.0340		1.0	338.0	11.88	0.0006	e
	L	0.0351		1.0	338.0	11.88	0.0006	e
	R	0.0351		1.0	338.0	11.88	0.0006	e
Category	W	0.9990	1	1.0	338.0	0.33	0.5647	e
	P	0.0010		1.0	338.0	0.33	0.5647	e
	L	0.0010		1.0	338.0	0.33	0.5647	e
	R	0.0010		1.0	338.0	0.33	0.5647	e
Group	W	.9999	1	1.0	338.0	0.03	0.8590	e
	P	0.0001		1.0	338.0	0.03	0.8590	e
	L	0.0001		1.0	338.0	0.03	0.8590	e
	R	0.0001		1.0	338.0	0.03	0.8590	e
Sex#group	W	0.9626	1	1.0	338.0	13.14	0.0003	e
	P	0.0374		1.0	338.0	13.14	0.0003	e
	L	0.0389		1.0	338.0	13.14	0.0003	e
	R	0.0389		1.0	338.0	13.14	0.0003	e
Sex#category	W	0.9953	1	1.0	338.0	1.60	0.2065	e
	P	0.0047		1.0	338.0	1.60	0.2065	e
	L	0.0047		1.0	338.0	1.60	0.2065	e
	R	0.0047		1.0	338.0	1.60	0.2065	e
Group#Category	W	0.9977	1	1.0	338.0	0.77	0.3805	e
	P	0.0023		1.0	338.0	0.77	0.3805	e
	L	0.0023		1.0	338.0	0.77	0.3805	e
	R	0.0023		1.0	338.0	0.77	0.3805	e
Residual			338					
Total			344					

e = exact, a = approximate, u = upper bound on F
W = Wilks' lambda, P = Pillai's trace, R = Lawley-Hotelling trace, R = Roy's largest root

The statistical results in table 4.20 shows that with regard to gender, $F(1, 338) = 4.84$, $p = 0.0006$ ($p < 0.05$) are statistically significant. However, in the pre-test scores, there were no statistically significant differences in performance between the experimental and control groups but in the post-test scores, the experimental group performed significantly better than the control group. This indicates that it was CBCCM that improved the student's performance in the post-test rather than gender. However, the effect of gender could be attributed to different learning environments because the boys and the girls were in different schools. There could have been some factors in the girls' schools that were favourable as far as learning Biology is concerned compared to the boys' schools.

The effect of group, $F(1, 338) = 0.03$, $p = 0.8590$ ($p > 0.05$) are not statistically significant. This could be attributed to the random assignment of schools into experimental groups which equalized the error between the groups (Cynthia Gaffney, 2019). Category of school, $F(1, 338) = 0.33$, $p = 0.5647$ ($p > 0.05$) shows that the results are not statistically significant. The student samples were drawn from extra-county schools with more or less similar entry behaviour and consequently, their intellectual capabilities are expected to be more or less equal.

The interaction effects between gender and group $F(1, 338) = 13.14$, $p = 0.0003$ ($p < 0.05$) the results are statistically significant. This indicates that gender affected the performance of students in the experimental and control groups whereby the girls outperformed the boys. Probably the girls use CBCCM as a teaching, and learning strategy compared to the boys. The interaction effects between gender and category $F(1, 338) = 1.60$, $p = 0.2065$ ($p > 0.05$) are not statistically significant. This indicates that the interaction between the two extraneous variables did not affect the learners' performance. The interaction effects between group and category $F(1, 338) = 0.77$, $p = 0.3805$ ($p > 0.05$) the results are not statistically significant. This could be because the learners were from extra-county schools which were randomly assigned into experimental and control groups.

The statistics results indicate there were no significant differences in the pre-test scores of the two groups (experimental and control) indicating that the prior scores in the Biology test for the two groups were equivalent before the experiment. After the experiment, there was a significant difference in the post-test scores in the experimental and control groups indicating that the scores in the Biology test for the two groups were non-equivalent after the experiment. Based on the results, the study rejected the null hypothesis that there is no significant difference in students' attitudes towards Biology between control and experimental groups and conclude that there were significant differences between experimental and control groups. Based on this finding, the study rejected the H_{04} and concluded that CBCCM has a significant effect on students' academic performance in biology.

The effect of the CBCCM on students' attitudes toward biology is explained by theoretical and empirical literature. Considering that CBCCM is an active, blended learning activity, the effects can be explained by several studies which have shown that active learning tends to involve and impact learning by changing the way the learners construct and apply new knowledge (Jones, Antonenko, & Greenwood, 2012; Hong & Lin, 2019; Ma *et al.,* 2020; Chen *et al.,* 2017) and the cumulative effect of knowledge awareness (Cheng & Chu, 2019; Kwon, Liu, and Johnson. 2014). Research in science education shows that active learning has many positive outcomes such as the enhancement of motivation, increases inquisitiveness, facilitates knowledge retention, improves classroom performance, and fosters the development of critical thinking skills (Wambugu, 2013).

Active learning promotes the personal relevance and applicability of course material to students and often improves overall attitudes toward learning (Kalkanis, 2002; Minas, 2003 & Vlachos, 2004). The involvement of students in the learning process could be achieved through active rather than passive learning approaches. Active learning involves students directly in the learning process. This means that instead of simply receiving information verbally and visually students should actively participate in the construction of meaning from learning. Active learning includes everything from listening practices that helps students absorb what they hear to complex group exercises in which students apply course material to real-life situations and/ or to new problems (Warner, & Osborne, 2006; Sener & Huseyin, 2010).

Collaborative learning fosters creativity and focuses through the social environment and management. Collaborative support fosters students' creativity and problem-solving through intensive interaction, reflection and participation, thus the success of one student aids in the success of other students as well (Wu, Hwang, Kuo & Huang, 2013). Collaborative learning as a learning technique promotes knowledge acquisition within the collaborative environment by reinforcing what was taught and encouraging cooperative learning activities (Ma *et al.,* 2020) while contributing towards the achievement of shared learning targets (Jones, Antonenko, & Greenwood, 2012).

Studies have shown that there is a close relationship between social interaction in courses and achievement (Schneider & Preckel, 2017). Collaborative problem-based learning (CPBL) helps improve students' learning attitudes, motivation and self-evaluation (Chao, Chen & Chuang, 2015). Students learn best when they are exposed along with their co-learners to collaborative learn and accomplish certain learning tasks together (Sugano & Nabua, 2020).

