EFFECTS OF CONCEPT MAPPING TEACHING APPROACH ON SECONDARY SCHOOL STUDENTS' ACHIEVEMENT AND MOTIVATION TO LEARN BIOLOGY IN KITUI COUNTY, KENYA

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DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work, and it has not been submitted to this or any other university for the award of a degree.

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Recommendation

This thesis has been submitted with our recommendations as University Supervisors.

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DEDICATION

I dedicate this thesis to my family members for their continued prayers and support.

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ABSTRACT

Science subjects are essential tools for any country's industrial and technological growth. Biology is an essential discipline in the secondary school science curriculum in Kenya. However, students' performance in Biology in Kenyan secondary schools is inferior. This poor performance may be partly attributed to the continued use of teacher-centred instructional approaches by Biology teachers, as well as to students' low motivation. This study assessed how the Concept Mapping Teaching Approach (CMTA) influenced form four students' achievement and motivation in Biology in selected Kitui County secondary schools. A quasi-experimental research design, employing the Solomon Four-Group model with non-equivalent groups, was used. The target population consisted of all secondary school Biology students in Kitui County. The accessible population consisted of all form four Biology students in co-educational sub-county secondary schools. Purposive sampling was used to select four co-educational secondary schools in Kitui County. The total sample consisted of 173 students, comprising 82 boys and 91 girls. Two schools were randomly designated as experimental groups and taught using the (CMTA), while the other two acted as control groups and received instruction through Conventional Teaching Methods (CTM). The study was guided by four research objectives and four null hypotheses. Data collection tools included the Students' Motivation Questionnaire (SMQ) and the Biology Achievement Test (BAT), which were validated by two experienced secondary school Biology teachers and five science education experts. The instruments were piloted, and their reliability was estimated using Cronbach's alpha, yielding coefficients of 0.81 for the SMQ and 0.78 for the BAT. Data analysis involved calculating means, standard deviations, one-way ANOVA, ANCOVA, and t-tests. All hypotheses were tested at an alpha level of 0.05.The study results showed that, students exposed to CMTA exhibited significant improvements in Biology achievement and motivation compared to those taught with conventional methods. It is recommended that CMTA be integrated into Biology and other science subjects to enhance students' achievement and motivation. These findings may benefit national curriculum developers and Biology teachers by identifying effective teaching approaches that improve instructional quality and, consequently, enhance students' achievement.

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LIST OF ABREVIATIONS AND ACRONYMS

AIDS	Acquired Immuno Deficiency Syndrome
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
BAT	Biology Achievement Test
BOM	Board of Management
CEMASTEA	Centre for Mathematics, Science and Technology Education in Africa
CEO	County Education Office
CIEM	Curriculum, Instruction and Education Management
CMTA	Concept Mapping Teaching Approach
CTM	Conventional Teaching Methods
DNA	Deoxyribo-Nucleic Acid
FAWE	Forum for African Women Educationists
GOK	Government of Kenya
HIV	Human Immunodeficiency Virus
JICA	Japan International Cooperation Agency
KCPE	Kenya Certificate of Primary Education
KCSE	Kenya Certificate of Secondary Education
KICD	Kenya Institute of Curriculum Development
KIE	Kenya Institute of Education
KNEC	Kenya National Examinations Council
MOEST	Ministry of Education, Science and Technology
NACOSTI	National Commission for Science, Technology and Innovation
NG-CDF	National Government Constituency Development Fund
QASO	Quality Assurance and Standards Officer
ROK	Republic of Kenya
SDGs	Sustainable Development Goals
SDT	Self-Determination Theory
SMASSE	Strengthening of Mathematics and Sciences in Secondary Education
SMQ	Student Motivation Questionnaire
SSP	School Science Project
SST	Stimulus Sampling Theory
ST&I	Science, Technology and Innovations
STEM	Science, Technology, Engineering and Mathematics

STIs	Sexually Transmitted Infections
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Education Fund

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Science is essential in driving a nation's industrial and technological progress. Science, Technology, and Innovation (ST&I) are vital for fostering industrialization, economic growth, and achieving the Sustainable Development Goals (SDGs) (Republic of Kenya (RoK), 2021b). By 2030, Kenya and other African nations plan to achieve the 17 SDGs. This commitment follows the resolutions made during the September 2015 United Nations Summit in New York. These goals include eradicating extreme poverty, reducing hunger through food security and better nutrition, and promoting good health and well-being. They also highlight the importance of providing inclusive, equitable, quality education and lifelong learning opportunities for all (United Nations, 2015). It is therefore crucial to prioritize science and technology, as they are fundamental to realizing these goals. Science makes significant contributions to advancements in healthcare, communication, and economic growth.

Biology is one of the science subjects in the Kenyan secondary school curriculum (KICD, 2012). It has broad applications and is vital in economic, industrial, and agricultural development (Sani, 2012). Teaching Biology in secondary schools aims to equip students with relevant knowledge and skills to effectively communicate biological concepts professionally, logically, and rationally. It also encourages the application of biological knowledge to maintain personal, family, and community health. Furthermore, it provides foundational skills for further education and training in various scientific fields such as health sciences, agricultural sciences, and engineering (KICD, 2006).

Biological knowledge underpins agricultural practices, a vital sector that contributes significantly to Kenya's economic growth. Research in environmental conservation has also been considerably advanced through the application of Biology (Muraya & Kimamo, 2011). Forensic applications, such as DNA fingerprinting, have played a crucial role in resolving paternity disputes and identifying suspects in high-profile criminal cases. Additionally, biological science research has led to the development of early maturing animal breeds and disease-resistant crop varieties. These developments have made it easier to maintain global food security. Strong performance in Biology in the Kenya Certificate of Secondary Education (KCSE) examination is crucial for students who aspire to pursue careers in the fields of environmental sciences, agriculture, and health sciences. However, KCSE results from 2020 to 2024 show poor performance in Biology (KNEC, 2020-2024). A summary of

KCSE candidates' performance in the three Biology papers from 2020 to 2024 is provided in Table 1.

Table 1

Candidates' 2020-2024 KCSE Biology Papers Performance

Year	Candidature	Biology performance pe paper		Maximum possible score	National % Mean Scor
2020	651,236	Paper 1	16.03	80	29.50
		Paper 2	19.83	80	
		Paper 3	16.59	40	
2021	710,533	Paper 1	19.58	80	28.54
		Paper 2	21.73	80	
		Paper 3	15.72	40	
2022	752,154	Paper 1	24.04	80	28.68
		Paper 2	19.87	80	
		Paper 3	13.47	40	
2023	783,453	Paper 1	25.06	80	30.45
		Paper 2	18.93	80	
		Paper 3	16.91	40	
2024	830,512	Paper 1	27.38	80	33.75
		Paper 2	21.72	80	
		Paper 3	18.41	40	

Source: KNEC Reports 2020 - 2024

Table 1 presents the percentage mean scores in Biology in KCSE for the sampled years (2020-2024). The data show poor results, ranging from 28.54% to 33.75%. Biology paper 3 (231/3), which evaluates students' practical skills, has the lowest mean scores in most examined years. The low scores result from a lack of proper understanding of concepts in Biology, the inability to correctly use scientific language in communication, and the failure to make expected observations, leading to wrong conclusions (KNEC, 2022). According to the KNEC grading system, students who score 50% are considered average. Low Achievement would mean that learners have not acquired a basic understanding of biological concepts and skills. As a result, students' chances for admission into careers where Biology is a compulsory requirement are significantly limited (Wachanga *et al.,* 2015).

This could signal that understanding and eventual mastery of biological concepts still present major challenges to secondary school students. Additionally, the situation is more pronounced among girls than boys, yet mastery of biological concepts is crucial for good performance in this science subject (KNEC, 2021). This prevailing poor performance has been partly attributed to the use by Biology teachers of teaching approaches that do not foster active and meaningful learner participation in the learning process, with the majority opting for the application of Conventional Teaching Methods (CTM). Available data demonstrate that implementing various teaching approaches that engage learners can improve both academic performance and the desire to learn the subject (Ajaja, 2013; Kinchin, 2011; Ongowo *et al.*, 2011; O'Neill & McMahon, 2005; Smith, 2010; Stanisavljević & Stanisavljević, 2014).

The Achievement in Biology in Kitui County has consistently been below the national mean score (CDE Kitui County, 2022). This demonstrates an inadequate understanding of concepts and the acquisition of skills in Biology among students. This has raised concerns among stakeholders, including education officers, parents, school Boards of Management (BOMs), and school sponsors. Table 2 presents a summary of the Biology KCSE examination results for students in Kitui County between 2020 and 2024.

Table 2

Candidates' Overall Performance in KCSE Biology Between 2020 to 2024 in Kitui County

Year	Candidature	KCSE Biology percentage Mean Score
2020	24,439	26.00
2021	24,705	24.63
2022	25,358	23.82
2023	25,781	29.62
2024	26,143	31.35

Source: CDE Kitui County Report on KCSE results 2020- 2024

According to the statistics in Table 2 above, Kitui County students' average Biology scores have remained continuously low across the sampled years (2020–2024). It indicates that Achievement in Biology among students from the County in the KCSE examination in the sampled years was poor, ranging from 23.82 to 31.35%. It also indicates that performance in Biology in 2022 was the lowest among the sampled years. This low Achievement in Biology has raised serious concerns among education stakeholders, namely, parents, schools' Boards of Management (BOMs), and school sponsors (KNEC, 2022). This poor performance in Biology has led to low enrollment in STEM courses by form four graduates in tertiary institutions. Students' achievement in Biology can be adversely affected by various factors, including perceptions of the subject as being inherently difficult, reliance on teacher-centred instructional approaches, inadequate teaching and learning resources, and limitations in teachers' academic competence (Ongowo *et al.*, 2011).

To achieve excellent performance in this key science subject, those responsible for teaching must adopt learner-centred active learning approaches. These approaches have improved students' scientific skills (Ministry of Education, 2012). However, teachers have relied mainly on Conventional Teaching Methods (CTM) when instructing their students in Biology. Additionally, it has been noted that the most commonly used method is the chalk-and-talk approach (Abogonye, 2015). Various stakeholders have emphasised the need to adopt teaching methods that promote active learner engagement in the construction of knowledge (Weimar, 2013). Gender should also be considered in students' academic Achievement (Musa & Samuel, 2019). According to KNEC (2021), girls scored lower in the KCSE Biology examinations than boys. Similarly, UNESCO (2020) reports that girls perform worse in Biology than boys. Gender stereotyping contributes to gender inequality (UNESCO, 2020). Girls should be taught with approaches that equip them with the skills and knowledge to overcome gender stereotypes and boost their self-esteem (Republic of Kenya (ROK), 2022). Table 3 presents the performance of candidates in Biology by gender from 2020 to 2024.

Table 3

KCSE Biology Mean Scores by Gender Between 2020 and 2024 in Kenya

Year	Male Candidates		Female Candidates	
	Enrolled candidates	**Average Score (%**	**Enrolled candidates**	**Average score (%)**
2020	343,911	31.17	307,325	27.83
2021	383,505	28.33	327,028	26.75
2022	387,562	29.84	364,592	27.52
2023	425,170	31.75	358,283	29.17
2024	461,921	36.69	368,591	30.81

Source: Kenya National Examinations Council (KNEC) Reports, 2020 –2024

For sampled years, there were more male candidates than their female counterparts. Male candidates outperformed the female candidates throughout the sampled years, as shown in Table 3. There was no period within the sampled time when female students performed better than male students, or even at the same level. To achieve gender parity in Biology performance, the relevant teaching approaches that provide equal opportunities for participation by girls should be employed (UNESCO, 2023). Teachers' use of instructional approaches that emphasize rote memorization rather than engaging learners in critical thinking and knowledge construction may have contributed to poor achievement in Biology (KNEC, 2024). Therefore, this led to the current research investigating the effects of using CMTA to improve students' Achievement and motivation to learn Biology in Kitui County, Kenya.

Concept mapping has been regarded as one of the ways that an instructor facilitates learning in the framework of student-centred approaches. Knowledge can be arranged and represented graphically with concept maps. According to Ebenezer and Conner (1998), concept maps illustrate concepts and their interrelationships, using a preposition to connect each pair of related concepts. According to Novak and Gowin (1984), concept mapping is a hierarchical method of organising ideas that begins with more basic concepts and moves on to more specific or less general thoughts. By showing the relationships between concepts, concept mapping has been found to support meaningful learning (Adamczyk *et al.*, 1994; Fisher *et al.*, 2000; Novak & Gowin, 1984).

Conceptual change, motivation, and cognitive engagement have all been found to be correlated. In the end, highly motivated students are more likely to participate fully in class activities, which raise performance levels (Nelson, 2000). According to Novak and Gowin (1984), CMTA helps students build meaningful learning by allowing them to integrate new material into their previous knowledge. Learning becomes more effective when new material is integrated with previously learned knowledge. Higher-order thinking abilities, critical reasoning, and information retention are all improved by this reinforcement.

Research by Keraro *et al.* (2007) observed that the Cooperative Concept Mapping Teaching Approach generated interest in learning biology among high school students in Gucha District. Therefore, it increased their motivation to learn. Furthermore, Otieno (2015) found that concept mapping improved the teaching process and students' attitudes toward learning physics in sampled public secondary schools in Nairobi. Ongowo *et al.* (2011) found that the integration of concept mapping in the teaching of biology increased motivation in the students and thereby the outcome. The results indicate that student engagement may be enhanced by getting the teachers to use a more interactive method of delivering lessons to them, so that learning is improved. The research was also implemented to ascertain how it is possible to teach girls and boys to obtain comparable outcomes on the examinations. The study's objective was to investigate the impact of CMTA on the academic performance and motivation of Biology students in Kitui County, Kenya.

1.2 Statement of the Problem

Biology is the cornerstone of life sciences. It plays vital roles in addressing some of humanity's most pressing challenges. Some of these include eradicating extreme poverty, mitigating hunger through food security and enhanced nutrition, and ensuring healthy lives for all. Despite the critical role Biology plays in various career pathways, its overall performance in the KCSE in Kitui County between 2020 and 2024 has remained consistently low, with mean scores ranging from 23.82% to 31.35%. The trend implies there is an incessant weakness in the teaching and learning of Biology. One of the factors is perhaps the persistent teacher-centered teaching approach used by Biology teachers, which encourages rote learning instead of meaningful learning that enhance cognitive gain. This scenario presents the necessity to consider other teaching options that could raise the interest of the learners in the subject, as well as boost their performance. Concept Mapping Teaching Approach (CMTA) may be a workable approach for teaching that may be applied to solve the problem of low grades in Biology. Nonetheless, it has limited documented research evidence of its use in Kitui County, Kenya. This study, therefore, seeks to fill this research gap by examining the effects of CMTA on the achievement and motivation of secondary school students to learn Biology in Kitui County, Kenya.

1.3 The General Objectives

This study aimed to determine the effects of the Concept Mapping Teaching Approach (CMTA) on the academic achievement and motivation of secondary school students in Kitui County. Students' gains in achievement and motivation were compared between those instructed with CMTA and those exposed to CTM.

1.3.1 Specific Objectives

The following four objectives guided this study:

i. To compare Biology achievement between students instructed through CMTA and those taught using CTM.

ii. To examine the effects of CMTA and CTM instructional approaches on students' motivation to learn biology.

iii. To examine the impact of gender on students' achievement in Biology when taught through CMTA.

iv. To assess gender differences in students' motivation to learn Biology when exposed to CMTA.

1.4 Hypotheses of the Study

The following null hypotheses were tested:

$H_0$1: There is no significant statistical difference in the Biology achievement of students instructed using CMTA compared to those taught using CTM.

$H_0$2: There is no statistically significant difference in motivation to learn Biology between students taught using CMTA and those taught using CTM.

$H_0$3: There is no statistically significant gender difference in Biology achievement between students exposed to CMTA.

$H_0$4: There is no significant statistical difference in students' Biology motivation based on gender when taught using CMTA.