Studies have highlighted the potential benefits of information and communication technologies (ICT) for improving educational outcomes (Sangrà & González-Sanmamed, 2010). For instance, the use of mindtools as 'intellectual partners' to facilitate critical thinking and high-order learning (Kirschner & Erkens, 2006; Kirschner & Wopereis, 2003; Chu *et al.,* 2009; Kazantzis & Hadjileontiadou, 2021; Hwang, Shi & Chu, 2011). Among the existing Mindtools is concept mapping which provides a ubiquitous learning experience (Hwang, Shi & Chu, 2011) and serves as an extension of the mind as it can engage learners in constructing higher-order critical learning (Hwang, Shi & Chu, 2011).

The advances in technologies have enabled various new learning approaches that situate students in environments and combine real-world and digital-world learning resources (Hwang, Shi & Chu, 2011). This includes concept mapping which has become widely accepted as an educational tool (Hwang, Wu & Kuo, 2013) and has been reported to improve learning outcomes (Sanchiz *et al.,* 2019). Computer-supported collaborative learning increases knowledge awareness within the group, promotes group participation and facilitates social regulation in learning activities (Kwon, Liu, and Johnson, 2014). Knowledge sharing within the collaborative environment predicts learning achievement. (Cheng & Chu, 2019).

Computer-aided learning significantly impacts learning by positively transforming the learning environment (La Velle *et al.,* 2003) promote self-evaluation and reflection on the learning process while providing immediate feedback and reinforcement(Serin, 2011). Computer-assisted learning also allows learners to absorb more learning responsibilities (Županec, Miljanović & Pribićević, 2013). In addition, computer-assisted learning provides interactive mediums such as text, graphs, audio, video, pictures, animation and simulation which helps pace learning (Tekbiyik & Akdeniz, 2010). Mindtools such as concept mapping tools are interactive and enjoyable (Abbas, Eldin & Elsayed, 2018) and help learners engage in higher-order thinking (Liu, 2011; Wu, *et al.,* 2013) while promoting knowledge construction and retention (Cheng & Chu, 2019). Mindtools provide the required scaffolding and thus are an effective way of assisting students to interpret and organize their knowledge structures (Hwang, Wu & Ke, 2011).

The use of collaborative and computer-aided instruction positive affects learning in several ways; by guaranteeing the teachers the good use of the time to guide and help the students, enhancing critical thinking, self-learning, building experiences, communication skills, and cooperation among students and providing an assessment technique for evaluating the student's weaknesses and strengths in their understanding of content (Elian & Hamaidi, 2018). The availability of CBCCM learning tools encourages the students to take a more active role in their learning and to prepare for their classes each day instead of studying just before the exams. Thus the use of learning tools is beneficial in having deeper activity in the classroom. First of all, the focus on the explanation of the most relevant and difficult concepts may allow a better understanding and second is that the tools used in the approach save some time for other learning activities (Herrero & Quiroga, 2020).

The use of models, symbols (abstract) and various representations, in small teams (groupings) and integrating technology helps the students to explore the knowledge domains of the subject(Sugano & Nabua, 2020). Achievement is also strongly associated with the stimulation of meaningful learning by clearly presenting information, relating it to the students, and using conceptually demanding learning tasks. Instruction and communication technology have comparably weak effect sizes, which did not increase over time (Schneider & Preckel, 2017).

Learning is less effective when students partake in routines in the classroom but is more effective when the learning process was made visible, reflected on, and deliberately shaped by teachers and students (Schneider & Preckel, 2017). The students in the experimental group tend to move learning outside the classroom to deliver content; this enhances learning and provides more opportunities for practice, which usually takes a great deal of time within limited class hours (Karadag & Keskin, 2017). It also enriches the learning environment, which increases the effectiveness of lessons and makes learning and teaching more communicative (Gencer, Gurbulak & Adıguzel, 2014). Other advantages include the opportunities for individualised learning regarding learning pace and styles as well as learning the content before practice; allowing students to take more responsibility for their learning; and creating a more transparent learning environment carrying learning outside the walls of a classroom setting (Karadag & Keskin, 2017). Students with high achievement are characterized by high self-efficacy, high prior achievement and intelligence, conscientiousness, and the goal-directed use of learning strategies (Schneider & Preckel, 2017).

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.0 Introduction

In this chapter, the summary is presented and conclusions from the findings are drawn in line with the objectives. It also gives recommendations. Finally, suggestions for further research.

The study examined the effect of computer-based collaborative concept mapping on the student's academic achievement in biology in secondary schools in Kenya. The objectives of the study were; to determine the effects of CBCCM and conventional methods on student's attitudes towards Biology; evaluate the gender differences in students' attitudes towards Biology between control and experimental groups; examine the gender differences in students' academic achievement in Biology between control and experimental groups, and compare the effect of computer-based collaborative concept mapping and conventional methods on student's academic achievement in Biology

5.1 Summary

The study was carried out in eight extra–county schools of different categories with the aid of the Solomon IV non-equivalent group quasi-experimental design. The experimental group was taught using computed–based collaborative concept mapping while the group were taught using the conventional learning technique. The target population comprised all the 149 schools in Uasin Gishu County out of which 345 form – two students from eight extra–county participated in the study. The study had two instruments; the student attitudinal questionnaire and the Biology Achievement test which were validated before the commencement of the study. The inferential statistics used to test the null hypotheses included a t-test, One-way ANOVA and MANOVA. Hypotheses were tested at a 0.05 level of significance.

5.1.1 Gender differences in students' attitudes towards biology

Based on the results of the hypothesis testing, the study did not reject the H_{01} and concluded that CBCCM has no significant effect on students' attitudes towards biology. This indicates that students maintained a positive attitude towards Biology regardless of the teaching strategy employed. This indicates that attitudinal components displayed towards Biology by both genders during the post-test were not different from one another suggesting both girls and boys had more or less similar attitudes, thereby excluding the attitudinal component as a cause of variances in performance

5.1.2 Effect of CBCCM on student's attitudes towards Biology

Based on the results of the hypothesis testing, the study rejected the H_{02} and concluded there was a significant difference in students' attitudes towards Biology between the control and experimental groups. The attitudes exhibited by the experimental group were significantly different from the attitudes of the control group and this indicates that students' attitudes towards Biology in the experimental group were significantly higher. Thus, computer-based collaborative concept mapping had a positive influence on the student's attitudes.

5.1.3 Gender differences in student's academic performance

Based on the results of the hypothesis testing, the study rejected the H_{03} and concluded that there were significant gender differences in academic performance between the experimental and control groups. The test scores indicate that girls outperformed the boys after being exposed to CBCCM and thus it can be inferred that computer-based collaborative concept mapping had a positive effect on the girls' academic performance in Biology as compared to the boys' academic performance.

5.1.4 Effect of CBCCM on student’s academic achievement

Based on the results of the hypothesis testing, the study rejected the H_{04} and concluded that there were significant differences in academic performance between the experimental and control groups. The test scores indicate that the experimental group outperformed the control group after being exposed to CBCCM and thus it can be inferred that computer-based collaborative concept mapping had a positive effect on the student's academic performance in Biology. It was concluded that CBCCM enhances students' learning of school Biology, but does not minimize the gender disparities in the performance of science subjects in secondary schools.

5.2 Conclusions

This study makes the following conclusion;

Concept mapping helps learners learn new knowledge, structure and manage to learn and can be used to evaluate academic achievement.

The computer-based collaborative concept mapping (CBCCM) has no significant impact on the learners' attitudes but may improve the learner's attitudes and interest towards the topic.

The computer-based collaborative concept mapping impacts the different sexes significantly. Thus, there were gender differences in attitudes and attitudes and learning associated with academic achievement. There were gender differences in academic performance between girls and boys as shown by the results whereby girls outperformed boys on the post-test.

Computer-based collaborative concept mapping has a significant impact on academic performance. Therefore, there was a likelihood that CBCCM affected students' attitudes positively and the positive attitude, in turn, affected the learners' academic performance.

5.3 Recommendations

Based on the findings of this study and the discussion it is recommended that concept mapping is beneficial in enhancing students' attitudes towards Biology and improving their academic performance in form two. Therefore, it is recommended that:

1. Textbook being a primary tool to deliver the concept to the students lays a heavy responsibility on the textbook writers to develop a balanced textbook in terms of content, methodology, practical activities and assessment exercises. The textbook writers are urged to include concept maps and concept mapping activities in the textbooks
2. The Kenya National Examinations Council (KNEC) may include concept mapping as an evaluative tool in their examinations. It will also promote concept mapping as an evaluation tool in formative and summative assessments in schools. The impact will then filter down to the teachers requiring them to use it as a classroom teaching-learning strategy
3. Concept mapping is an emerging teaching-learning strategy. Pre-service and in-service teacher education programs ought to incorporate it into the curriculum to prepare teachers with respect to its philosophical background, theoretical base and practical usage.

5.4 Suggestions for further research

1. The study suggests that a longitudinal research study be conducted to determine the impact of computer-based collaborative concept mapping on students' performance over a long period.
2. The results of this study revealed that concept mapping is found to be more beneficial for girls than boys in terms of academic performance. Hence qualitative or quantitative research is recommended for the exploration of those variables that affect the learning patterns of girls and boys.
3. In this study whole classes were taken as experimental groups. The students in each class belong to mixed ability levels. It is suggested that research may be conducted to find out the effect of concept mapping on students with different ability levels.

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APPENDICES

Appendix I: Biology achievement test (BAT) (pre-test)

Answer all the questions in the spaces provided

1. Explain the following terms;

   (3mks)

   a)Classification…………………………………………………………………

………………………………………………………………………………………
……………………………………

   b)Taxonomy……………………………………………………………………

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

   c)Binomial

nomenclature……………………………………………………………….................

2. Which organelle would be abundant in?

   a) Skeletal muscle cell ………………………………………………

   (1mk)

   b) Palisade cell……………………………………………………

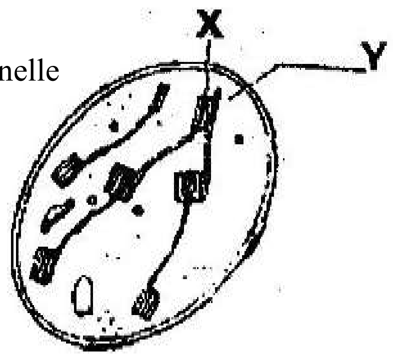
   (1mk)

3. State the function of cristae in mitochondria

   (1mk)

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

4. The diagram below represents a cell organelle



(i) Name the part labeled Y ……………………………………… (1mk)

(ii) State the function of the part labeled X

(2 mks)

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

5. The diameter field of view of a light microscopic is 3.5mm. Plant cells lying of the diameter are 10. Determine the size of one cell microns (1mm = 1000µm) (3mks)

…………………………………………………………………………………………

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…………………………………………………………………………………………

6. Distinguish between diffusion and osmosis. (2mks)

…………………………………………………………………………………………

…………………………………………………………………………………………

7. Explain why:

a) Red blood cells burst when placed in distilled water while plant cells remain intact. (1mk)

…………………………………………………………………………………………

…………………………………………………………………………………………

b) Freshwater protozoa like amoeba do not burst when placed in distilled water (1mk)

…………………………………………………………………………………………

………………….

8. a) State the role of light in the process of photosynthesis (2mks)

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

b) Name one product of dark reaction in Photosynthesis (1mk)

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

9. Name two mineral elements that are necessary for the synthesis of chlorophyll. (2mks)

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…………………………………………………………………………………………
………………………………………………………………………………………

10. What is the role of the vascular bundles in plants nutrition?
(3mks)

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

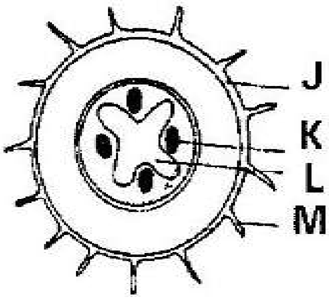
11 State any three functions of the mucus, which is secreted along the wall of the alimentary canal.
(3mks)

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

12. Explain why the digestion of starch stops after food enters the stomach.
(3mks)

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

13. The diagram below represents a transverse section through a plant organ.



a) From which plant organ was the section obtained? (1mk)

…………………………………………………………………………………………
…………………………………………………………………………………………

b) Give two reasons for your answer in (a) above. (2mks)

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

c) Name the parts labeled J, K and L (3mks)