1.5 Significance of the Study

The following organisations and individuals would benefit from the study's findings: - First KICD in reviewing and organising the secondary school Biology curriculum by developing educational materials that support the teaching of Biology. The conclusions would also enable KICD to develop suitable approaches for teaching Biology at the high school level. Second, the institutions in charge of Biology teacher education. The findings can be applied to improve teacher education programs designed to develop qualified Biology teachers who encourage students' participation in the classroom rather than treating them as passive information consumers. Third, it would support Biology teachers in developing and implementing effective teaching practices that lead to active learning instead of memorisation. Finally, Biology students' achievement is likely to improve as the study may provide a huge blueprint for coaching and learning that may be applied in the Biology classroom.

1.6 Scope of the Study

The study focused on Biology students in the fourth form at secondary institutions in Kitui County, Kenya, that were co-educational. Given that they teach male and female students in the same classroom, the Sub-County coeducational secondary schools were chosen for this study. This made it easier to assess the differences in achievement and willingness to learn Biology across genders. Additionally, students from the same region who exhibit similar entry behaviour to their programs get admitted to those institutions. The topic of support and movement in animals was selected for study because it remains a persistent challenge for both teachers and learners (KNEC, 2020). This strand is incorporated into the form four Biology curricula in all secondary schools in Kenya (KICD, 2012). The strand covers a wide range of pertinent concepts that describe the processes by which animals progressively change their position and maintain their body weight and form. The high school Biology curriculum served as the foundation for the educational materials that were created. After the intervention had been in place for a month, a post-test was given. According to the curriculum for the KICD Biology course, the topic of support and movement in animals is covered in 20 sessions, or four weeks. The study's goal was to investigate how CMTA affected secondary school Biology students' academic achievement and interest.

1.7 Limitations of the Study

Different conditions and situations limited the research study. First, school administrators do not permit restructuring entire classes for research purposes. Therefore, there was no randomisation of the study's participant population (Mills & Gay, 2016). Consequently, schools with multiple streams received the same treatment. However, one stream was selected for data analysis using simple random sampling. Second, the study's findings were specific to the sampled schools and may differ from those in other schools due to their distinct characteristics. Consequently, it is possible to apply the investigation's findings to the secondary institutions in Kitui County that were part of the sample with caution.

1.8 Assumptions of the study

Here were the study assumptions:

i. The experimental and control groups were from schools of the same type and followed the same admission procedures, which made their classroom learning conditions comparable.

ii. The responses provided by the respondents in the BAT and SMQ comprised the complete and accurate documentation of their individual, impartial, and autonomous opinions.

1.9 Definition of Terms

Achievement: It is a successful accomplishment or completion (Oxford dictionary). For this study, it denotes students' scores on the Biology Achievement Test (BAT) on the topic of support and movement in animals.

Co-educational secondary school: It signifies a learning centre that caters to both boys and girls within the same institution (Wambugu *et al.,* 2013). In this study, it denotes institutions in which students of both gender engage collectively in the learning process within a traditional classroom context g.

Concept Mapping: depicts relations among the most essential components (Enebechi & Nzewi, 2017). In this study, concept map refers to diagrammatic representation of concepts to show the relationship between major and minor concepts in support and movement in animals

Conventional Teaching Methods: According to Wachanga *et al.* (2015), these are exposition-based teaching and learning approaches in which students are treated as passive consumers of knowledge. In this research, it implies teaching approaches where a teacher instructs while passive learners observe and listen, for example, the lecture method.

Effects: it means the change caused by the action (Hornby, 2000). In this study, it means a change in behaviour due to treatment.

Gender: Highlights how male and female learners adopt different social roles, which could affect their capacity to learn Biology at school (Wachanga *et al.,* 2015). It refers to a student's classification as either male or female.

Instructional Concept Maps: These are diagrams that depict suggested relationships between concepts (Enebechi & Nzewi, 2017). In this study, they are visual instructional instruments used to organise and represent knowledge, as well as to demonstrate the associations among concepts.

Motivation: It refers to a student's innate desire to learn (Oxford dictionary). In this research study, they refer to scores attained by students in Student Motivation Questionnaires.

Performance in Biology: This is the mark that the students get upon sitting the Biology examination. In this study, it is defined as the measurable level of students' success in the Biology test, as indicated by their standardized test scores.

Teaching Approach: It means the methods that have been taken up to facilitate the organisation and presentation of content in a manner that facilitates learning (Omondi *et al.,* 2018). For this study, it means designing as well as supporting learning activities.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of relevant literature regarding the research topic. It examines the importance of Biology at the secondary school level in Kenya, the formulation of a curriculum to teach Biology in Kenyan secondary schools, and the intended learning outcomes of Biology in secondary schools in Kenya. It also examines the trends in the achievement of Biology among Kenyan secondary school students, investigates gender disparities in performance, and explores key factors that influence the students' interest to learn Biology. It also outlines the various categories of motivation applicable to Biology instruction, and it emphasises the role of the teacher in creating a favorable learning environment. Furthermore, it examines the relationship between Biology students' performance and motivation and provides a comprehensive discussion of the Concept Mapping Teaching Approach (CMTA) and critically examines the instructional approaches implemented in Kenyan secondary school Biology classrooms. The conclusion of the chapter presents a discussion of relevant learning theories and an analysis of the theoretical and conceptual framework supporting the study.

2.2 Significance of Teaching Biology in Kenyan Secondary Schools

Biology education can be intrinsically and extrinsically oriented. The intrinsic aspect looks at the study of Biology to further the field. In contrast, the extrinsic aspect concentrates on the learning process as an acquisition of skills, knowledge, and attitudes that serve the development of society. Biological knowledge, therefore, functions for academic as well as social purposes. Academically, it involves gaining scientific knowledge, skills, and competencies applicable to biotechnology, agriculture, and medicine. Socially, it prepares individuals for careers in economic and technology-related sectors. Today, Biology plays a crucial role in various fields, including health and nutrition, and is essential in medical advancements that combat diseases such as cancer and HIV/AIDS. Additionally, environmental conservation fosters an appreciation for biodiversity, promoting sustainable living, while biotechnology continues to enhance agricultural development.

Biological knowledge has been widely applied in various industries, including bread baking, beer brewing, milk processing, and waste management. It also plays a crucial role in forensic science, helping to identify criminals involved in serious crimes such as murder and rape. Additionally, Biology has been instrumental in population control efforts (Brown, 1995).

Due to its broad relevance, Biology is an essential science subject in the Kenyan secondary schools' curriculum.

2.3 Evolution of Secondary School Biology Curriculum in Kenya

The initial post-colonial curriculum was formulated in 1963. It was mainly driven by both a teacher and book-centred approach, hence it was considered unsuitable because it neglected the fact that learners pursue broad interests and are equipped with a wide variety of capabilities and potentials (Eshiwani, 1985; Kenya government, 1976). It therefore failed to demonstrate the activities learners undertake during the learning process. Another Biology curriculum was introduced to address the shortcomings of the existing curriculum. The UNESCO pilot project was developed in 1967. The teacher conducted all the experiments, while the students observed and recorded what they saw. For this reason, the teaching technique was teacher-centred, which necessitated continued exploration of a learner-centred curriculum. Kenya established a new curriculum in 1968, known as the Nuffield Project. This curriculum strongly emphasised the application of problem-solving and discovery methods when teaching and learning science. However, due to the massive importation of books and equipment for use in Kenya, the initiative failed soon after it was adopted. Even with its learner-centred approach, it was unable to meet Kenyans' needs (UNESCO, 2007).

A new curriculum known as the School Science Project (SSP) was developed in 1973. Wachanga (2005) observed that the SSP was identical to the Nuffield project; however, the significant difference was that the former sought to utilise locally available materials. Eshiwani (1993) also notes that because most schools in Kenya could not afford the demands of SSP, which required appropriately equipped laboratories, skilled teachers, and a good school environment, very few schools executed it. The shortcomings of the SSP also led to the introduction of a substitute science curriculum, known as the traditional curriculum, in 1973. This alternative curriculum offered three feasible options: Pure, General, and Physical science. The choices were primarily influenced by the readily available instructional materials the school had on hand. This substitute curriculum was offered in conjunction with the SSP, but in most cases, the SSP was primarily provided in schools that were best equipped. As previously mentioned, this led to various schools in Kenya providing different curricula, prompting the education ministry to develop a new curriculum in 1981, known as the New Kenya Examination Council Syllabi. Additionally, learning Biology became mandatory for form one and two students with the introduction of the 8-4-4 school system in 1985.

The main objective of various curriculum reviews in Kenya was to develop a curriculum that would better prepare graduates for the global landscape (Republic of Kenya, 2012a). A key focus was implementing a student-centred, research-based teaching approach, leading to an increased emphasis on project-based learning in Biology education. The options considered were the 8-4-4 Biology and 8-4-4 Biological Science curricula. However, the 2002 revisions introduced a pure Biology curriculum, which is still in use today. Despite efforts by curriculum developers to promote student-centred teaching approaches, Biology instruction in secondary schools has largely remained conventional and lecture-based (KICD, 2013; Maundu *et al.*, 1998; SMASSE, 2004). This continued reliance on Conventional Teaching Methods (CTM) may be one of the reasons for the persistently low performance in Biology.

2.4 Goals of Teaching Biology in Secondary Schools in Kenya

According to KICD (2012), the primary objectives of teaching Biology in Kenyan secondary schools include enabling students to clearly and accurately explain biological concepts. Additionally, learners must learn how the plants, animals, human beings, and the surrounding environment relate to each other. They must also use their biological knowledge in enhancing the protection and strengthening of individual, family, and community health. Besides, the students will be required to analyse and determine the features of both the familiar and unfamiliar specimens, which will facilitate classification of organisms, together with how the various parts of the body work. KICD added other objectives to achieve better learning, which are to provide a positive attitude and interest towards Biology, build skills on practical matters, and incite scientific reasoning, technical prowess, and resourcefulness. In addition, a cooperative problem-solving approach should be learnt by the students and they should develop a firm grip of biological knowledge, skills, and attitudes required to meet future research and challenges in a science-related career.

The Biology curriculum has a practical part in all the topics, and this serves as a practical learning experience. It provides answers to modern problems like HIV/AIDS, sexually transmitted diseases (STIs), and drug abuse as well. The curriculum is designed and held to last four years, with a particular time dedicated to each of the topics. It comprises seventeen learning areas that are taught for four years. KICD underlines that teaching approaches to be employed by teachers of Biology must be of such a nature that they provide students with opportunities to interact with the process of learning. In this study, CMTA was applied to ascertain the effects of the achievement and motivation of students on learning Biology.

2.5 Biology Achievement in Secondary Schools in Kenya

Biology is a key science discipline in the Kenyan educational system. Various factors have impaired the performance of students in this subject, including the teaching approaches applied by the teachers, accessibility of the teaching and learning materials, as well as the interest of the students, among others. The performance of students in Biology in the Kenya Certificate of Secondary Education (KCSE) test has been influenced by a variety of circumstances over the years. Although some students demonstrate exceptional levels of performance, others are incapable of fulfilling the necessary evaluation criteria. Those schools with properly equipped laboratories, competent teachers, and access to the latest learning materials are likely to produce students with better performance compared to the schools that lack such teaching and learning resources.

Conversely, the Kenya Certificate of Secondary Education (KCSE) examination is implemented to evaluate students' comprehension of Biology in Kenyan secondary schools. This examination is administered to the students after they have completed four years of formal education. The low achievement in Biology among secondary school students in Kenya has been a major concern (RoK, 2012a). Investigations have revealed that achievement in Biology among students at the KCSE level is poor (Ongowo & Indoshi, 2013). According to KNEC (2024), Biology results at the KCSE level fall significantly below the 50% benchmark. Moreover, Situma and Sawamwa (2010) highlighted that a considerable number of KCSE candidates perform poorly in science subjects. Furthermore, upon enrolling for the Kenya Certificate of Secondary Education (KCSE) examination, candidates who score exceptionally well in the science subject at the Kenya Certificate of Primary Education (KCPE) level end up faring poorly in the same subjects.

Over the years, student achievement in Biology at the secondary level has remained unsatisfactory (Ali *et al.,* 2014). Nationally, KCSE Biology performance has been consistently low, with reports showing a decline in students' academic Achievement (KNEC, 2023). The Ministry of Education, Science, and Technology (MOEST) has embarked on a project of improving teaching and learning strategies by instituting another program that involves mitigating teaching and learning with the assistance of JICA, the SMASSE initiative (RoK, 2014). MOEST and JICA have also provided projects aimed at erecting and furnishing science laboratories to enhance the quality of teaching and learning in science subjects because of low performance. The best solution for implementing solutions to these challenges involves a multi-pronged strategy that comprises the recruitment and training of science teachers, government investment in educational infrastructure, and ongoing evaluation of curriculum. Kenya can resolve these issues and improve students' performance in Biology, thereby contributing to the development of a scientifically literate society.

2.5.1 Gender Differences in Biology Achievement in Kenya

According to Akani (2017), gender has a major impact on students' academic achievement in the discipline of Biology. In 2017, the United Nations Children's Fund (UNICEF) found that secondary school biology students in Kenya continue to perform differently based on their gender. Males have been observed to outperform females in the Biology examinations that are part of the Kenya Certificate of Secondary Education (KCSE) (UNESCO, 2021). Furthermore, compared to their male counterparts, female students are less likely to seek post-secondary education in STEM (science, technology, engineering, and mathematics)-related sectors (UNESCO, 2021). In a 2023 study on STEM, the Forum for African Women Educationalists (FAWE) found that gender norms and stereotypes were the main causes of secondary school students' low interest in and performance in biology and other science courses. According to a baseline survey done in 2022 by the Kenya National Examinations Council (KNEC), form two Biology students scored an average of 26.8 percent. The minimal competency standard of 50% is significantly higher than this result (KNEC, 2022).

The data additionally implied that larger numbers of boys attained the 50 % proficiency in Biology as compared to the girls. It has been argued that teacher attitude has partly contributed to this gender disparity of performance since the teachers tend to set low academic standards against female students (KNEC, 2022). Such factors as the lack of access to sanitary towels or difficulties with pregnancy also reduce the number of females who take Biology courses (KNEC, 2022). The gender disparity is also present among the Biology teachers, whereby male teachers outnumber female teachers (KNEC, 2022). There is some research supporting this idea based on gender imbalances in the staffing of teaching staff in schools that lead to inequality in the enrollment and achievement of students in the Biology department (Limo & Kipkoech, 2017). According to KNEC (2022), in schools that have a relatively high male teacher population in the Biology department, female students might not be encouraged to take careers related to Biology because they lack role models. The report goes further to indicate that 65.7 % of Biology teachers are male compared to 34.3 % of female ones (KNEC, 2022).

2.6 Motivation

Motivation is defined as a psychological process that stimulates behaviour towards a particular goal, and it causes action (Orora *et al.,* 2005). Motivated students work in the classroom with enthusiasm, eagerly, concentrate, and are dedicated to their studies. Conversely, lack of motivation is normally depicted in the failure by the students to be keen and create havoc (Kiemer *et al.,* 2018).

2.6.1 Categories of Motivation

Motivation is categorized into two main types namely intrinsic and extrinsic. Intrinsic motivation in education is the student's internal drive to know something because they have a personal interest in the topic, they enjoy learning, and they get satisfaction out of knowing the topic. Such motivation is driven by the sense of curiosity, the impulse to know, a desire to feel competent, and a desire to become personal (Gopalan *et al.,* 2017; Lepper *et al.,* 1973; Morgan, 1983). Intrinsic motivation is self-generated; hence, Ryan and Deci (2000a) define intrinsic motivation as a natural tendency that pushes an individual to learn new things. Conversely, extrinsic motivation is determined by external forces and is aimed at the realisation of particular results. As an example, students who commit their efforts to achieve high grades are people who are extrinsically motivated. Still, learners who actively engage in the learning process and demonstrate strong enthusiasm for their learning activities are considered as intrinsically motivated According to Keller (1983), educators should consider four key factors when evaluating student motivation:

i. **Interest** – the level of a student's curiosity and how long it lasts.
ii. **Relevance** – the student's perception of how the learning material relates to their needs or goals.
iii. **Expectancy** – the student's belief in their ability to succeed academically through personal effort and control; and
iv. **Gratification** – the learner’s internal drive and response to external rewards.

Research suggests that effective and consistent teaching approaches are more successful in addressing student disengagement than direct motivational strategies (Christensen, 1978). For example, removing grades from examinations and encouraging students to engage in activities such as creating concept maps in Biology may help increase their interest in the subject and enhance cognitive development (Davis, 1999; Lepper, 1988). Therefore, the Concept Mapping Teaching Approach (CMTA) can effectively improve student engagement and learning outcomes. This is because it is designed to encourage learners to develop their knowledge actively.

2.6.2 The Teachers' Role in Creating a Motivational Learning Environment

According to Mangal (2007), Teachers enhance student motivation by employing learner-friendly techniques. Motivation can be improved through child-centred approaches, connecting new learning to prior knowledge, and using praise or constructive criticism strategically. The teacher's role in motivation involves creating a classroom environment that fosters engagement, guidance, and sustained interest in learning (Hiver, 2022). This role significantly influences learning dynamics and group cohesion, ensuring students remain enthusiastic about educational goals and assigned or self-initiated tasks. Hiver (2022) further explains that teachers establish conditions that make students' learning efforts more purposeful and productive. By cultivating an atmosphere where students experience academic success through achieving their personal and school-related goals, teachers contribute to their motivation.

Additionally, a teacher's attitude, enthusiasm, and interest in the subject may influence students' motivation to learn (Singh & Singh, 2021). Singh and Singh (2021) also emphasise that teachers can further support student motivation by respecting their choices and fostering autonomy in learning. Moreover, instructors encourage students' competence by providing constructive feedback, which helps learners refine their skills and build confidence (Ames, 1990; Johnson, 2017).

2.7 Students' Achievement and Motivation

Urhahne and Wijnia (2023) define motivation as the direction, initiation, intensity, and persistence of behaviour. It is the process through which goal-oriented activities are regulated and sustained. Students express motivation in various ways; for example, they may strive to master the spelling of a specific Biology term as a short-term goal or work toward a long-term aspiration, such as becoming a microbiologist. Furthermore, research suggests that teaching disengaged students can be highly discouraging for educators (Deci & Ryan, 2013). Consequently, motivation is regarded as a critical component of learning.

Educators often believe that when students are motivated to complete their assignments effectively, they engage in learning that aligns with their academic potential. As a result, teachers should strive to cultivate motivation in their students, as it enhances their learning outcomes. Additionally, motivation has been shown to help teachers manage their instructional schedules more efficiently, making lesson delivery less challenging. This stems from the belief that academically motivated students typically maintain a positive learning environment, requiring minimal disciplinary action. They remain focused, when necessary, as they are genuinely interested in the subject matter being taught (Nauzeer & Jaunky, 2021). Furthermore, teachers' professional motivation is closely linked to student motivation. When students are academically driven, teachers work harder to provide a meaningful learning experience, which in turn leads to greater job satisfaction.

Deci and Ryan (1991) categorised motivation into two primary types: intrinsic and extrinsic. When students perceive themselves as capable and self-sufficient, they are primarily driven by intrinsic motivation. This form of motivation is self-directed, meaning external influences have little impact on their sense of autonomy and self-regulation (Ryan & Deci, 2000b). Intrinsically motivated students engage with learning material out of genuine interest and a desire to master the subject, rather than relying on rote memorisation to achieve high grades. These students set clear objectives and participate in activities they find both personally rewarding and intellectually stimulating. They complete tasks voluntarily, without requiring external pressure (Ryan & Deci, 2000a).

According to Deci and Ryan (1991), students who are driven by outside forces frequently believe they are not competent or autonomous. Consequently, their behaviour is largely shaped and controlled by external influences. For instance, students lacking confidence in their abilities may focus on comparing themselves to peers they believe are more capable. This preoccupation with comparison can lead to distractions, making it difficult for them to concentrate on their tasks or experience the intrinsic satisfaction of completing them successfully. Instead, such students may become more concerned with how their teacher perceives their performance, whether they can receive assistance from classmates, the potential rewards for completing a task successfully, or how they compare to the top-performing student in the class. Extrinsic motivation is primarily driven by external pressures, including coercion, social recognition, rewards, fear of punishment, praise, and approval (Ryan & Deci, 2000b).

Clanton Harpine (2024) pointed out that fostering intrinsic motivation in students is not always straightforward. Lack of preparedness among learners to take ownership of their learning environment can undermine their sense of self-determination, ultimately resulting in decreased motivation. This indicates that intrinsic motivation results from the combined effects of perceived control and mastery. Therefore, educators should strive to cultivate intrinsic motivation while addressing these psychological factors. However, because inherent motivation is deeply rooted in an individual’s mental state, achieving an entirely intrinsic learning experience is difficult.

Academic achievement, on the other hand, refers to how well a student can apply and understand subject matter knowledge in a certain subject within a specified time. To properly deliver lessons, teachers must adhere to a set of rigorous instructional standards that are specific to each grade level. These guidelines serve as a methodical structure. Improving student performance by ensuring that instructional objectives are accomplished is one of the main goals of high-quality teaching practices. Biology students' final scores on the Kenya Certificate of Secondary Education (KCSE) Biology exam and their overall performance in their coursework are commonly used to gauge their academic success (Imanda, 2021).

Student achievement is primarily influenced by their needs, expectations, and the learning environment (Conger *et al.,* 2021). To effectively motivate students, educators must be observant and attentive to various factors that impact their engagement. Motivation represents the internal drive that students use to enhance their learning abilities. Educators are encouraged to adopt a constructivist approach for instruction, where students actively engage with learning materials to improve their understanding. According to Rohles *et al.* (2022), the development of meta-cognitive approaches plays a crucial role in fostering meaningful learning, enabling students to study more effectively. These approaches empower learners to take control of their learning process, allowing them to engage with the material in a personally meaningful way.

2.8 Methods Employed in Biology Instruction in Secondary Schools in Kenya ``

Among the many difficulties Biology education in Kenya has faced are the breadth of the curriculum, the accessibility of instructional resources, and the degree of readiness and experience of teachers. Due to inadequate training and the extensive curriculum, many teachers prefer to use the Conventional Teaching Method (CMT). According to Namasaka *et al.* (2013), the teaching approach adopted by educators has a significant influence on student performance. In Kenya, secondary school teachers predominantly rely on the Conventional Teaching Method (CMT), such as the lecture method and teacher-led discussions (SMASSE, 2007). Many educators favour teacher-centred approaches as they enable swift content coverage within a short time, often without ensuring that learning objectives are fully achieved. This heavy reliance on conventional teaching approaches may be cited as contributing to the declining performance of Biology in Kenya over recent years. Wachanga (2005) emphasises that teaching should be an evolving process in which instructional approaches are regularly assessed and modified. Therefore, integrating innovative teaching approaches that actively involve students and foster motivation could be a key solution to enhancing academic Achievement in Biology.

2.8.1 Lecture Method

The lecture method, known as the "chalk and talk" approach, involves delivering information based on a well-structured framework (Namasaka, 2009). Because it focuses primarily on the transfer of knowledge from the instructor to the student, who is the participant, this approach is considered teacher-centered. Because they play a passive role in the learning process, students gain knowledge with little involvement. Despite its efficiency in delivering content logically and sequentially within a short period, the lecture method has several limitations (Young, 2014). Students often struggle to grasp complex Biology concepts as the approach does not encourage active learning. Lengthy lectures can become monotonous, notably if the teacher lacks practical communication skills.

Additionally, the approach neglects research-based learning, which is fundamental in modern scientific education. Furthermore, the approach limits students' opportunities for critical thinking and active participation. CMTA addresses these challenges by promoting an interactive, student-centred learning environment. Unlike the lecture style, the CMTA method encourages students to interact with the content through discussion and inquiry. By allowing students to create their knowledge rather than just absorb it actively, it promotes the growth of a deeper understanding.

2.8.2 Demonstration Method as a Teacher-Centred Approach

As a teacher-centred instructional approach, the demonstration method is one in which the educator actively performs an experiment, illustrates a concept, or showcases a skill while students observe. The primary role of the students is to watch, listen, and occasionally respond to questions, making it a largely passive learning approach (Namasaka, 2009). The teacher remains the primary source of knowledge, directing the lesson, controlling the pace, and ensuring students follow along without much active involvement in constructing their understanding. Since students are mostly observers, they may not develop problem-solving and critical-thinking skills essential for scientific inquiry (Namasaka *et al.*, 2013). CMTA offers an alternative to the passive nature of the demonstration approach by encouraging active student participation and fostering collaborative learning. Unlike the demonstration method, in situations where the teacher is the main information source, CMTA focuses on the students, allowing them to explore, inquire, and construct their understanding of concepts.

2.8.3 Recitation and Rote Learning as Teacher-Centred Approaches

Recitation and rote learning are teacher-centred instructional approaches in which students memorise and repeatedly recall information as instructed by the teacher. These methods emphasise repetition and verbal recall rather than deep comprehension or critical thinking (Namasaka, 2009). The teacher plays a dominant role by presenting information, prompting students to repeat it, and assessing their ability to recall facts verbatim. While these approaches can help memorise definitions, formulas, or scientific terminology, they do not necessarily foster conceptual understanding. CMTA offers a student-centred alternative that encourages active participation, critical thinking, and deep comprehension, rather than relying on rote learning. Additionally, CMTA emphasises experiential learning, inquiry, and problem-solving, ensuring that students not only recall facts but also understand and apply them in various contexts.

2.8.4 Teacher-Centred Discussion Approach

Teacher-centred discussion is an instructional approach in which the teacher directs and controls the conversation, while students participate in a limited capacity. In this approach, the teacher asks questions, provides explanations, and guides the discussion based on predetermined content, with little room for student-led exploration (Namasaka, 2009). Although it allows some level of interaction, the teacher remains the primary source of knowledge, limiting students' ability to develop independent thinking skills. Students often rely on the teacher's guidance rather than exploring ideas independently, which restricts their creativity and critical thinking (Rohles, 2022). While students may contribute to the discussion, they often respond to teacher-led questions rather than initiating inquiries or leading debates (Bryan *et al.*, 2011). CMTA shifts the focus from a teacher-dominated discussion to a student-centred approach that encourages active engagement, collaboration, and critical thinking.

2.8.5 Textbook-Based Teaching Approach

The textbook-based teaching approach is a teacher-centred instructional approach in which the teacher relies heavily on textbooks as the primary source of information. In this approach, lessons are structured strictly around textbook content, with little room for student exploration beyond the prescribed material. The teacher controls the pace and focus of learning, often limiting students to memorising information rather than engaging in critical thinking or hands-on activities (Namasaka, 2009). Textbook-based teaching leaves little room for inquiry-based learning, problem-solving, or creative explorations, as students follow a predetermined set of facts rather than developing their own ideas (Biggs, 2017). CMTA enhances learning by engaging students in active, inquiry-driven, hands-on learning activities rather than relying entirely on textbooks.

2.9 Concept Mapping Teaching Approach

Jamil *et al.* (2024) describe a concept map as an instructional tool that helps students structure their learning effectively. Initially introduced as a classroom activity at Cornell University, concept mapping involves visual diagrams depicting the relationships between at least two concepts. This approach clarifies how primary concepts relate to other concepts, thereby improving students' understanding of the content (Keown, 2008). Concept maps serve as valuable tools for illustrating knowledge structures in a logically organised and cognitively meaningful way. Concept maps can be constructed using various methods. Novak and Gowin (1984) proposed a straightforward technique in which learners are given a list of related concepts organised hierarchically, with the most comprehensive concepts at the top and progressively less detailed ones below. This method requires students to determine the most effective way to structure the hierarchy and select appropriate linking words to illustrate relationships between concepts. Another approach involves identifying key terms within a text and using them to create a hierarchical concept map. A more imaginative solution would mean having students create a concept map on their own and based on their previous knowledge of a specific subject.

The concept mapping as the assessment tool consists of two main elements: the task that students do to show their knowledge about a concept, and the rubric that teachers utilise to assess their knowledge. Teachers have been looking into how concept mapping could be used in most of the subject areas. As an example, Hinck *et al.* (2006) examined its facilitating potential concerning meaningful learning during nursing education in the U.S. The same study was carried out in Canada (Oyeyemi *et al.*, 2024), in Saudi Arabia (Almulla & Alamri, 2021), or in Nigeria (Udeani & Okafor, 2012) to outline concept mapping as an effective instructional method. These results confirm those of Novak (1993), who stressed the importance of concept mapping in helping students to increase their knowledge and clear their misunderstandings. Concept mapping is a learning strategy organised for enabling learners to identify, relate, and combine various ideas. It brings a holistic approach to subjects, it reduces fear towards tough subjects, and bridges the gap between gender disparity in science education (Jr, 1987). It also improves long-term memory, allows easy retention of knowledge, and allows good problem-solving skills.

The idea of concept mapping enables the students to assemble and combine information, analyse the given current knowledge, and more thoroughly understand the topic. The method will help the pupils organise, internalise, and synthesise a variety of concepts, which improves their critical thinking ability. This clarity in understanding of the topic can be achieved because students can see their knowledge in diagrammatic form and check where they have misconceptions and violations. The idea of concept mapping has been embraced as an effective pedagogical tool in the context of encouraging meaningful learning. It helps the students to structure new knowledge, summarise and refine the existing knowledge, as well as connect the unknown concepts into a clear and coherent pattern (Sakiyo & Waziri, 2015).

The findings of the research depict that concept mapping is critical in realising curriculum improvement, especially in Biology learning. This strategy, when taken to Kenya, would be very useful because a large number of students find that Biology is quite hard to cope with because its concepts are intertwined. These complexities cannot be covered well using the rote method of learning in secondary schools. On the contrary, concept mapping enables meaningful learning, and it is an adequate approach to teach Biology (Namasaka *et al.,* 2017).

According to Alqasham and Al-Ahdal (2022), a combination of traditional and digital concept mapping methods can be used to improve the educational outcomes of students and stimulate them to take part in the classes. Likewise, Ahmed *et al.* (2021) found that the use of concept mapping in learning enhanced critical thinking and improved the academic performance of the learners. Moreover, Charity and Ebikebuna (2022) stated that those learners who were introduced to basic technology using Concept Mapping showed more interest in that topic compared to their counterparts who were taught the same topic using traditional methods.

2.10 Teachers' Perspective on Concept Mapping Teaching Approach

Biology is one of the course subjects that is highly adapted to using concept mapping as a learning process (Oyeyemi *et al.,* 2024). The nature and the composition of biology allow the smooth integration of concept mapping into the study of Biology (Orora *et al.,* 2007; Pestana *et al.,* 2023). On an instructional level, the learning outcomes can be improved once the student is provided with techniques that can maximise their learning (Shi *et al.,* 2023). Biology teachers in secondary schools realise that concept mapping is an effective method because it is accurate in presenting subject matter, accurate in reflecting biological concepts in the course of experiments, and effective in adopting language. A few worthy benefits of concept mapping, as pointed out by the teachers, are that more students will now be engaged in practical study opportunities, time wastage will be minimised, students will now perform their tasks way better, and the classes will be more effective in their discussions (Shi *et al.,* 2023). Moreover, the concept mapping is especially helpful when it is applied regularly during test training (Appaw *et al.,* 2021). The teachers can also determine the knowledge of students depending on how they express desired learning results by applying their concept maps.

2.11 Criticisms of Concept Mapping Teaching Approach

Despite the high utility of concept mapping as a method of teaching, this tool has elicited the concerns of the educationists when it comes to its application in the educational process (Bramwell-Lalor & Rainford, 2014). Some scholars on the topic believe that science teachers need to have profound knowledge of the constructivist philosophy and the role concept mapping can play in developing the cognitive thinking of the students before they consider its use in the teaching and learning process (Bentley *et al.,* 2011; Horton *et al.,* 1993). Additionally, Bentley *et al.* (2011) emphasise the importance of training all teachers on practical approaches for integrating concept maps into their teaching practices.

Researchers have identified several challenges related to the concept mapping approach. One key challenge is that students need significant time to master the strategy and see measurable improvements in their test scores. Additionally, students must understand and value the benefits of concept mapping for their learning (Bentley *et al.,* 2011; Ruiz-Primo & Shavelson, 1996). Cheema and Mirza (2013) also suggest that errors can be spotted by either the instructor or the students during standard classroom discussions. However, they also point out that the nature of concept mapping activities can sometimes cause students to develop a defeatist attitude. Therefore, biology teachers must receive adequate training in the proper use of CMTA in the classroom when teaching biology and other scientific subjects.