J___________________________________

K___________________________________

L___________________________________

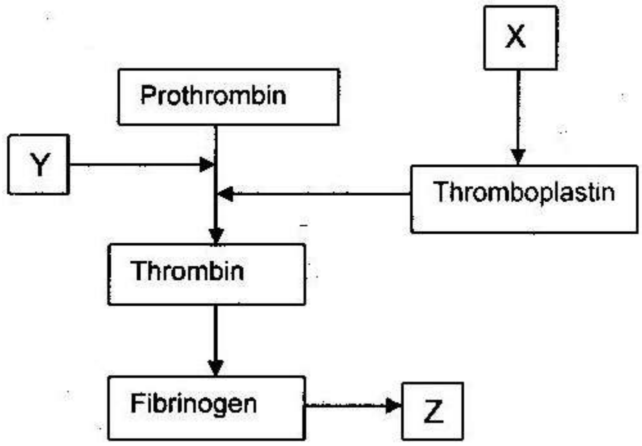
d) State two functions of the part labeled M. (2mks)

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

14. The chart below is a summary of the blood clotting mechanism in man.



Name

i) The blood cells represented by X (1mk)

…………………………………………………………………………………………

…………………………………………………………………………………………

ii) Metal ion represented by Y (1mk)

…………………………………………………………………………………………

…………………………………………………………………………………………

iii) The end product of the mechanism represented Z (1mk)

…………………………………………………………………………………………

…………………………………………………………………………………………

iv) How can excess bleeding result in death? (2mks)

…………………………………………………………………………………………

…………………………………………………………………………………………

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15. State three factors that make alveolus adapt to its function. (3mks

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16. a) Name two structures used for gaseous exchange in plants. (2mks)

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…………………………………………………………………………………………

…………………………………………………………………………………………

b) State two ways in which floating leaves of aquatic plants are adapted to gaseous exchange (2mks)

…………………………………………………………………………………………

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………………………………………………………………………………………..

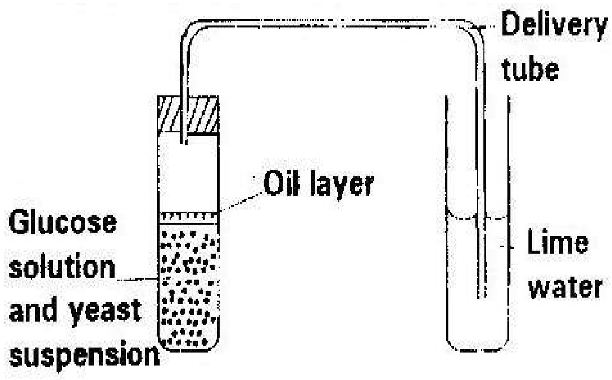
Appendix II: Table of specifications for BAT

Behavioural objective	Content (subtopic)					
	Definition and significance of respiration	Types of respiration	Phases of aerobic respiration	Oxygen debt	Economic importance of anaerobic respiration	Respiratory quotient (RQ) and its significance
Knowledge	1,1(2 items)	1,1,1 (3items)	1(1item)	1,1 (2items	1(1item)	1(1item)
Comprehension	1,1,1,1(4items)	1,1,1 (3items)		1 (1item)	1(1item)	1,1(2items)
Application	1,1,1(3items)			1 (1item)		1(1item)
Analysis	1,			1 (1item)		
Synthesis				1 (1item)		
evaluation						

Appendix III: Biology Achievement Test (BAT) post-test

Answer all the questions in the spaces provided

1.The diagram below shows a set – up that was used to demonstrate fermentation



Glucose solution was boiled and oil was added on top of it. The glucose solution was then allowed to cool before the suspension.

a. Why was the glucose solution boiled before adding the yeast suspension? (1 mk)

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

b.What was the importance of cooling the glucose solution before adding the yeast suspension? (1 mk)

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………………………………………………………………………………………….

c. What was the use of oil in the experiment? (1 mk)

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………………………………………………………………………………..……………

……………………………………………………………………………………………..

d. What observation would be made in test tube B at the end of the experiment? (1 mk)

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………………………………………………………………………………………………

………………………………………………………………………………………………

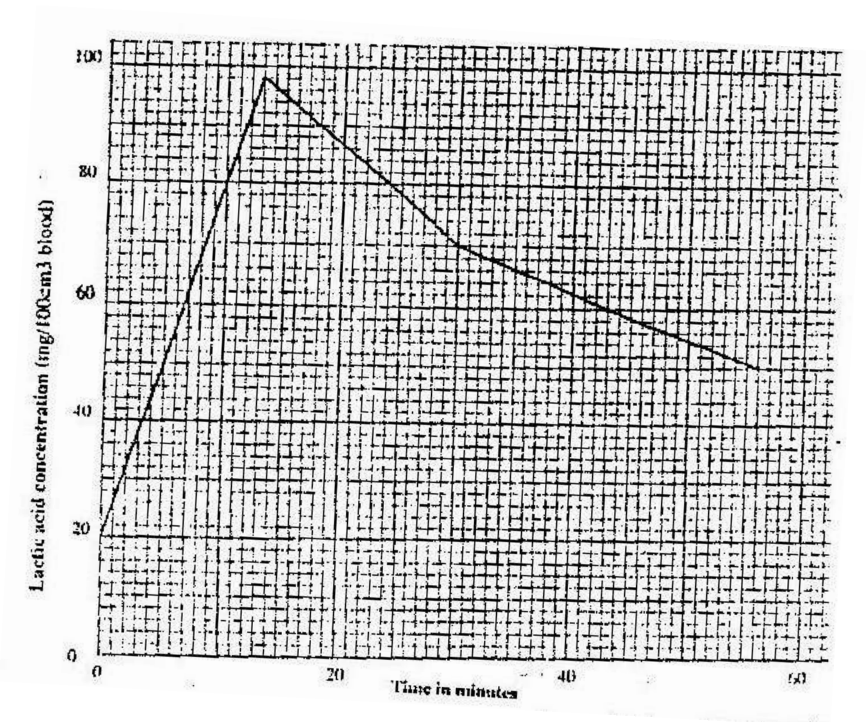
e. Suggest a control for this experiment (1mk)

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

2. The concentration of the lactic acid in blood during and after an exercise was determined. The results are shown in the graph below



a.(i) By how much did the lactic acid increase at the end of 13 minutes? (1mk)

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

(ii) After how many minutes was the lactic acid concentration 71mg/ 100cm^3?