2.12 Theories of Learning

Learning theories seek to explain the processes through which learning occurs. These theories provide a structured and systematic framework for understanding human learning. In Biology education, learning theories can guide the selection of practical instructional approaches. Accordingly, the study has identified several relevant learning theories, which are discussed below.

2.12.1 Jean Piaget's Cognitive Development Theory

According to Piaget (1983), one of the hallmarks of children's cognitive development is the creation of mental structures, commonly known as "mental maps." Active and adaptive building are characteristics that set this method apart. Because of these cerebral frameworks, children can understand and react to the physical experiences that take place in their surroundings. Additionally, Piaget distinguished four phases of children's cognitive development: the preoperational stage, which lasts from two to seven years of age; the concrete operational stage, which lasts from seven to eleven years of age; the formal operational stage, which lasts from roughly eleven to fifteen years of age; and the sensory-motor stage, which lasts from birth to two years of age. As children progress through these stages, they develop cognitive structures that enhance their understanding of the world and their sense of self (Piaget, 1983). Piaget viewed intellectual development as a biological function. He emphasised the growth and adaptation of cognitive processes, such as classification and counting, which evolve through active interactions with the environment. In Biology education, concept maps and experiments provide students with opportunities to engage in such interactions, fostering cognitive growth.

2.12.2 Repair Theory

VanLehn (1990), a leading proponent of Repair Theory, asserts that the theory focuses on how learners develop procedural skills, highlighting the importance of identifying and understanding the sources of their mistakes. The theory is centred on the concept that mistakes in a particular activity can be identified and fixed so that it enhances the performance of the learners, and the instructional style applied in teaching the process is also corrected. The theory also implies that procedural tasks involve mostly deduction or inference among students, and the cause of errors committed is due to the biases provided through examples and feedback received during the practice of such tasks. Essentially, it implies that learners will tend to commit errors when trying to apply the methods after the initial sample that is given to them. In turn, Repair Theory is of great interest in any learning process that deals with procedural knowledge.

2.12.3 The Constructivist Learning Theory

According to Efgivia *et al.* (2021), constructivism is the key concept that influences modern science education. Starting as a learning model, constructivism developed to be a complex theory of education embracing instructional tools, generation of concepts, and acquisition of personal and scientific knowledge. What is more, Efgivia points out that constructivism is a more effective way to reach an educational goal as compared to other models that only lay stress on cognitive development. Therefore, constructivism is largely known as a postmodern theory of knowledge. According to Agarkar and Brock (2017), constructivism should be more effective in learning theory and learning objectives as compared to other approaches to learning. They add that it not only influences instructional approaches, but constructivism is an ethical approach as it challenges the old way of objectively viewing science and knowledge. It is also about the reformation of the individual epistemologies, teaching, and student-teaching relationships.

Kusuma (2021) strengthens this point of view, saying that constructivism associates science learning with the process of creating a personal meaning. He says that it brings insights into how individuals learn something and gives a philosophical approach to different kinds of subjects. Similarly, Mathews (1998) indicates that constructivism resonates with the way human beings naturally think, and therefore affects science learning in addition to other disciplines. In addition, constructivism recognises that trainees are perceptive of the world in terms of cognition, hearing, sight, taste, and touch. Matthews (2021) says that these sensory perceptions construct how individuals develop the nature of reality. This supports the constructivist view that students bring prior knowledge into the learning process, shaping how they construct new understanding.

Henriksson *et al.* (2025) argued that knowledge is not acquired merely by passively absorbing external information. Instead, teachers play a crucial role in guiding students on how to learn effectively (Triantafyllou, 2022). To achieve this, educators must adopt a learner-centred approach, treating all students equitably while fostering an inclusive and supportive learning environment. This approach involves providing equal learning opportunities, actively listening to students, integrating their ideas and experiences, gently challenging their thinking, and supplying necessary resources. Additionally, teachers should encourage diverse forms of communication and cultivate scientific skills in all learners. Beyond mastering subject content, educators must also present information in a way that is engaging and motivating.

Science educators often face challenges teaching abstract and seemingly unrelated scientific concepts using constructivist approaches. Ogodo (2024) stresses that while hands-on experiences are essential, students must also engage with fundamental scientific concepts and frameworks. The primary challenge for educators is to support students in independently constructing these frameworks, understanding their significance, and applying them appropriately in various contexts. Science education faces several challenges, including low student motivation, teachers' limited content mastery, and inadequate school teaching and learning resources. However, constructivism has significantly enhanced science learning by recognising the role of prior knowledge, encouraging goal setting in instruction, and fostering active student engagement in the classroom.

2.13 Theoretical Framework

The constructivist learning paradigm guided the study. The majority of people believe that Jean Piaget was the one who formally established constructivism as a theory of learning. Piaget developed the processes by which students create and assimilate knowledge. According to Piaget (1965), assimilation and accommodation are the two main ways that people pick up new knowledge and skills. The process by which people incorporate new experiences into their established mental structures is known as assimilation. On the other hand, accommodation begins when new experiences conflict with previously learnt information. As a result, mental images are rearranged to make room for the most recent knowledge.

By applying constructivism, the student's position is changed from that of a passive information consumer to that of an active learner. A constructivist classroom is characterised by a learning process using collaboration and interaction. In most cases, students collaborate with the familiarity of the subject and activities, and with groups. This is in direct opposition to the traditional paradigm of a classroom, where typically the value of individual interaction with the student and repetition is stressed within the learning process. The study is based on constructivist ideas, which prioritise the usefulness of active and interactive generation of knowledge, the facilitative role of the instructor, the dynamic character of knowledge, which is adjusted to the current experience, and the importance of group work. Nurlinda *et al.* (2024) argue that it offers students the chance to engage in activities that demand them to use their hands, develop their critical thinking skills, and create new knowledge. The objective of this study was to examine the influence of the Concept Mapping Teaching Approach (CMTA) on the academic performance and motivation of biology students.

2.14 Conceptual Framework

Constructivist learning theory guided the development of the conceptual framework that formed the basis of this study. This method views the teacher as a facilitator who is responsible for creating an atmosphere that allows learners to learn and comprehend the subject matter on their own. The teacher in a constructivist classroom interacts with students by negotiating and using constant communication. This method will turn students who are considered to be passive learners into active learners. As opposed to the conventional classes, where the learners tend to work separately and rely on drilling, the learning in a constructivist classroom follows the principle of interaction and collaboration, where students group and extend their existing understanding. The Concept Mapping Teaching Approach (CMTA) is debated to be a good intervention for teaching support and movement in animals.

Figure 1 depicts the conceptual framework that was used in the study. The figure's left-hand part displays the independent variables, the middle section displays the intervening variables, and the right-hand section displays the dependent variables. Gender, Conventional Teaching Methods (CTM), and the Concept Mapping Teaching Approach (CMTA) were the independent variables taken into account for this study. The researcher observed that students' achievement and motivation levels, as the study's dependent variables, were significantly affected by the independent variables. Intervening variables, including the characteristics of the teacher and the classroom environment, may also influence the independent variables; however, this study did not consider them due to the researcher's inadequate awareness of their existence. For this study, teacher characteristics included teacher qualifications and the work experience of Biology teachers. As a result, the researcher employed educators who had worked as high school teachers for at least three years. For teacher qualification, the researcher used teachers with at least a diploma in secondary education. The classroom environment included the school type and the learners' academic abilities. Sub-county schools were used to check for the classroom environment because they enrol students with comparable KCPE marks. In this study, teaching approaches and gender were investigated as independent variables. Figure 1 illustrates the interaction among the independent variables, intervening variables, and dependent variables in the research study.

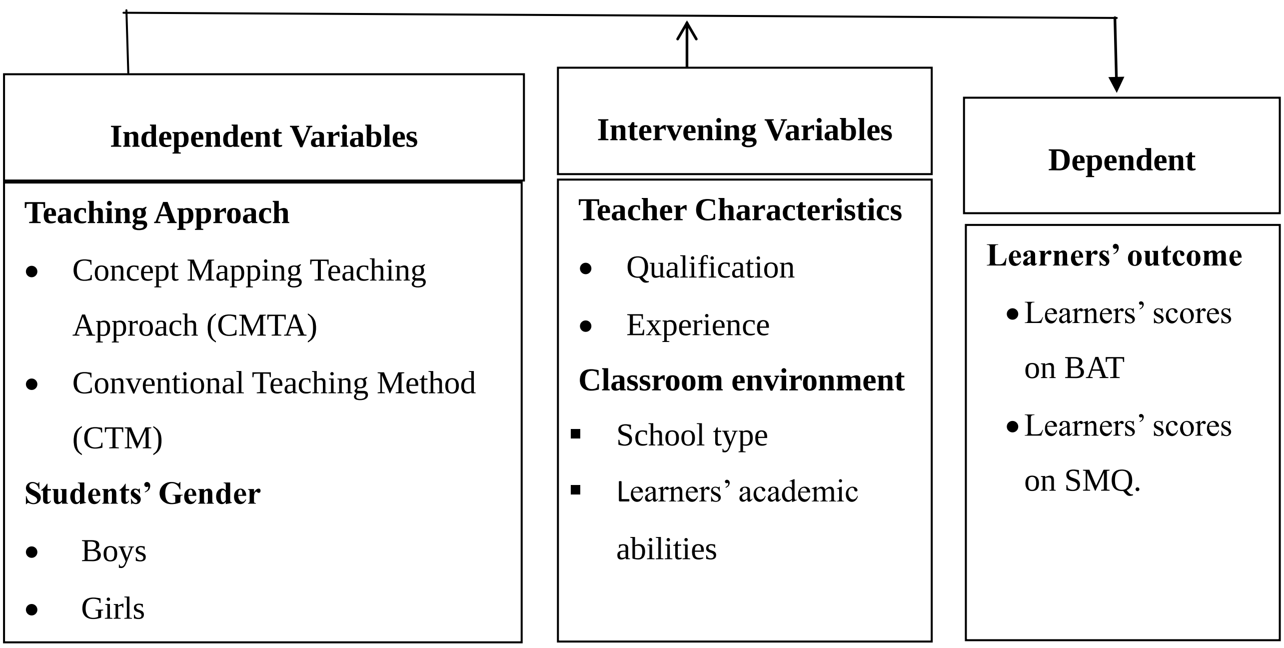

Figure 1: Conceptualization of Relationships among Key Study Variables

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

The study's approach is thoroughly explained in this chapter. This explanation includes the study's location, the target and accessible populations. The sample size and sampling procedures are also addressed, together with the research instruments used, their validity, and reliability. In conclusion, it discusses the procedures that were involved in data collection, the statistical techniques that were used to analyze the data, and the ethical issues that were taken into account.

3.2 Research Design

According to Murray (2015), research design refers to the all-encompassing approach used to logically and cohesively integrate the many parts of a study, offering a full solution to the research problem. During this empirical study, the Solomon Four-Group Non-Equivalent Control design was used. For research studies that cannot fully rely on experimental procedures, this technique is a useful strategy. According to Mertler (2024), in this setting, secondary school classes were deemed whole units, and teachers were not allowed to divide them for the sake of study. According to Fraenkel and Wallen (2019), pre-tests are crucial in quasi-experimental research since they allow for the evaluation of group equivalency before the intervention. According to Cham *et al.* (2024), the researchers used this research methodology to determine the degree to which the intervention impacted on the students' motivation and accomplishment levels. The Solomon Four Non-equivalent Control Group Design is illustrated in Figure 2.

GROUP	PRE-TEST	TREATMENT	POST-TEST
Group I	O1	X	O2
Group II	O3	C	O4
Group III	__	X	O5
Group IV	__	C	O6

Figure 2: Solomon Four-Group Design with Non-equivalent Control Groups

Key; O_1 and O_3 represented pre-tests; O_2, O_4, O_5 and O_6 represented post-tests. Because the dotted lines indicated that the learners were already in intact groups, the grouping was not done randomly. Groups III and IV were not subjected to any preliminary examination, as indicated by the dash (-). Learners who received instruction using the Concept Mapping

Teaching Approach (CMTA) were represented by the letter X. Learners were the topic support and movement using the lecture approach, with condition C acting as the control.

i. Group I took the pretest as a member of the experimental group, received the therapy (X), and then completed a post-test.
ii. Group II was the control group, which took a pre-test, experienced the control condition (C), and subsequently took a post-test.
iii. Group III was another experimental group that received therapy X and underwent a post-test, but not a pre-test.
iv. Group IV was a second control group and was administered only the post-test.
v. The Lecture Method was employed to instruct Groups II and IV.

The study employed the Solomon Four-Non-Equivalent Control Group Design. It was utilised because, according to Mertler (2024), it is considered suitable for realising the following objectives.

i. Evaluate the experimental procedure and the regulator treatment.
ii. To compare the impact of two control groups and a pre-test with a post-test.
iii. To investigate the impact of pre-tests on treatment conditions.
iv. Ascertain the level of uniformity of groups concerning the performance of treatment.

Selection and interaction bias were reduced because schools were randomly assigned to either the control or treatment groups. The conditions under which the instruments were administered were standardized as much as possible to address the selection challenge more effectively. Four-week duration was adopted for the trial to mitigate the effects of maturation.

3.3 Location of the Study

Kitui County was the designated location of study. (**See Appendix F**). This county was selected as the study site due to its consistently lower performance in science subjects, especially Biology, in the KCSE examination relative to other counties in Kenya's lower Eastern region. Over the past ten years, there has been a significant gender gap in the Biology performance in favour of male students. Furthermore, few secondary school graduates have enrolled in science-based courses at post-secondary educational institutions (CDE, Kitui County 2023).

The size of Kitui County is approximately 30,496 square kilometres, with a population of 1,147,200 (Republic of Kenya, 2021a). The seven counties that border Kitui are Taita Taveta to the south, Tana River to the east, Machakos and Makueni to the west, Tharaka Nithi and

Meru to the north, and Embu to the north-west. During the study period, the County had 430 secondary schools. Among those, two were national schools, twelve were extra-county schools, forty-four were county schools, three hundred and sixty were sub-county schools, and twelve were private schools. The student population in Kitui County secondary schools was approximately 107,500, consisting of 54,283 boys and 53,217 girls. Three-quarters of the County is arid and semi-arid, characterised by high poverty levels (Republic of Kenya, 2018). Numerous schools within the county face significant challenges, including limited access to clean and safe water, inadequate physical infrastructure, and shortages of qualified teachers. Additionally, the majority of parents depend on subsistence farming as their primary source of livelihood.

3.4 Target and Accessible Populations

The target population consisted of all Biology students, approximately 107,500, from sub-county co-educational secondary schools in Kitui County. The accessible population comprised four Biology teachers from Sub county secondary schools and 173 enrolled Biology students. Since all secondary schools in Kenya teach the topic of support and movement in animals at form four level, this study focused on form four Biology students (KICD, 2012). At their age of over sixteen years, form four students are in the formal operational stage of cognitive development, Piaget (1983). Students can develop hypotheses, carry out experiments, assess results, and use deductive reasoning. Teachers of Biology with at least three years of classroom teaching experience, a Diploma certificate in teacher education, and examiners who had received training and contracted by the Kenya National Examination Council (KNEC) were also involved in the study.

Co-educational institutions were chosen because they provide an environment where students of both genders attend the same school and study together (Wambugu *et al.*, 2013). They also admit students with similar entry behaviour; hence, their students are of comparable learning abilities. Additionally, those schools provide an identical environment for their learners because they are in the same category.

3.5 Sample Size and Sampling Procedures

The study included four Biology teachers and a total of 173 students. The selected schools had student populations of 36, 44, 47, and 46, making up the sample size. The study selected secondary schools as the sampling unit instead of individual students, as secondary school students typically learn in intact groups (Mertler, 2024). To conduct this analysis, four coeducational secondary schools were purposively selected. The County Director of Education provided a list of 430 secondary schools, which was used to create a sampling frame. There were 360 mixed-educational institutions among them.

Four co-educational institutions that were identified for the study were selected using a purposive sampling technique. As defined by Mugenda & Mugenda (2013), purposive sampling involves choosing the most representative cases related to the research topic. This method was suitable because not all sub-county schools fulfilled the necessary research requirements. It enabled the researcher to focus on participants most relevant to the study, gather detailed data, and customise the selection process to fit the study's needs. Eligibility criteria for the selected schools included a balanced student gender ratio, a well-equipped science laboratory for practical work, and Biology teachers holding a Diploma in secondary education with at least three years of classroom teaching experience.

Using a straightforward random sample technique, two schools were chosen to act as experimental groups and the other schools as control groups. In institutions with multiple streams, all four form streams received the same instructional intervention; however, only one stream was chosen at random for data collection and analysis. To maintain consistency in education, their regular Biology teachers were used to teach both the experimental and control groups. To minimise the risk of experimental treatment diffusion, the selected schools were geographically distant from one another. Biology teachers assigned to the experimental groups received training on the Concept Mapping Teaching Approach (CMTA). They were also provided with validated lesson plans to ensure they followed the structured teaching methodology as intended by the researcher **(See Appendix C**). To ensure that any differences in student performance could be ascribed to the instructional intervention and not to variations in teaching strategies, this controlled approach was put into place. Table 4 presents the distribution of the sample size across the four schools.

Table 4

Sample size N, Across the Four Schools

Group	Treatment	Boys	Girls	Size of the Sample, N pe school
Group I	Experimental 1	19	17	36
Group II	Control 1	21	23	44
Group III	Experimental 2	22	25	47
Group IV	Control 2	20	26	46
Total		82	91	173

173 students participated in this study.

3.6 Instrumentation

The Biology Achievement Test (BAT) and the Student Motivation Questionnaire (SMQ) were the two distinct tools used by the researcher to gather data. The instruments were piloted using two secondary schools in Kitui County. These schools exhibited similar attributes to the schools in the sample; however, they were not included in the original study.The purpose of this procedure was to estimate their reliability.

3.6.1 Biology Achievement Test (BAT)

A Biology Achievement Test was used to assess learners' achievement in Biology. The BAT items were taken from previous KCSE Biology examination papers. The questions were adjusted in length and difficulty to suit this study. It included 26 short-answer questions about support and movement in animals (**See Appendix B**). Scores for items ranged from one to six, depending on their difficulty level. The total possible score was 80 marks, which were then converted into a percentage of 100%. Each section was redesigned to follow an open-ended format. The format was deemed most appropriate for form four students in Kenyan secondary schools because it aligns with the evaluation procedures typically used (KNEC, 2022). According to Bloom's (1956), the items being evaluated were categorized and divided into three different cognitive levels: knowledge, comprehension, and application. This classification was based on Bloom's Taxonomy, a framework for differentiating learning objectives in the cognitive domain. Bloom's framework guided the development of these levels, with the three lower levels chosen because they are most important for standardised testing, ensuring consistent assessment of students' achievement. This helped the researcher determine whether students at different cognitive levels successfully achieved the CMTA outcomes.

The test consisted of 14 items at the knowledge level, with a maximum of 38 marks, where students were expected to memorise and recall information. For comprehension, which assessed students' understanding of concepts, there were 7 items worth 23 marks. The application category, which required students to apply prior knowledge to new problems, comprised 5 items totalling 19 marks. Throughout the test development, a specification table was used to guide the selection of content from the support and movement in the Animals. This table also ensured that all three levels of cognition were covered. The purpose of the study was to ascertain whether the BAT mean scores for the two groups that had done the pre-test differed based on gender. After the two groups were combined, a calculation was made to find the average ratings of the male and female study participants.

3.6.2 Students' Motivation Questionnaire (SMQ)

To evaluate students' motivation in learning the topic "Support and Movement in Animals," the Student Motivation Questionnaire was administered (**see Appendix A**). The questionnaire created by Wachanga (2002) and Barchok (2006) was restructured by the researcher. This modified version of the SMQ had 37 items and was rated on a five-point Likert scale. That is, Strongly Disagree (**0**), Disagree (**1**), Undecided (**2**), Agree (**3**), and Strongly Agree (**4**) were the responses and scores for the SMQ items. However, for negatively worded items on the SMQ, the scores were inverted to represent their intended opposite meanings correctly. A student, who strongly disagrees with the statement, "Learning Biology using concept maps prepared by students made me feel like I was wasting my time," it would indicate a highly positive perception of learning Biology.

The highest score attainable was 148, and the lowest was 0. The scale was designed so that higher scores indicate stronger agreement with a statement, reflecting a more positive response. This scoring method aligns with the standard grading system used in Kenya's education system, where higher numbers represent better performance and lower numbers indicate weaker results. In this study, motivation was viewed as a measure of the positive or negative effect, ranging from strongly negative to strongly positive.

3.7 Validity and Reliability of Research Instruments

3.7.1 Validity of Instruments

Two seasoned secondary school Biology teachers and five educational research specialists in science education validated the BAT. The primary focus was on content validity, which was assessed by determining how well BAT reflected the learning objectives of the biology topic, support and movement in animals. Fitzpatrick (1983) asserts that achievement assessments can benefit from content validity. Research experts carefully examined the tools to ensure the content was thorough, relevant, acceptable, and readable. The instruments were improved according to the recommendations of subject matter experts and researchers.

3.7.2 Reliability of Instruments

Pilot data was used to determine the reliability of the instruments. Cronbach's alpha coefficient was employed, as it is the most appropriate statistical method for determining internal consistency in instruments that use non-dichotomous scoring (Mertler, 2024). This statistical technique was deemed appropriate for this analysis since it evaluates internal consistency by ensuring that the items within each instrument accurately measure the intended constructs. Additionally, the data collection instruments utilized had continuous response formats rather than multiple options such as true-or-false or right-or-wrong.

The BAT yielded a reliability coefficient of 0.78, surpassing the recommended threshold of 0.70 (Mugenda & Mugenda, 2003). This confirmed its suitability for the study. Likewise, the SMQ yielded a reliability coefficient of 0.81, exceeding the minimum required threshold, validating its effectiveness in assessing students' motivation to learn Biology when taught using CMTA.

3.8 Data Collection Procedures

The Egerton University Board of Postgraduate Studies introduced the researcher to NACOSTI, confirming that the researcher had enrolled as a student in the university. Some basic data provided by the Kitui County Director of Education assisted the researcher in carrying out the sampling process. Permission was sought from the principals of the selected co-educational secondary schools. The form four Biology teachers responsible for the experimental groups (I and III) were identified. They received training on the use of the Concept Mapping Teaching Approach (CMTA) prior to the start of the study. Those teachers were issued with instruction modules **(Appendix C**) and teacher training instructional modules (**Appendix E**), which were designed explicitly for Concept Mapping.

Regular teachers were used to teach students in both experimental and control groups. Groups I and II were subjected to pretest (BAT and SMQ) before the implementation of CMTA. Groups I and III, which comprised the experimental groups, were instructed on support and movement in animal using a concept map created by the investigator. In contrast, the control groups consisted of students from group II and IV schools, who received their instructions through conventional methods. After four weeks of the intervention, all four group categories received post-test BAT and SMQ.

3.9 Data Analysis Procedure

The data was anonymised for ethical reasons to safeguard its confidentiality. The data was analysed using the SPSS computer program, version 28. Inferential and descriptive statistical methods were employed in the study. Analysis of Variance (ANOVA) was used to test the first and second hypotheses. ANOVA is employed to examine the distinctions between two or more categories. The initial difference among the groups was catered for by carrying out an ANCOVA. A t-test was implemented to evaluate hypotheses three and four. The null hypothesis was retained when the calculated p-value was greater than 0.05. Conversely, the hypotheses were rejected when the p-value was less than 0.05. Furthermore the hypotheses were presented in the same order as the results. Statistical evaluations are necessary to ensure that the conclusions derived from the data accurately reflect the situation. The significance of each test was assessed using an alpha threshold of 0.05.

For the aims of this study, the effectiveness of the Concept Mapping Teaching Approach (CMTA) on students' academic performance and motivation in relation to their gender was assessed using the t- test computation method. A one-way Analysis of Variance was conducted to ascertain whether there was a statistically significant difference in motivation and achievement among the four study groups. Table 5 provides a summary of the variables and statistical procedures used in the study to test the four hypotheses.

Table 5

Variables and Statistical Procedures Used in the Study

Hypothesis	Independent Variable	Dependent Variable	Methods Of Analysis an Statistical Test
1: There is no significant statistica difference in the Biology achievement of students instructed using CMTA compared to those taught using CTM.	CMTA CTM	Achievement (Test Scores)	One-Way Analysis of Variance (ANOVA)
$H_0$2: There is no statistically significant difference in motivation to learn Biology between students taught using CMTA and those taught using CTM.	CMTA CTM	Students' Motivation questionnaire (SMQ scores)	One-Way Analysis of Variance (ANOVA)
$H_0$3: There is no statistically significant gender difference in Biology achievement between students exposed to CMTA.	CMTA	Achievement (Test Scores)	t-test
$H_0$4: There is no significant statistical difference in students' Biology motivation based on gender when taught using CMTA.	CMTA	Motivation questionnaire SMQ scores	t-test

Note. Table developed by the author on 4th August 2023

3.10 Ethical Considerations

Study participants were instructed they write their registration numbers on BAT and SMQ to hide their identities. As a result, respondents who were in both the experimental and control groups were assured of their anonymity. The information gathered was kept private and utilised exclusively for study (Dannels, 2018). Lastly, the researcher did not withhold his results for personal benefit.

CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter discusses the findings and presents the investigation's results. To display numerical data, tables were used. ANCOVA was used to account for initial individual differences across the groups, and a t-test was conducted to compare the mean differences between the two groups at a significance level of 0.05. The post hoc analysis was helpful as it employed pairwise comparisons with a Bonferroni test to evaluate group differences. The rest of the results are presented under the following subtopics:

i. Results of the Pre-test.
ii. The Effects of CMTA on Students' Biology Achievement.
iii. CMTA Effects on Students' Motivation to Learn Biology.
iv. Gender Differences in Students' Achievement When Exposed to CMTA.
v. Effects of CMTA on the motivation of male and female students to learn Biology.

4.2 Pre-test Results

This study employed a Solomon Four Non-Equivalent Control Group Design, where both Group I (the experimental group) and Group II (the control group) were pre-tested before administering the treatment. The pretest was significant in ensuring that the control and experimental groups were equivalent. An independent sample t-test was used to determine whether there was a statistically significant difference in the mean scores of the two groups. According to Mertler (2024), in using the Solomon Four Non-Equivalent Control Group Design, the sample groups should be as identical as possible at the beginning of the study. The pre-tests enabled the researcher to:

i. Before starting the CMTA treatment, ascertain how similar the groups are.
ii. Examine the effects of administering a pre-test versus not administering a pre-test.
iii. Identify any practice effects.
iv. Analyse the interaction between the pre-test and the CMTA treatment

Table 6 displays Pre-Test mean scores for groups 1 and 2.

Table 6

Pre-Test Mean Scores of BAT and Independent Samples t-Test Results

Group 1, N=36;	Group2, N=44		Boys =38	Girls=42		
Variable	**Group**	**Mean**	**SD**	**Df**	**t-value**	**p-value**
Method of instruction	Group 1	16.47	5.02	78	0.2936	0.7698
	Group II	16.84	5.09			
Gender	Boys	17.10	5.93		0.6489	0.5183
	Girls	16.29	5.09			

Table 6 presents the results, which indicate that the mean score for the experimental group was lower, with an average of 16.47 and a standard deviation (SD) of 5.02, compared with that of group II, which was higher at 16.87 and 5.09, respectively. The data showed a higher mean score among boys than among girls, with M = 17.10, SD = 5.97, and M = 16.29, SD = 5.09, respectively. The results indicate that at a 0.05 significance level, the mean scores of Groups I and II were not statistically significant, with t (78) = 0.2936, P = 0.7698, and P > 0.05. Due to their comparable characteristics, matching these groups for the investigation was considered appropriate. Based on the analysed data, there was no statistically significant difference in gender-specific mean scores at the 0.05 level of significance t (78) = 0.6489, P = 0.5183, P > 0.05). The equivalent performance of boys and girls in Biology strengthened the study's credibility. The SMQ entry behaviour was examined to determine their motivation for learning biology. Table 7 displays the results of the t-tests for groups I and II.

Table 7

Pre-Test Independent Samples t-Test Results on SMQ

Group 1, N=36;	Group 2, N=44;	Boys =38	Girls=42			
Variable	**Group**	**Mean**	**SD**	**df**	**t-value**	**p-value**
Teaching approach	Group 1	2.5	1.09	78	1.064	0.2906
	Group II	2.25	1.05			
Gender	Boys	2.39	1.97		0.4819	0.6212
	Girls	2.29	1.04			

Table 7 indicates that although Group I had a higher mean score than Group II, the difference was not statistically significant at the 0.05 level, with t (78) = 1.064, P = 0.2906, and

P > 0.05. This suggests that the two groups were suitable for the study due to their comparable SMQ characteristics. Table 7 also indicates that the mean scores for male students were slightly higher than those of female students: M = 2.39, SD = 1.97; M = 2.29, SD = 1.04. Nevertheless, the gender difference in mean scores was not statistically different at the 0.05 probability level, despite t (78) = 0.4819, P = 0.6212, P > 0.05. This suggests that male students were just as motivated for Biology as their female counterparts. Since both groups had comparable SMQ mean scores upon entry, the researcher deemed this acceptable for sample selection.

4.3 The Effects of CMTA on Students' Biology Achievement

The first hypothesis (H_01) was examined in this investigation. The objective of this investigation was to determine whether there was a statistically significant difference in the level of achievement in Biology between secondary school students who were instructed through CTM and those who were instructed using CMTA. The evaluation of the impact of CMTA on the level of accomplishment that students attained in Biology was facilitated by the analysis of the post-test BAT means scores. Table 8 shows the mean scores for the four groups.

Table 8

Comparison of Students' Post-Test BAT Mean Scores Among the Four Groups

Group	**N**	**Mean**	**SD**
Group I	36	30.055	8.042
Group II	44	22.022	7.283
Group III	47	30.127	8.940
Group IV	46	23.279	7.159

According to the results in Table 8, the experimental groups I (M = 30.055, SD = 8.042) and III (M = 30.127, SD = 8.940) had higher mean scores compared to the control groups II (M = 22.022, SD = 7.283) and IV (M = 23.279, SD = 7.159). This finding demonstrates that experimental groups performed better on the BAT post-test than control groups. To determine whether there were statistically significant differences in the group mean scores, an analysis of variance (ANOVA) was performed. The results are displayed in Table 9.

Table 9

ANOVA Results of Post-Test BAT

Scale	Sum Squares	Df	mean squares	F-Ratio	p-value
Between treatment	2329.0552	3	776.3517	F=12.4613	0.000*
Within treatment	10528.8176	169	62.3007		
Total	12857.8728	172			

The results in Table 9 indicate that, with F (3, 169) = 12.4613 and p = 0.000*, there was a statistically significant difference between groups I and IV at the 0.05 level. To explore these differences further, an ANCOVA test was performed to determine if the differences remained significant at the 0.05 level. The results are presented in Table 10.

Table 10

Adjusted BAT Post-Test Mean Scores from the ANCOVA with KCPE as a Covariate

Group	N	Adjusted BAT Mean scores	SD	std Error
Group I	36	29.46	10.12	1.75
Group II	44	23.21	6.45	1.44
Group III	47	31.42	9.20	1.63
Group IV	46	19.78	8.75	1.42

KCPE = 235.32

Table 10 indicates that even after adjustments, the experimental groups I (M = 29.46) and III (M = 31.42) continued to have higher mean scores than the control groups II (M = 23.21) and IV (M = 19.78). However, the results did not specify where the differences occurred. To determine the differences between the group averages, a post hoc pairwise multiple comparisons test was necessary. Given its applicability to various statistical tests, the Bonferroni test was considered the most suitable choice for multiple comparisons (Howell, 2002). The differences between the four groups were demonstrated by the results of the Bonferroni test. Table 11 presents the findings.