(2mks)

…………………………………………………………………………………………

…………………………………………………………………………………………

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…………………………………………………………………………………………

(iii) What would be the concentration of lactic acid at the 60th minute? (1mk)

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…………………………………………………………………………………………

…………………………………………………………………………………………

b.Give a reason for the high rate of production of lactic acid during the exercise

(1mk)

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

c.Give reasons for the decrease in the concentration of lactic acid after the exercise

(2mks)

…………………………………………………………………………………………

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…………………………………………………………………………………………

d.Give two reasons why the accumulation of lactic acid during vigorous exercise leads to an increase in heartbeat. (2mks)

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……………………………………………………………………………………………

…………………………………………………………………………………………

3.A process that occurs in plants is represented by the equation below.

$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$ + Energy

(Glucose) (Ethanol) (Carbon dioxide)

a. Name the process. (1mk)

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

b.State two economic importance of the process named in (a) above (2mks)

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………

4.Give three differences between aerobic and anaerobic respiration (3mks)

Aerobic	Anaerobic

5.

a. A dog weighing 15.2kg requires 216kj while a mouse weighing 50g requires 2736kj per day. Explain. (2mks)

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

b. Give three factors that determine the amount of energy a human being require in a day (3mks)

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

6. $5C_{51}H_{98}O_6 + 145O_2 \longrightarrow 102CO_2 + 98\,H_2O$ + energy

The above equation shows an oxidation reaction of food substances.

a. What do you understand by the term respiratory quotient? (1mk)

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………..

b. Determine the respiratory quotient of the oxidation of food substances. (2mks)

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

c. Identify the food substances. (1mk)

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

d.What is the importance of respiratory quotient (2mks)

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

7.Write differences between aerobic respiration and photosynthesis. (4mks)

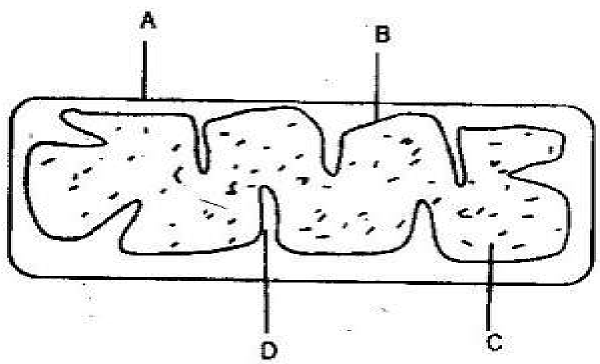
…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

8.Below is a diagram of an organelle that is involved in aerobic respiration.



a.Name the organelle (1mk)

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

b.Name the parts labelled A, B, C and D (3mks)

A………………………………………………………………………………………

B………………………………………………………………………………………

C………………………………………………………………………………………

D………………………………………………………………………………………

c. Give the chemical compound which is formed in the organelle and forms the immediate source of energy. (1mk)

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

d.How is the organelle you have named in (a) above adapted to its functions (2mks)

…………………………………………………………………………………………

…………………………………………………………………………………………..

……………………………………………………………………………………..…

9.In an experiment, disinfected soaked bean seeds were put in a vacuum flask which was then fitted with a thermometer as shown in the diagram below. The temperature readings were taken every morning for three consecutive days.

a. Which process was being investigated (1mk)

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………………………………………………………………………………………

………………………………………………………………………………………

b.i)What were the expected results (1mk)

………………………………………………………………………………………

……………………………………………………………………………………….

……………………………………………………………………………………….

ii)Account for the results in (b) (i) above (2mks)

………………………………………………………………………………………

……………………………………………………………………………………….

……………………………………………………………………………………….

c. Why were the seeds disinfected (2mks)

………………………………………………………………………………………

………………………………………………………………………………………..

……………………………………………………………………………………….

d.Why was a vacuum flask used in the set-up (1mk)

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

e.How would a control for this experiment be set (1mk)

…………………………………………………………………………………………

…………………………………………………………………………………………….

…………………………………………………………………………………………….

Appendix IV: Student Attitude Questionnaire (SAQ) pre-test

Dear student, this questionnaire is meant for research purposes only. You are kindly required to respond to the following items as genuinely as possible. All the information will be kept confidential. Indicate the extent to which you agree with the following statements. Respond by putting a tick (√)

SA: Strongly Agree

A: Agree

U: undecided

D: Disagree

SD: Strongly Disagree

		1	2	3	4	5
NO	STATEMENT	SD	D	U	A	SA
1	Biology is very interesting to me					
2	I don't like biology and it scares me to have to take it					
3	I'm always under a terrible strain in a biology class					
4	Biology is fascinating and fun					
5	Biology makes me feel secure and at the same time is stimulating					
6	Biology makes me feel uncomfortable, restless, irritable and impatient					
7	In general, I have a good feeling towards biology					
8	In general, I have a bad feeling towards Biology					
9	The word "Biology" feels me with enthusiasm					
10	When I hear the word "biology" I have a feeling of dislike					
11	I approach biology with a feeling of hesitation					
12	I like biology					
13	I don't like Biology at all					

14	I have always enjoyed studying biology in school					
15	Given a chance, I would drop Biology					
16	It makes me nervous to even think about doing a biology experiment					
17	I always look forward to Biology experiments					
18	I feel at ease with biology and I like it very much					
19	I feel a definite positive reaction to biology; it's enjoyable					
20	Biology is awful and I hate it					

Appendix V: Student Attitude Questionnaire (SAQ) post-test

Part Two

Indicate the extent to which you agree with the following statements. Respond by putting a tick ( )

SA: Strongly Agree

A: Agree

U: undecided

D: Disagree

SD: Strongly Disagree

		1	2	3	4	5
NO	STATEMENT	SD	D	U	A	SA
1	Constructing Biology concept maps is interesting and fun					
2	Concept maps are a waste of time					
3	Biology concept maps have enabled me to understand Biology more than before					
4	Concept maps make me confused during Biology lessons					
5	Biology concept maps have made me like Biology more					
6	Concept maps have made me develop a dislike for Biology					
7	Construction of biology concept maps has made me creative					
8	I prefer constructing concept maps than doing assignments from textbooks					
9	I would rather answer Biology revision questions than construct Biology concept maps					
10	Construction of Biology concept maps enables me to demonstrate what I have learnt					

11	Biology concept maps don't make sense to me at all					
12	Construction of Biology concept maps has made learning much easier than memorizing ideas					
13	Biology concept maps have enabled me to enjoy my Biology lessons					
14	Construction of concept maps always make nervous and irritable during the Biology lessons					
15	I can now remember what I'm taught better because the maps I construct register in my mind for a long time					
16	I prefer reading and memorization of Biology concepts to the construction of Biology concept maps					
17	Since I was introduced to concept mapping, I have always looked forward to our Biology lesson					
18	Concept maps have made my Biology lessons more and more unpleasant					
19	Construction of concept maps with my peers has made my learning of biology fascinating and fun					
20	Construction of concept maps has developed in me a more positive feeling towards biology					

Part Two

In about ten sentences, express your views on how the use of computer-based concept maps has influenced your learning and understanding of biology.