Table 11

Results of Pairwise Post-Hoc Comparisons of Post-Test BAT Mean Scores Among the Four Groups

Group (I)	Group (J)	Mean Difference(I-J)	p-value
Group I	Group II	8.033	0.000*
Group I	Group III	-0.072	1.0000
Group I	Group IV	6.776	0.0019
Group II	Group III	-8.105	0.000*
Group II	Group IV	-1.257	0.7690
Group III	Group IV	6.848	0.000*

Table 11 shows that there were significant differences between group pairs I and II (p = 0.000*), I and IV (p = 0.0019), II & III (p = 0.000*), and III & IV (p = 0.000*). Statistical analysis was used to identify these disparities. After careful analysis, these differences were shown to be statistically significant. However, there was no statistically significant difference between groups I and III (p = 1) and groups II and IV (p = 0.769) according to the investigation. Another finding was that the experimental group outperformed the control group by a statistically significant margin. This was illustrated by the substantial disparity between the mean ratings of the control and experimental groups. Ultimately, this discrepancy was the result of the intervention's use of CMTA. Despite the absence of any significant difference between groups I and II in the pretest results, it was determined that the use of ANCOVA was appropriate. This statistical technique helps to account for initial discrepancies by modifying the mean scores on the post-test. The ANCOVA test was conducted using the standard BAT post-test mean scores, as shown in Table 12, and the students' KCPE marks were used as covariates.

Table 12

ANCOVA BAT Post-Test Mean Scores

Scale	Sum of Squares	Df	mean squares	F-Ratio	p-value
KCPE	1423.02	1	1423.02	29.74	0.000*
Contrast	2229.02	3	743.0	14.12	0.000*
Error	10326.47	169	61.10		

F = 14.12 df = 3, P < 0.05 KCPE = 235.32

Results in Table 12 indicate statistically significant differences at the 0.05 level among the mean scores of groups I, II, III, and IV ($F(3, 169) = 14.12$, $p < 0.05$). KCPE marks were considered the best covariate since they correlated fairly well with the BAT. Additionally, all students in the sampled groups had sat for the KCPE examination. An ANCOVA-based test was used to perform post hoc pairwise comparisons on the adjusted mean scores, pinpointing the differences in the average scores. The results are presented in Table 13.

Table 13

Results of Pairwise Multiple Comparisons for Adjusted Mean Scores for the Four Groups

Group (I)	**Group (J)**	**Mean Difference(I-J)**	**p-value**
Group I	Group II	6.25	0.002
Group I	Group III	-1.96	0.97
Group I	Group IV	9.68	0.000*
Group II	Group III	-8.21	0.000*
Group II	Group IV	3.43	0.069
Group III	Group IV	11.64	0.000*

At $p < 0.05$, the mean difference is significant.

The means of groups I & II (p = 0.002), groups I & IV (P = 0.000*), groups II & III (p = 0.000*), and groups III & IV (p = 0.000) differed significantly from one another as per the results in Table 13. The statistical analysis revealed a statistically significant difference between groups I and III (p = 0.97), but no significant difference between groups II and IV (p = 0.069). This shows that the ANOVA results are accurate and reveals the following:

i. The BAT pre-test scores and the treatment conditions did not significantly interact, according to the available data. Had this not been the case, the results obtained during the pre-test would have been very different for the groups of learners who took the test and those who failed to take it.
ii. Pre-tests failed to affect the students' view of the Biology material to be taught. This is evidenced by the fact that the results do not show a significant difference between the first group that underwent a pre-test and those from other groups.
iii. Since groups I and III scored significantly higher than the other groups, using CMTA occasioned higher student attainment compared with CTM for teaching the control groups. The null hypothesis (H_0) was rejected considering these findings, which show that the experimental groups exposed to the Concept Mapping Teaching Approach outperformed the control groups by a considerable margin.

According to the study's findings, students who received instruction utilizing CMTA outperformed those who received instruction using CTM in terms of their BAT scores. The study by Keraro *et al.* (2007) provided more evidence for the conclusions that were made. Following their investigation, they found that form two high school students who received cooperative concept mapping instruction in Biology outperformed those who received instruction regular methods. Wambugu *et al.* (2013) found that experiential cooperative concept mapping improved the academic performance of secondary school students in the physics course. These findings are consistent with those of the ongoing study. Additionally, the findings presented here are in line with those of Githae *et al.* (2015), who show that the collaborative concept mapping teaching approach improves biology students' understanding in secondary schools.

Furthermore, the findings of this study align with the findings reached by Namasaka (2009). He discovered that in his research on the effects of Concept Vee Mapping Strategy (CVMS) increased the performance of Biology students at secondary institutions. According to Ajaja (2013), students who received instruction in cooperative learning and learning cycle tactics outperformed their counterparts who received lecture-based instruction on accomplishment tests. According to Izci and Akkoc (2024), concept mapping is a strategy that may be used to improve academic achievement and ought to be incorporated into teachers' professional development.

Research carried out by Wanjala (2023) on the possible effects of the Advance Organiser Concept Mapping Teaching Strategy (AOCMTS) on form two students' academic achievement and interest to learn physics. According to the study’s findings, AOCMTS was more effective than traditional teaching methods in enhancing students’ motivation and achievement in physics. Such findings justify the present research since it shows that AOCMTS is effective in combating low engagement in physics, which is commonly acquired through teacher-oriented techniques and scarcity of resources. Regarding the educational outcomes of students and the use of concept maps, the findings of the current study are comparable to those of Bii (2019). They found in their study that concept maps significantly increase student achievement.

A study by Mbonu-Adigwe *et al*. (2024) found that the concept mapping instructional strategy significantly improved students’ achievement in basic science more than the non-concept mapping instructional approach. The above findings align with the findings of this research. This study demonstrates that when students with varying abilities work in manageable groups and are exposed to CMTA, the approach provides them with the best opportunity to develop knowledge and self-esteem. Therefore, CMTA enables the learners to construct knowledge independently, increasing cognitive gain. CMTA promotes student learning, particularly when students work in small groups of mixed abilities. The findings suggest that CMTA leads to better academic achievement than CTM. However, its success depends on student teamwork, implying that it is less effective when students prefer to work alone or when groups consist of students with similar academic abilities

4.4 CMTA Effects on Students' Motivation to Learn Biology

The second hypothesis (H_02) of the research was to examine the influence of CMTA on the level of motivation that students have to learn Biology. As per the hypothesis, there was no statistically significant difference in the level of motivation to learn Biology between students who were instructed using the CMTA approach and those who were instructed using the CTM strategy. The mean scores on the SMQ were obtained by administering a post-test SMQ. These scores were utilized to evaluate the effects of CMTA on the motivation of students to study Biology.

4.4.1 Results of SMQ Post-test Mean Score Analysis

Through an analysis of the mean scores from the SMQ post-test, the effect of CMTA on students' motivation to study biology was determined. . One-way ANOVA and the post Hoc multiple comparisons test were used. Tables 14, 15, and 16 display the outcomes, respectively.

Table 14

Post-Test SMQ Results

Group	N	Mean	SD
Group I	36	4.0	0.75
Group II	44	1.41	0.49
Group III	47	4.11	0.72
Group IV	46	1.43	0.50

Table 14 reveals that the treatment groups, I (M = 4.0, SD = 0.75) and III (M = 4.11, SD = 0.72), had greater mean scores compared to the control groups, II (M = 1.41, SD = 0.49) and IV (M = 1.43, SD = 0.50). An ANOVA test was conducted to examine the extent of mean score differences. Table 15 displays the results.

Table 15

ANOVA Post-test SMQ Results

Scale	Sum of Squares	Df	mean squares	F-Ratio	p-value
Between treatment	300.73	3	100.2452	F=255.108	0.000*
Within treatment	66.40	169	0.393		
Total	367.14	172			

Table 15 shows a significant difference in the post-test SMQ mean scores among the four groups, with an F-value of 100.2452 and a p-value of less than 0.05. To compare the mean differences for each group in the foregoing results, a post hoc test using the Bonferroni multiple comparison test was conducted. The results are presented in Table 16.

Table 16

Results of the Post-Hoc Pairwise Multiple Comparisons Test for the Mean SMQ Scores Across the Four Groups After the Post-Test

Group (I)	Group (J)	Mean Difference(I-J)	p-value
Group I	Group II	2.59	0.000*
Group I	Group III	0.11	0.861
Group I	Group IV	2.57	0.000*
Group II	Group III	2.70	0.000*
Group II	Group IV	0.02	0.997
Group III	Group IV	2.68	0.000*

The SMQ post-test differences between groups I and II, as well as between groups I and IV (p-value of 0.000*), groups II and III (p-value of 0.000*), and groups III and IV (p-value of 0.000*), are shown to be statistically significant in Table 16. According to their respective p-values of 0.861 and 0.997, groups I and III did not substantially differ in the study's outcome. This means that, although there are significant differences between most pairs of treatment-control groups, no significant difference exists in comparisons within the sets of treatment groups or control groups. These observed differences could be attributed to CMTA’s positive effect on students’ motivation, which may explain the differences. Additionally, using KCPE marks as a covariate, an ANCOVA follow-up analysis was performed to determine whether the SMQ post-test mean scores differed significantly at the 0.05 level. The findings of this study are summarized in Table 17.

Table 17

Adjusted Post-Test SMQ Mean Scores Based on ANCOVA Using KCPE Marks as Covariate

Scale	Sum of Squares	Df	mean squares	F-Ratio	p-value
KCPE	3.4	1	3.4	F=0.065	0.56
Contrast	5.289	3	2.600	F=6.12	0.000*
Error	58.255	169	0.291		

F = 6.12 df = 3, P < 0.05 Covariate KCPE marks = 235.32

Table 17 shows that there are statistically significant variations between the mean values of the four groups at the 0.05 level of significance. Since the model was statistically significant, a post hoc pairwise multiple comparisons test was performed to determine the precise differences between each pair of groups. The results are presented in Table 18.

Table 18

Pairwise Post-Hoc Analysis of SMQ Post-Test Mean Scores Among the Four Study Groups

Group (I)	Group (J)	Mean Difference(I-J)	p-value
Group I	Group II	0.78	0.000*
Group I	Group III	0.01	0.07
Group I	Group IV	0.81	0.000*
Group II	Group III	0.75	0.000*
Group II	Group IV	0.02	0.089
Group III	Group IV	0..79	0.000*

In Table 18, Significant differences were found between groups I and II (p = 0.000*), I and IV (p = 0.000*), II and III (p = 0.000*), and III and IV (p = 0.000*). It was concluded that these differences were statistically significant. The difference between groups I and III (p = 0.07) and groups II and IV (p = 0.089) was statistically significant, although not statistically significant (P > 0.05). This demonstrates that, compared to CTM given to control groups, CMTA has superior features that positively enhance learner motivation. These results suggest that:

i. There was no substantial interaction between the treatment conditions and the SMQ pre-test. This is because neither Group I nor Group II took the pre-test and had significantly different SMQ mean scores.

ii. Since Group I and III scored significantly higher on the SMQ than the other groups, implementing CMTA led to higher student motivation compared to Conventional Teaching Methods (CTM).
iii. As a result, hypothesis H_02 was disproved; learners exposed to CMTA and those exposed to CTM differ in motivation in a statistically meaningful manner.

4.4.2 Results of SMQ Gain Analysis

A gain analysis was conducted to determine which of the two pre-tested and post-tested groups, Group I and Group II, exhibited stronger motivation. Table 19 provides an overview of the gains made by the two groups.

Table 19

Results of SMQ Pre-Test and SMQ Post-Test Mean Scores

		Group I	**Group II**
Pre-test	N	36	44
	Mean	2.5	2.25
	SD	1.0	1.05
Post test	N	36	44
	Mean	4.0	1.41
	SD	0.75	0.49
Mean Gain		1.5	0.84

Results of Table 19 show that the experiment group I mean gain (M = 1.5) was greater than the control group II (M = 0.84). The mean scores on the SMQ post-test were shown to be higher after treatment. This implies that CMTA promoted the desire to study Biology in students, as opposed to CTM. They found out that Group I enjoyed increased motivation due to CMTA treatment. As research results show, the Concept Mapping Teaching Approach (CMTA) is more effective in promoting student motivation in comparison to the Conventional Teaching Methods (CTM). This is because CMTA places much stress on the active involvement of students in the learning process, which promotes a higher understanding of biological concepts through the process of cognitive engagement.

Moreover, the collaborative aspect of CMTA could have led to better performance in the task, which in turn enhanced the self-confidence and motivation of the students as they manoeuvred through Biology concepts. These results are consistent with those reported by

Keraro *et al*; (2007), where a significant difference in students' motivation levels was observed between those taught using CMTA and those instructed through CTM. After conducting their analysis, they concluded that there was no appreciable difference between the motivation levels of male and female students with regard to the CMTA. In the study, teachers have to encourage equal participation of learners by making balanced groups of learners with different ability levels.

In the same way, Ajaja (2013) was keen to mention that group discussions are useful in fostering clarity of new concepts, retention, and assisting students to combine new information with pre-existing understanding, hence boosting performance and motivation. In the previous studies conducted by Slavin (2018), it was proposed that learning goals that are created based on groups and addressed to individual needs can directly affect cognitive engagement, promoting peer modelling and critical thinking. Conversely, the Conventional Teaching Method (CTM) positions students as passive consumers of knowledge, who rely primarily on their teachers as the central source of information. CMTA, in turn, encourages the idea of hands-on learning among the collaborative groups so that the students can use the knowledge they have gained in a meaningful context. Therefore, the teaching approaches that increase student performance and motivation, in which CMTA is among them, should be broadly accepted.

In addition, CMTA is an effective alternative to CTM, especially in schools that lack laboratory facilities in instructing Biology, because it can be well delivered even in the absence of laboratory facilities (Ajaja, 2013). Supporting these findings, Varois and Varois (2024) conducted a study examining the impact of the 5E Learning Model enhanced by the Concept Mapping Approach. They stated that CMTA has a positive effect on student motivation. They conclude in agreement with the study by AlDmour *et al.* (2017), showing the same result that CMTA increases student motivation. As it was proven by Cabiling and Magday (2022), the concept mapping also succeeds in increasing the motivation of the students to learn science-related subjects. In conclusion, both the current study and existing literature indicate that CMTA is an effective instructional strategy for boosting students' motivation to learn Biology.

4.5 Achievement Levels of Male and Female Students Exposed to CMTA

According to the third hypothesis ($H_0 3$), when Biology students are taught utilizing CMTA, there is no statistically significant difference in their academic achievement based on their gender. By comparing the mean scores of male and female students on the post-test BAT following CMTA treatment, the validity of this hypothesis was examined. The comparison's findings, which show the mean scores for each gender separately, are shown in Table 20.

Table 20

Gender-Based Comparison of Post-Test BAT Mean Scores for Students Under the CMTA

Gender	Mean	SD	Df	t-value	p-value
Boys	30.36	11.27	76	-0.302	0.3816
Girls	29.79	7.19			

Table 20 results show that the average score was slightly higher for boys (M = 30.36, SD = 11.27) than for girls (M = 29.79, SD = 7.19). It was found that the average scores of boys and girls did not differ significantly at the 0.05 level: t (76) = -0.302, $p > 0.05$. Both boys and girls gained equally from CMTA, so gender inequality did not affect academic performance. The findings validated the study's third hypothesis, revealing no statistically significant difference in academic performance between male and female students after exposure to CMTA. Additionally, according to the same findings, students who received instruction using CMTA outperformed those who received instruction using CTM in terms of scores. Sometimes the learning ability of girls is discouraged, not directly, but in the classroom setting, which seems to favour boys. Boys often receive more attention in the presence of teachers, which can demoralise girls and make them feel less significant.

A study by Keraro and Shihusa (2005) used advance organizers to increase students' interest in studying Biology. Boys and girls had significantly different degrees of motivation, with males showing higher levels than females, according to the investigation's findings. However, they developed the same motivation because CMTA provided them with equal opportunities to learn. Research has shown that girls often experience low self-esteem and lack confidence in themselves. Such beliefs translate to low motivation and may, in return, lead to poor performance, especially in science courses where such students believe that science is a man's world. When given the same educational opportunities, both boys and girls can excel in the discipline of Biology. This consequently creates a powerful feeling of gender equity, which again guarantees admission to elite science-related occupations.