Appendix VI Extra-county schools in Uasin-Gishu County

EXTRA-COUNTY SCHOOLS IN UASIN-GISHU COUNTY	
BOYS	GIRLS
Chebisaas	Loreto High Matunda
Paul Boit	Sugoi
Kipsangui	Turbo
Arnesen’s	Kerotet
Kapng’etuny	Bishop Birech
Kipkabus	Plateau
Kimoning	Seko
Moiben	Hill School
Cheplaskei	St. Catherine Kesses
	kapkoiga
	Ngeria
	Dry’s
	Kaptagat

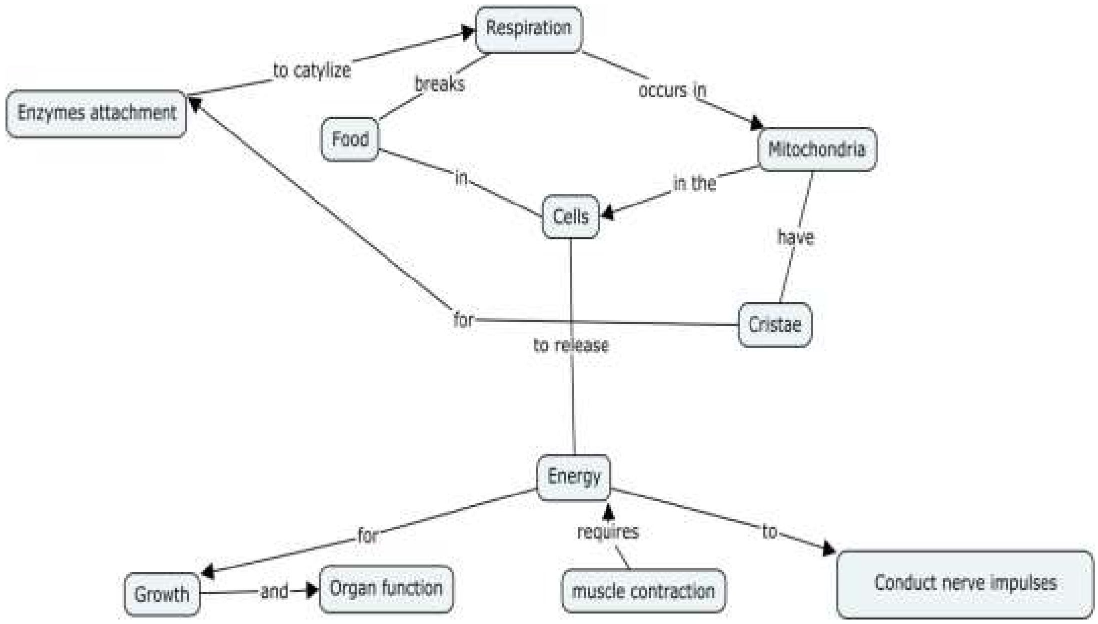
Appendix VII: How to Build a Collaborative Concept Map

1. Identify a focus question that addresses the problem, issues, or knowledge domain you wish to map. Brainstorm a set of 10 to 20 concepts that are pertinent to the question and list these. Using the concept mapping software, produce a list of concepts on your computer. Concept labels should be a single word, or at most two or three words.
2. Place the broadest most general and inclusive idea at the top of the map. It is sometimes difficult to identify the broadest, most inclusive concept. As such, it is helpful to reflect on your focus question to help decide the order of the concepts.
3. Work down the list and add more concepts as needed.
4. Begin to build your map by placing the most inclusive, most general concept(s) at the top. Usually, there will be only one, two, or three most general concepts at the top of the map.
5. Next, select the two, three, or four subconcepts to place under each general concept. Avoid placing more than three or four concepts under any other concept. If there seem to be six or eight concepts that belong under a major concept or subconcept, it is usually possible to identify some appropriate concept of intermediate inclusiveness, thus creating another level of hierarchy in your map.
6. Connect the concepts by lines. Label the lines with one or a few linking words. The linking words should define the relationship between the two concepts so that it reads as a valid statement or proposition. The connection creates meaning. When you hierarchically link together a large number of related ideas, you can see the structure of meaning for a given subject domain. 7. Rework the structure of your map, which may include adding, subtracting, or changing superordinate

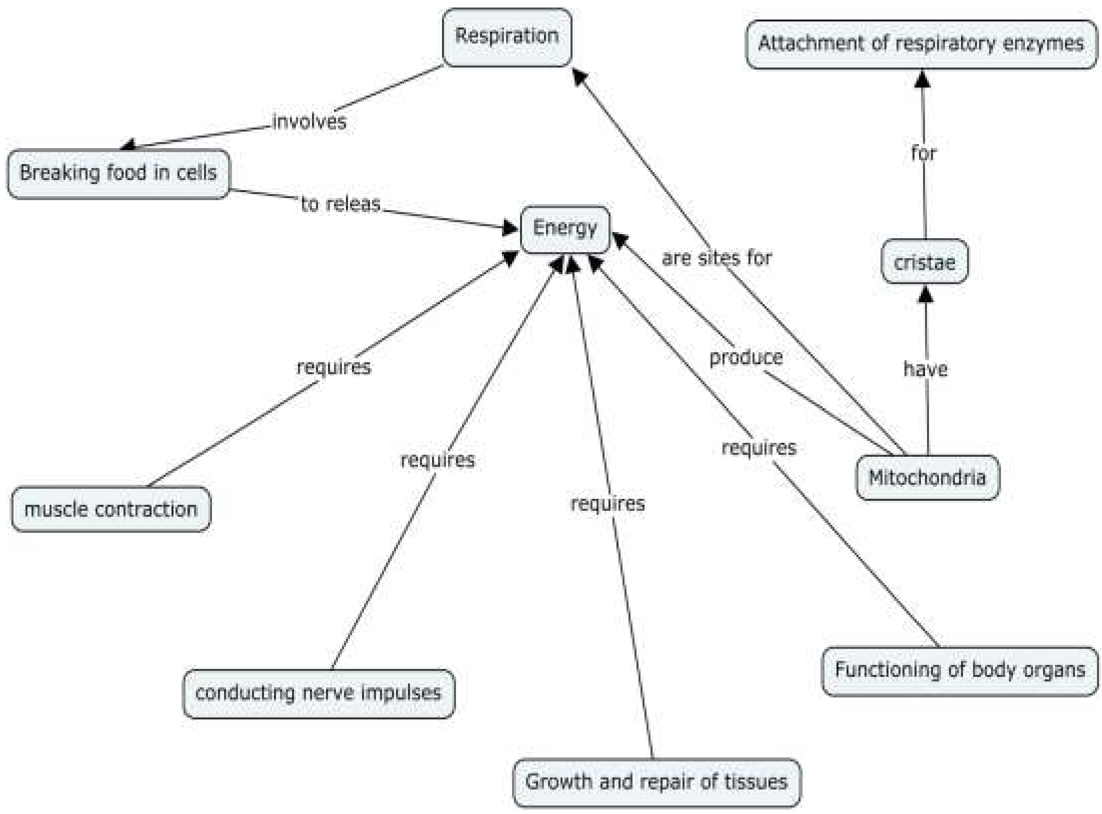
concepts. You may need to do this reworking several times, and this process can go on indefinitely as you gain new knowledge or new insights.

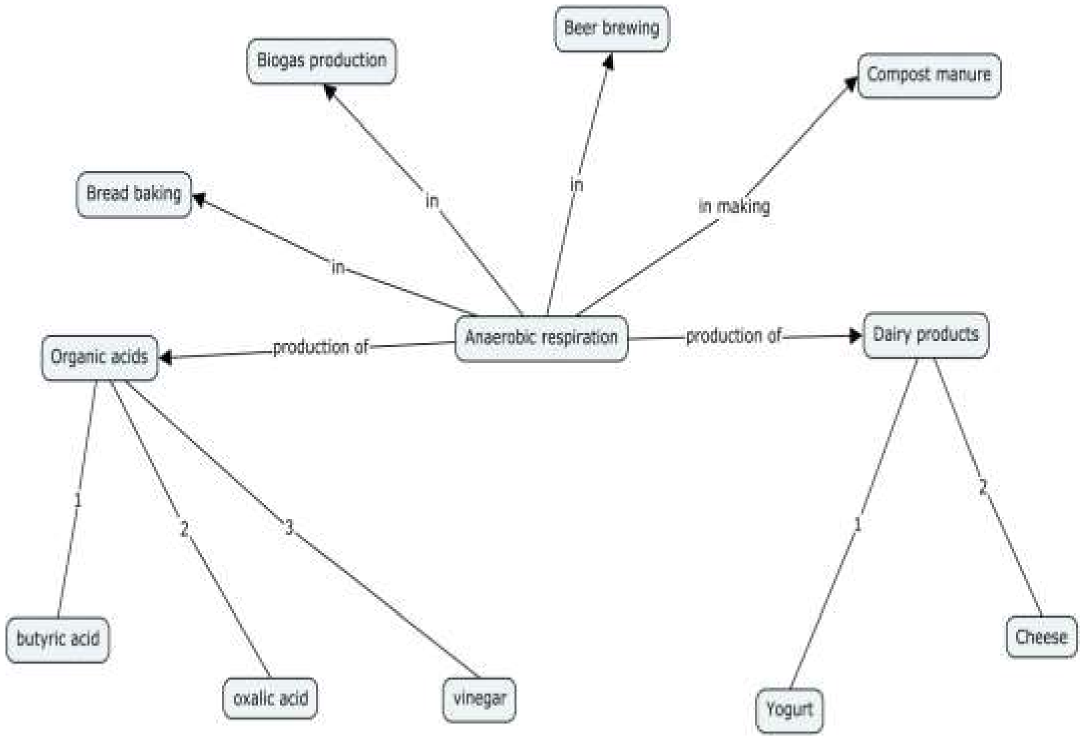
7. Look for crosslinks between concepts in different sections of the map and label these lines. Crosslinks can often help to see new creative relationships in the knowledge domain.
8. Specific examples of concepts can be attached to the concept labels (e.g., a golden retriever is a specific example of a dog breed).
9. Concept maps could be made in many different forms for the same set of concepts. There is no one way to draw a concept map. As your understanding of relationships between concepts changes, so will your maps.
10. Merge your map with your colleagues in class.
11. Modify your map based on any insights gained from the merged collaborative map.
12. Adapted from Appendix I from Joseph D. Novak, Learning, Creating, and Using Knowledge: Concept MapsTM as Facilitative Tools in Schools and Corporations, Mahwah, NJ: Lawrence Erlbaum Associates, Publishers, 1998.