Research on the effects of concept mapping, instructional strategies, and the use of discussion webs on biology students' learning experiences was carried out by Ayimbila and Akantagriwon (2021). The findings of that inquiry are in line with the findings of this study. The impact of these strategies on students' academic performance was examined during the process of learning and teaching genetics concepts. Their experiments were designed to explore these consequences. Regardless of whether gender concerns are present or not, Okoronka's (2018) research indicated that the concept mapping approach can improve learners' performance by improving their conceptual understanding and comprehension. The findings of the present investigation are consistent with those of Okoronka's 2018 study. The results of this study showed that, in all experimental groups examined, there was no statistically significant difference in the mean post-test scores of the boys and the girls. If girls are given the same educational chances as boys and are influenced by a positive gender perspective, they are likely to succeed to the same extent as boys. Using CMTA enables students to participate in discussions, promotes knowledge sharing, and helps them apply what they have learned to real-world situations. Participation in CMTA activities fosters self-directed learning and intrinsic motivation, as students assume responsibility for their own academic progress.

4.6 Effects of CMTA on Motivation of Male and Female Students to Learn Biology

The fourth hypothesis ($H_0 4$) revealed that there was no statistically significant difference in the levels of motivation that students exhibited when learning Biology in the through use of CMTA.To determine whether there was a statistically significant difference in the two groups' levels of motivation to learn Biology, the post-test mean scores were examined and compared. In Table 21, the post-test SMQ mean scores of boys and girls exposed to CMTA are compared, along with an example of the comparison.

Table 21

Gender-Based Comparison of SMQ Mean Scores Following CMTA Intervention

Gender	N	Mean	SD
Boys	82	3.92	0.44
Girls	91	4.19	0.64

According to the results in Table 21, the mean score for girls was slightly higher (M = 4.19, SD = 0.64) than the mean score for boys (M = 3.92, SD = 0.44). An independent sample t-test was used to determine whether the observed difference was statistically significant. The investigation's findings are shown in Table 22.

Table 22

Gender-Based Comparison of Post-Test SMQ Mean Scores Using t-Test Following CMTA Instruction

Gender	Mean	SD	Df	t-value	p-value
Boys	3.92	0.64	76	-1.62	0.056
Girls	4.19	0.44			

Table 22 indicates no statistically significant difference in motivation between male and female students when exposed to the Concept Mapping Teaching Approach (CMTA), as evidenced by a t-value of -1.62 and a p-value greater than 0.05. This indicates that there is no significant difference between the (SMQ) mean scores of both the boys and girls, meaning that CMTA is a welcoming approach in motivating the students irrespective of their gender. Consequently, male and female students registered similar motivation levels in Biology during the study, and hence, Hypothesis four ($H_0$4) was accepted. Its findings justify the fact that gender is not a very important factor in determining the level of motivation when students are taught using CMTA.

These results are in line with earlier research by Keraro *et al.* (2007), which found that when cooperative concept mapping was used, gender had little effect on the degree of motivation displayed by Biology students. Additionally, John and Barchok (2014) investigated whether there is a gender difference in motivation and the efficacy of the Cooperative Mastery Learning Approach (CMLA) Application in the Chemistry course. Their findings show that both male and female students benefit equally from the CMTA. This helps to lessen the gap between male and female students' academic achievement in traditionally male-dominated fields like science and mathematics. Additional support for this view comes from Ayimbilla and Akantagriwon (2021), whose investigation found no appreciable gender difference in motivation after implementation. Changeiywo *et al.* (2011) found that students who received instruction using the Mastery Learning Approach (MLA) demonstrated a considerably higher level of motivation than those who received instruction using Conventional Teaching Methods (CTM). They also found in their research that gender did not play any significant role in the motivation to study Physics, so MLA was proven to be an effective instructional strategy regarding the increased engagement of students. Nevertheless, the results offered by Shihusa and Keraro (2009) refute this pattern as the study they conducted on the application of advanced organisers in the process of Biology teaching showed that there were differences by gender and that at the beginning of Biology teaching, boys tended to be more motivated than girls.

Previous research has indicated that boys tend to be more motivated in Biology classes due to their more positive perceptions of the subject. This gap may also be explained by the preferential treatment boys received from teachers, which potentially discouraged girls from active participation (Wachanga, 2002).

In solving the problem of gender inequalities in science education, educators must come up with teaching approaches that are gender-sensitive as well as pedagogically effective. Adopting the Concept Mapping Teaching Approach (CMTA) promotes gender equity while strengthening students' conceptual understanding of science. Such gender-inclusive methods are vital for enhancing motivation, a key factor in academic performance. Implementing educational programs that actively engage both genders is essential in challenging the widespread perception that science is inherently difficult, especially among female students. In this study, all participants took part in group-based concept mapping activities, which included discussions, presentations, and collaborative error correction. This active approach promoted comprehension, fostered critical thinking, and enhanced cognitive acquisition. Moreover, the findings reveal that CMTA was especially effective in mixed institutions, where it enhanced female students' motivation to engage with biological concepts.

According to the findings, CMTA is a gender-neutral, pedagogically sound substitute for Conventional Teaching Methods (CTM). To improve the overall performance of female students on national examinations, CMTA should be used more widely. Choosing careers in Science, Technology, Engineering, and Mathematics (STEM) may significantly enhance their professional status and opportunities. These findings are in harmony with the United Nations Sustainable Development Goals (SDGs) and the strategic priorities outlined in Kenya's Vision 2030 for national development. It is strongly recommended that the Ministry of Education allocate resources toward the implementation of the Concept Mapping Teaching Approach (CMTA), emphasis on supply of adequate instructional materials to schools and providing specialized training for science teachers.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of the results, conclusions, and recommendations derived from the findings of this study. This section also presents suggestions, conclusions and potential areas for further investigations.

5.2 Summary of Findings

Based on the goals of the study, the following conclusions may be made on the motivation and performance of Biology students in sub-county co-educational secondary schools in Kitui County, Kenya:

i. The Concept Mapping Teaching Approach (CMTA) program introduced in the Biology course had an impressive academic performance by students than the Conventional Teaching Method (CTM). The latter depicts that CMTA is better than CTM in improving academic performance among students in Biology.

ii. CMTA was also used in promoting students' motivation towards learning Biology more than CTM. The approach boosted the level of motivation, which is a key determinant of academic performance in Biology.

iii. Employing CMTA was useful in closing the gender disparity in academic performance in Biology. Students of both genders showed comparable improvement in performance upon being taught via CMTA, which indicates that the approach is gender inclusive in improving learners' performance.

iv. In a similar manner, CMTA was found to reduce gender differences in motivation to study Biology, with results indicating that male and female learners were equally motivated when exposed to CMTA, unlike when instructed through CTM.

In conclusion, one of the most popular teaching strategies in the field of Biology education and learning is the Concept Mapping Teaching Approach (CMTA). In addition to having a favourable impact on the students' academic performance and willingness to learn biology, it also helps to achieve gender parity in Biology achievement.

5.3 Conclusions

The study findings prove that CMTA is a valuable instructional approach as it enhances both the performance of the students and their motivation. In this section, there are conclusions made based on the study objectives.

i. Implementing CMTA in Biology instruction leads to higher students' academic achievement compared to use of CTM.
ii. In Comparison to CTM, the use of CMTA significantly increases the motivation of learners to study Biology.
iii. The success of CMTA in the instruction of Biology bridges the gender achievement gap in comparison to CTM.
iv. The use of CMTA in teaching Biology closes the gender disparity in learners' motivation to learn compared to CTM.

5.4 Recommendations

The inclusion of CMTA in teaching Biology in secondary schools and teacher training programs holds the potential of enhancing the current trend of low achievement in Biology. This approach may help address obvious basic factors contributing to low grades in national Biology examinations. It is worth noting that CMTA has proven effective in minimizing gender gaps in Biology by enhancing both academic performance and motivation among male and female students. As a result, the study proposes the recommendations outlined below:

i. It is suggested that the teaching methodology that will help Biology teachers to improve the performance of the students in Biology is the Concept Mapping Teaching Approach (CMTA).
ii. Teachers of Biology can present the utilisation of CMTA during science clubs, science and engineering fairs, and symposiums, which help students realise more about the science process skills and better performance in the KCSE.
iii. To enable Biology teachers to effectively implement CMTA, the Centre for Mathematics, Science and Technology Education in Africa (CEMASTEA) should organize professional development programs in the form of workshops and seminars.
iv. KICD ought to recommend inclusion of the Concept Mapping Teaching Approach (CMTA) as a systematic component to enhance teaching of Biology in particular, since the implementing pedagogy has a great potential to improve the performance of students and close the gender gap in achievement in science subjects.

5.4.1 Suggestions for Further Research

Further research is needed in the following areas:

i. An examination of the impact of CMTA on junior secondary school students' comprehension of integrated science concepts.

ii. Studies on how to evaluate students' academic achievement in genetics using CMTA.

iii. An analysis of how CMTA affects junior secondary school students' creativity in integrated science.

iv. Research on improving Biology instruction through the use of inquiry-based learning.

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APPENDICES

Appendix A: Students' Motivation Questionnaire (SMQ) implementation Guidelines

1. This survey is designed to gather your opinions about Biology as a subject and is not intended to be a test or examination. Your information will only be utilised for this study, with the ultimate goal of enhancing Biology education in schools.
2. Before selecting an item that aligns with your beliefs, thoroughly read each to ensure you understand it. However, there is no right or incorrect response when answering the surveys.
3. Circle the letter that most accurately captures your feelings on the biology topic. Just one option should be circled.
4. This exercise does not require names.
5. The options are SD = Strongly Disagree, D = Disagree, U = Undecided, A= Agree, and SA = Strongly Agree.
6. You may carefully erase and circle a new response if you decide you no longer agree with the response to any question or statement.
7. As an illustration, if a student answers "yes" to the following statement, they would say:

Using concept mapping to solve challenges in practical Biology work was intriguing.

SD D U (A) SA

SECTION I: Demographic Information

1. Gender: Boy
2. Age in years
3. Class…………………. School …………………………………………..

4. K.C.P.E. Total Marks

SECTION II: Individual Perspectives on Biology Education

When the instructor used concept mapping to teach biology to students, it was:

1. Enjoyable	SD	D	U	A	SA
2. Gratifying	SD	D	U	A	SA
3. Insightful	SD	D	U	A	SA
4. Useful	SD	D	U	A	SA
5. Tedious	SD	D	U	A	SA
6. Frustrating	SD	D	U	A	SA
7. Hard	SD	D	U	A	SA
8. Challenging	SD	D	U	A	SA

Using concept mapping to independently learn the biology topic was:

1. Too stressful	SD	D	U	A	SA
2. Too Demanding	SD	D	U	A	SA
3. Fearful	SD	D	U	A	SA
4. Exciting	SD	D	U	A	SA
5. Worrying	SD	D	U	A	SA
6. Enjoyable	SD	D	U	A	SA

Using concept maps drawn by students to learn biology made me:

1. Doubt my ability to learn biology	SD	D	U	A	SA
2. feeling like I was misusing time	SD	D	U	A	SA
3. Happy	SD	D	U	A	SA
4. Excited	SD	D	U	A	SA
5. Feel a strong desire to understand biology	SD	D	U	A	SA
6. Have self-assurance in the biology subject	SD	D	U	A	SA
7. Frustrated	SD	D	U	A	SA
8. Unhappy	SD	D	U	A	SA
9. Want to use my expertise to address real-world issues	SD	D	U	A	SA

The Concept mapping learning approach made me:

1. Like Biology	SD	D	U	A	SA
2. Scared of Biology	SD	D	U	A	SA
3. Appreciate Biology	SD	D	U	A	SA
4. Dislike Biology	SD	D	U	A	SA
5. Gain interest in Biology	SD	D	U	A	SA

When the instructor used concept mapping to teach biology to students, it was:

1. Doubt my ability to learn Biology	SD	D	U	A	SA
2. Feeling like I was misusing time	SD	D	U	A	SA
3. Happy	SD	D	U	A	SA
4. Excited	SD	D	U	A	SA
5. Develop curiosity to learn Biology	SD	D	U	A	SA
6. Gain confidence to learn Biology	SD	D	U	A	SA
7. Frustrated	SD	D	U	A	SA
8. Unhappy	SD	D	U	A	SA
9. Want to use my expertise to address real-world issues	SD	D	U	A	SA

Appendix B: Biology Achievement Test (BAT): Pre-Test Guidelines

1. Answer all questions in the space provided on the question paper after each question.
2. Carefully read each question to make sure you understand it before answering.
3. Time allowed: **2 Hours.**

SECTION I: Demographic Information

1. Gender: Boy ☐ Girl ☐
2. Age in years ☐
3. Class…………………. School ………………………………………

SECTION II: Questions on Support and movement in animals.

1. State **two** importance functions of support in animals. (2mks)

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

2. Give **two** importance of locomotion in animals. (2mks)

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

3. State **three** types of skeletons found in animals. (3mks)

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

4. Name the fin in tilapia that:-

a) Control rolling (1mk)

……………………………………………………………………………..

b) Change direction and brake. (1mk)

……………………………………………………………………………..

5. Explain how each of the following structures adapts fish to their movement in water.

a) Swim bladder (2mks)

………………………………………………………………………………

b) Scales facing backwards and overlap each other (2mks)

……………………………………………………………………………………

c) Streamlined body shape (2mks)

……………………………………………………………………………………

6. Distinguish between a ball and socket joint. (2mks)

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

……………………………………………………………………………

7. Name **three** types of muscles found in the human body and state where each is located. (3mks)

	Muscle type	Where located

8. Distinguish between a tendon and a ligament. (2mks)

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………

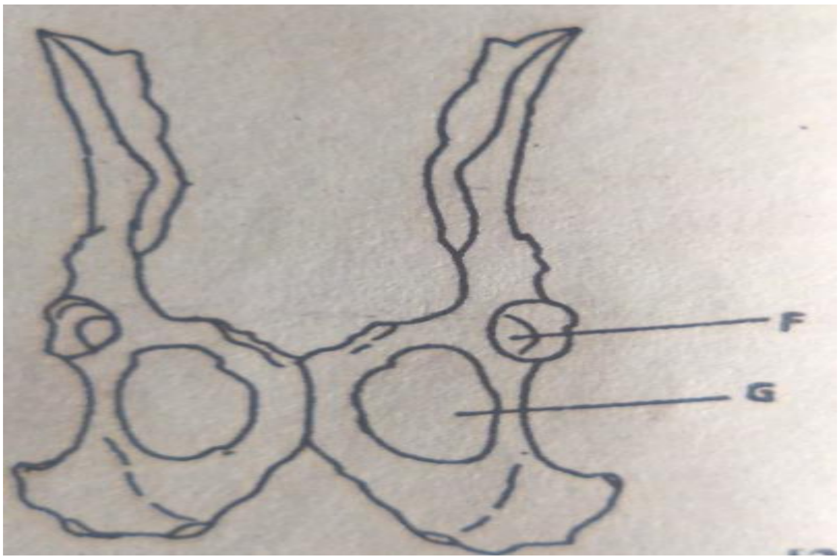
9. Explain how bending and straightening of the mammalian arm occurs to allow for movement. (4mks)

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………

10. The diagrams below represent two fused bones of a mammal.



a) Identify the bone (1 mark)

……………………………………………………………………………

b) Name the:-

i. Bone that articulates at point labelled F. (1mk)

………………………………………………………….……………

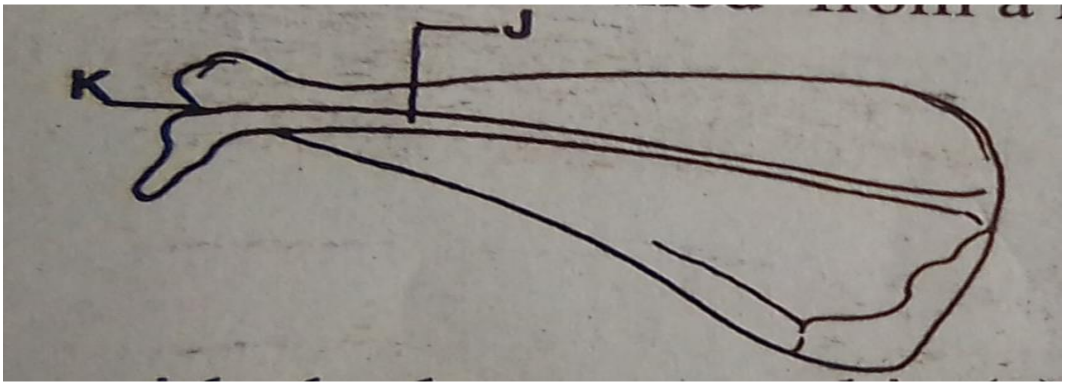
ii. The hole labelled G (1mk)

…………………………………………………………………..………

iii. The function of the hole is named in 10 **(ii**) above. (1mk)

……………………………………………………………………………

11. The diagram below represents a bone obtained from a mammal.



a) Identify the bone. (1mk)

………………………………………………………………………………….

b) Name the:-

i. Bone that articulates with the bone named I **(a**) above at the cavity labelled K. (1mk)

…………………………………………………………………………………………………

…………………………………………………………

ii. Joint formed by the **two** bones at cavity K (1mk)

…………………………………………………………………………………………………

……………………………………………………………………………

iii. State the function of part labelled J (1mk)

…………………………………………………………………………………………………

……………………………………………………………

12 A certain fish species was found to lack the ability to change direction when swimming, reduce speed and stabilise in water. Name the **two** types of fins that seem to have become nonfunctional. (2mks)

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………

13 Explain the significance of a prominent centrum in cervical vertebrae in mammals. (2mk)

…………………………………………………………………………………………………

…………………………………………………………………………

14. Outline **four** major structural differences between cervical and thoracic vertebrae in the mammalian body. (4mks)

Cervical vertebra	Thoracic vertebra
i)	
ii)	
iii)	
Iv)	

15. Outline **four** functions of the exoskeleton in members of the phylum Arthropoda. (4mk)

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

…………………………………………………………………………………………………

……………………………………………………………

16 Name the type of joint formed at the articulation of:-

a) Pelvic girdle and femur. (1mk)

………………………………………………………………………………………

b) Humerus and ulna (1mk)

………………………………………………………………………………………………

17 Explain **three** ways in which saccral vertebrae in mammals are adapted to their functions. (3mks)

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

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

…………………………………………………………………………

18. Outline **three** differences between a ball and socket joint . (3mk)

……………………………………………………………………………………………….