Appendix VIII: Expert concept maps

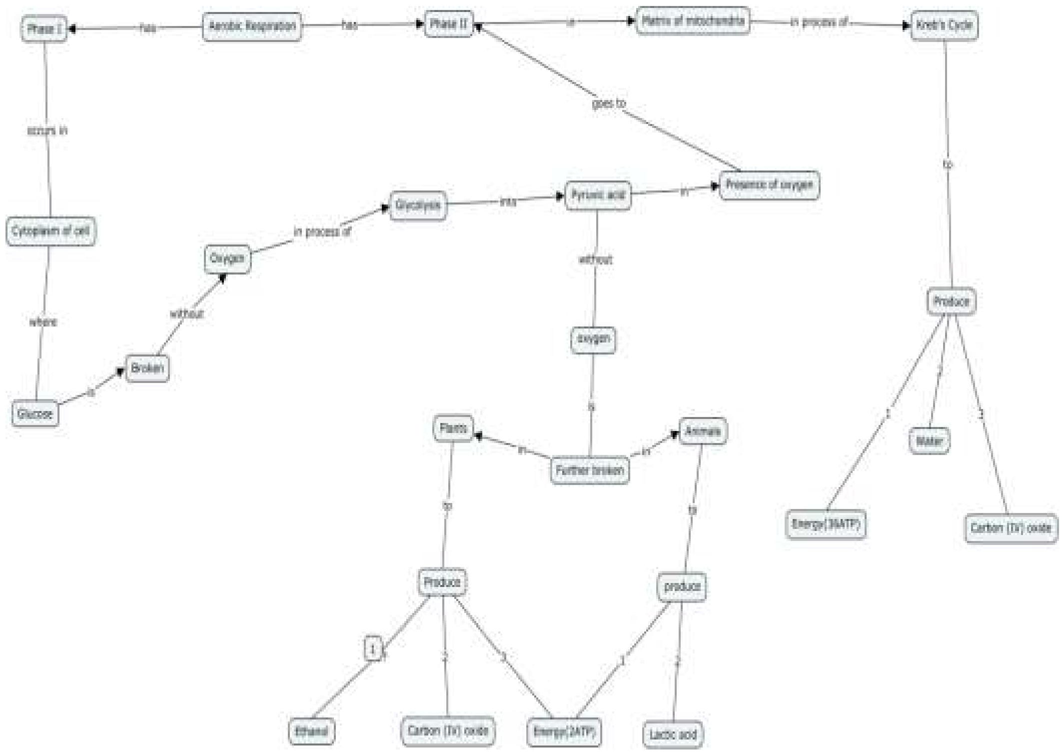


Concept maps on definition and significance of respiration

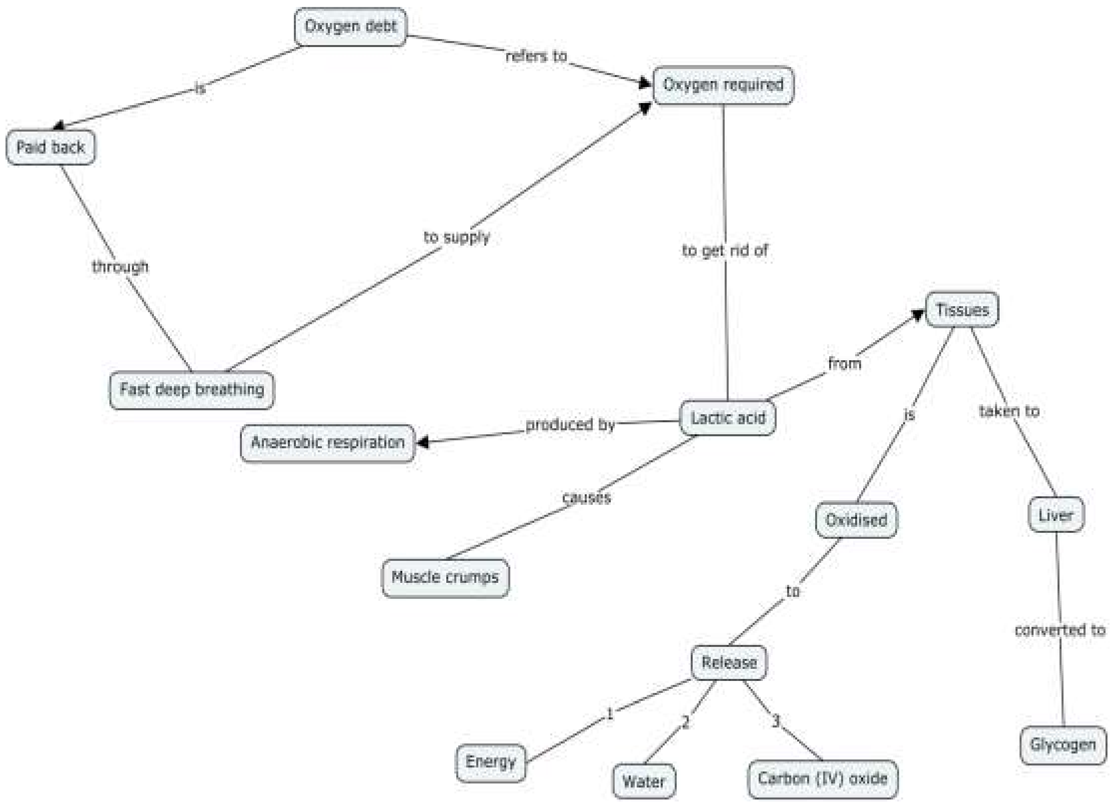




Concept map on the economic importance of anaerobic respiration



Concept map on phases of aerobic respiration



Concept map on oxygen debt

Appendix IX: KCSE ranking of counties by merit

COUNTY	POSITION	
	2012	2013
Samburu	1	1
Siaya	4	2
Elgeyo Marakwet	3	3
West Pokot	2	4
Trans-Nzoia	6	5
Bomet	7	6
kisumu	10	7
Busia	15	8
Embu	5	9
Uasin-Gishu	9	10
Migori	13	11
Kericho	11	12
Homa-Bay	14	13
Vihiga	12	14
Kakamega	18	15
Nandi	8	16
Laikipia	21	17
Tharaka Nithi	19	18
Nakuru	20	19
Turkana	25	20

Appendix X: NACOSTI Permit

THIS IS TO CERTIFY THAT:
MISS. CHEBOTIB NELLY
of MOI UNIVERSITY, 1380-30100
Eldoret,has been permitted to conduct
research in *Uasin-Gishu County*

on the topic: *COMPUTER-BASED COLLABORATIVE CONCEPT MAPPING: EFFECTS ON STUDENT ATTITUDE AND ACHIEVEMENT IN BIOLOGY IN SECONDARY SCHOOLS KENYA*

for the period ending:
22nd June,2018

Permit No : NACOSTI/P/17/45259/17391
Date Of Issue : 3rd July,2017
Fee Recieved :Ksh 2000

....
Applicant's
Signature

....
Director General
National Commission for Science,
Technology & Innovation

Appendix XI: NACOSTI Authorization

NACOSTI

NATIONAL COMMISSION FORSCIENCE, TECHNOLOGY ANDINNOVATION

Telephone:+254-20-2213471, 2241349,3310571,2219420
Fax: +254-20-318245,318249
Email: dg@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref. No. **NACOSTI/P/17/45259/17391**

Date: **3rd July, 2017**

Chebotib Nelly
Moi University
P.O. Box 3900-30100
ELDORET.

Forwarded. 13/7/2017

FOR THE COUNTY DIRECTOR OF EDUCATION
UASIN GISHU COUNTY
TEL: 053-2063342/0719127212
P.O. BOX 3843-30100, ELDORET

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Computer-based collaborative concept mapping: Effects on student attitude and achievement in biology in secondary schools Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Uasin Gishu County** for the period ending **22nd June, 2018.**

You are advised to report to **the County Commissioner and the County Director of Education, Uasin Gishu County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Uasin Gishu County.

The County Director of Education
Uasin Gishu County.

Proceed, 13/7/2017

COUNTY COMMISSIONER
UASIN GISHU COUNTY

National Commission for Science, Technology and Innovation isISO9001: 2008 Certified