…………………………………………………………………………………..……

19. Name the type of skeleton found in each of the following animals.

a) Locust (1mk)

………………………………………………………………………………………………

b) Birds ………………………………………………………………………..(1mk)

c) Earthworm……………………………………………………………………(1mk)

20. Name **two** types of involuntary muscles in mammals. (2mks)

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

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

…………………………………………………………………………

21. State **one** characteristic of muscles responsible for each of the following.

a) Peristaltic movement (1mk)

………………………………………………………………………………………………

b) Movement of limbs (1mk)

……………………………………………………………………………………………….

22. Explain **three** ways in which the pelvic girdle in mammals is adapted to their functions (6mks)

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

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

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

……………………………………………………………

23. Give **four** distinguishing features between skeletal muscles and visceral muscles

(4mks)

	Skeletal muscles	Visceral muscles
i.		
ii.		
iii.		
iv.		

24. Identify **two** characteristics of cardiac muscles that make them more special than other muscles. (2mks)

i. ………………………………………………………………………………………

ii. ………………………………………………………………………………………

25. State **four** advantages of having an exoskeleton in members of the class Insecta. (4mks)

……

……

……………………………………………………………………………

26. Give a reason for each of the following features observed in the thoracic vertebrae.

(i) Long and broad transverse processes……………………………………..(1mk)

(II) Extra processes……………………………………………….. (1mk)

(III) Wide neural canal…………………………………………. . (1mk)

END

Appendix C: Teachers' Instruction Module for Use on Support and Movement in Animals with Concept Mapping Teaching Approach.

OBJECTIVES.

By the end of the topic, the learner should be able to:-

(a) Explain the necessity for support and movement in animals.

(b) List the functions of exoskeleton, endoskeleton and hydrostatic skeleton.

(c) Identify the bones of the axial and appendicular skeleton in animals.

(d) Describe the structure and functions of different types of joints in mammals and explain how muscles bring about movement.

(e) Distinguish between different types of muscles, their location and functions.

Concept maps should be integrated throughout teaching and learning process. Learners should be given opportunities to construct concept maps both individually and collaboratively in manageable groups.

.

WEEK ONE

Lesson 1 & 2 Pilot testing

Lesson 3 & 4 Pre-testing

WEEK TWO

Lesson 1

Duration : 40minutes

Lesson topic : Necessity for support and movement in animals

Method : Ten minutes for class discussion

Development of Concept maps (15 minutes)

Students' presentation followed by interactive discussion. (15 minutes)

Group based interactive discussion (10 minutes)

It is important to note the following points:

- Importance of support in animals
- Importance of movement in animals
- Types of skeleton in animals
- Exoskeleton in arthropods and its importance

Concept mapping (15 minutes)

Students should be given assignments to create concept maps based on the material that has been covered. Instructors must make sure that every student contributes actively to the making of these maps. Additionally, teachers should provide support and guidance to learners who encounter difficulties during the process, helping them to overcome challenges and effectively develop their concept maps.

Oral presentation and peer engagement (15 minutes)

For a group discussion, a few students ought to be chosen to present their concept maps to the class. The instructor will next give closing remarks, highlighting the most important key insights and addressing any recurring problems noticed. Furthermore, the teacher should encourage all students to create concept maps individually, reinforcing their understanding and personal engagement with the material.

WEEK1

Lesson No 2

Lesson duration **:** 40 minutes

Lesson Topic **:** Endoskeleton in mammals

Method **:** Ten minutes for class discussion

: Engagement in Concept Mapping construction activity. (15 minutes)

: Oral Presentation and reflective discussion. (15 minutes)

Group based interactive discussion. (10 minutes)

It is important to note the following points:

- Functions of endoskeleton

- examples of endoskeleton

Concept mapping (15 minutes)

Instructor should make sure students create concept maps based on the material covered. Teacher to assist learners where they get stuck.

Presentation and discussion (15 minutes)

To facilitate meaningful discussion, students should present their structured concept maps in class. The teacher is then expected to provide concluding remarks.

Lesson No 3

Lesson duration **:** 40 minutes

Lesson Topic **:** Locomotion in finned fish

Method **:** Group based interactive discussion. (15 minutes)

Development of Concept maps. (10 minutes)

Oral presentation and reflective discussion. (15 minutes)

Group based interactive discussion. (15 minutes)

Teacher is expected to make any remarks to conclude.

- Observing the tilapia shape
- Identifying the external features for the tilapia
- Observing the arrangement of scales in tilapia
- Identifying paired and unpaired fins

Involvement in Concept Mapping activity. (10 minutes)

Students are expected to develop concept maps reflecting the material covered in discussion. The facilitator ensures each learner is involved in doing the maps. Facilitator to assist those learners facing challenges in getting concepts.

Presentation and discussion (15 minutes)

A few students from various groups will share their concepts for maps during the lesson. The instructor will make closing remarks.

Task

Students to draw and label a diagram of tilapia on student’s book page (128), fig. 4.9

WEEK TWO

Lesson No 4

Lesson duration **:** 40 minutes

Lesson Topic **:** Identification of axial skeleton

Method **:** Group based class discussion. (10 minutes)

: Development of Concept maps. (15 minutes)

: Oral presentation and reflective discussion. (15 minutes)

Facilitated classroom discussion. (10 minutes)

It is important to note the following points:

- Axial skeleton (skull, cervical vertebra, thoracic vertebra, lumber vertebra and sacral vertebra)
- Their distinguishing characteristics
- Their adaptation
- Where they are found in mammalian body.

Concept mapping (15 minutes)

Students will create concept maps in groups based on previously covered material. The teacher should circulate the classroom to make sure every student is fully engaged and to help them organize concepts from the most basic to the most detailed.

Presentation and discussion (15 minutes)

A single participant from every group will showcase their group's concept map to the whole class. Next, under the teacher's guidance, the class discusses the concept map. The instructor will provide closing comments about each concept map that was shown in class.

WEEK TWO

Lesson No 5

Lesson duration **:** 40 minutes

Lesson Topic **:** Appendicular skeleton

Method **:** Group based interactive discussion. (20 minutes)

: Development Concept maps (10 minutes)

: Oral presentation and reflective discussion. (10 minutes)

Group based interactive discussion. (20 minutes)

It is important to note the following points:

- Bones of the fore limbs
- Their location
- Their adaptations and functions

Development of Concept maps. (10 minutes)

Students to work in manageable groups to generate create concept maps based on previously studied content. The teacher will move around, ensuring all learners actively participate in constructing concept maps and assist where necessary.

Presentation and discussion (10 minutes)

To promote class engagement, the instructor will have group leaders present their concept maps, while the teacher provides support.

WEEK THREE

Lesson No 1 & 2

Lesson duration **:** 80 minutes

Lesson Topic **:** Bones of fore limb

Method **:** Facilitated classroom discussion. (30 minutes)

: Engagement in Concept mapping construction activity. (25 minutes)

: Oral presentation and reflective discussion.(25 minutes)

Facilitated classroom conversation. (30 minutes)

It is important to note the following points:

- Scapula and where found
- Humerus and its features
- Ulna and radius
- Carpals, meta carpals and phalanges

Engagement in Concept mapping construction activity. (25 minutes)

While learners develop concept maps on their own, the teacher to move around the classroom to check on their work and offer guidance.

Oral presentation and reflective discussion. (25 minutes)

To promote dialogue, some students will be asked to display their concept maps to the whole class, with the teacher providing direction.

WEEK THREE

Lesson No 3 & 4

Lesson duration **:** 80 minutes

Lesson Topic **:** Bones of the hind limb

Method **:** Facilitated classroom conversation. (30 minutes)

: Engagement in concept mapping construction. (25 minutes)

: Oral presentation and reflective discussion. (25 minutes)

Group based interactive discussion. (30 minutes)

It is important to note the following points:

- Pelvic girdle, its components and features.
- Femur
- Tibia and fibula

Engagement in concept mapping construction activity. (25 minutes)

Learners will develop their concept maps on their own, with the teacher observing and offering support where necessary.

Oral presentation and reflective discussion. (25 marks)

A few students will be chosen to showcase their concept maps promoting the whole class discussion guided by the teacher.

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WEEK THREE

Lesson No 5

Lesson duration **:** 40 minutes

Lesson Topic **:** Movable joints (ball and sockets)

Method **:** Facilitative classroom discussion. (20 minutes)

: Engagement in Concept mapping construction activity. (10 minutes)

: Oral presentation and reflective discussion. (10 minutes)

Facilitated classroom discussion. (20 minutes)

It is important to note the following points:

- Location of ball and socket joints
- Bones that form them
- Observe movement at hip and shoulder joints

Engagement in Concept mapping construction activity. (10 minutes)

Students will create concept maps on moveable joints in small groups. The instructor should circulate the classroom to make sure every student is engaged. The teacher should help students recognize concepts in the material and then group them according to hierarchy.

Presentation and discussion (10 minutes)

A learner in each group to be allowed to present the drawn concept map to class. Teacher to make concluding remarks.

WEEK FOUR

Lesson No 1 & 2

Lesson duration **:** 80 minutes

Lesson Topic **:** Movable joints (hinge joint)

Method **:** Facilitated classroom discussion. (30 minutes)

: Engagement in Concept mapping construction activity. (25 minutes)

: Oral presentation and reflective discussion. (25 minutes)

Oral presentation and reflective discussion. (30 minutes)

It is important to note the following points:

- Location of hinge joints
- Bones that form hinge joints
- Distinguishing features of hinge joints
- Observe movement at the elbow and knee.

Concept mapping (25 minutes)

Students will create concept maps in groups based on the material they have discussed. Teacher to assist those facing challenges.

Presentation and discussion (25 minutes)

A learner in each group to be allowed to present the drawn concept map to class. Remarks from the teacher will conclude.

Task

Student to draw and label a diagram of a hinge joint at humurus and radius.

WEEK FOUR

Lesson No 3 & 4

Lesson duration **:** 80 minutes

Lesson Topic **:** Types of muscles in mammals

Method : Class discussion (30 minutes)

: Engagement in Concept mapping construction activity. (25 minutes)

: Oral presentation and reflective discussion. (25 minutes)

Facilitated classroom discussion. (30 minutes)

It is important to note the following points:

- Muscles types
- Location of muscle types
- Characteristics of each type of muscles

Development of Concept maps.(25 minutes)

Students should recognize and prioritize the most vital concepts in the material. The teacher should go around the classroom making sure students are doing their work. Teacher to assist the learners where possible.

Presentation and discussion (25 minutes)

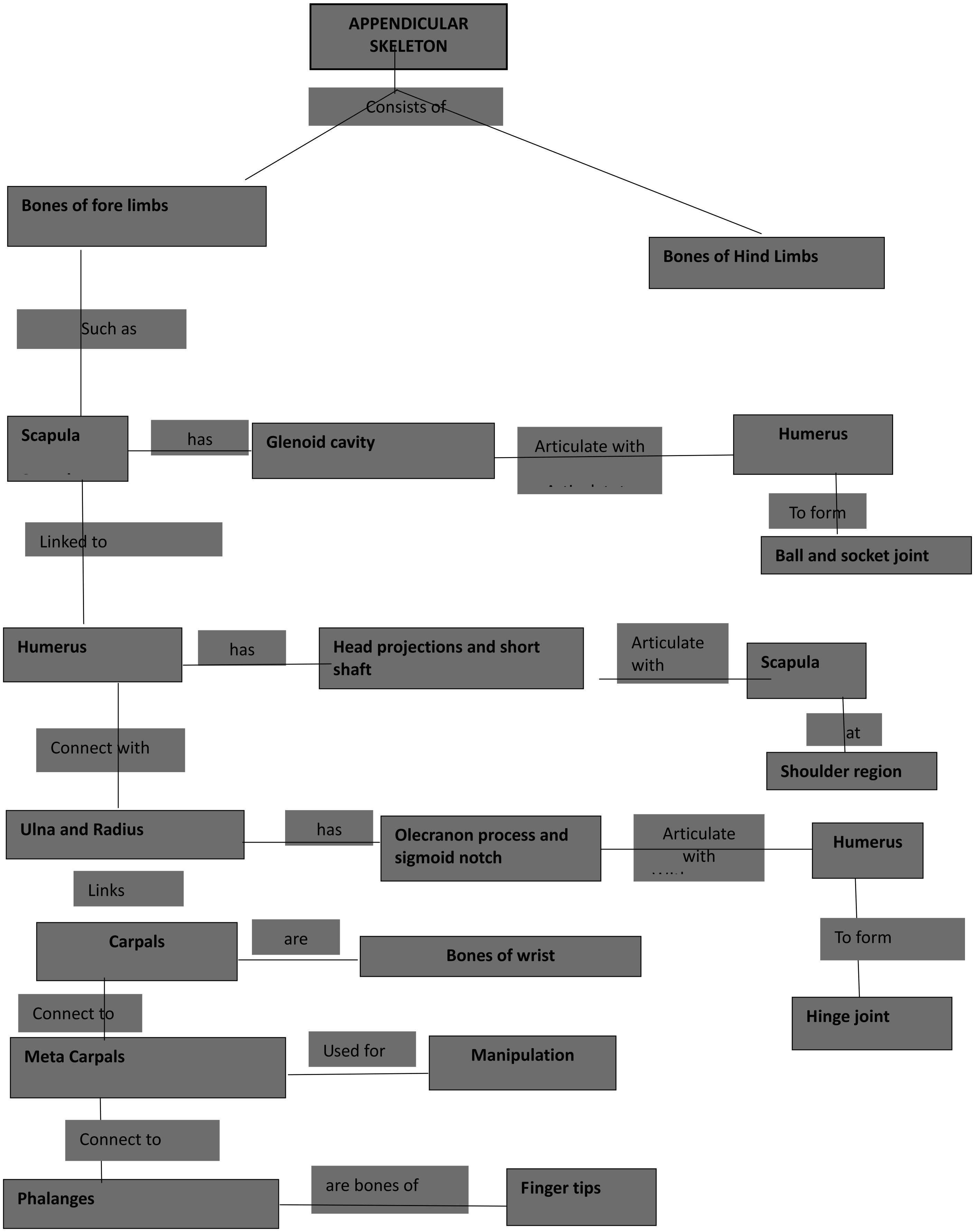
Each group will have a student who will be able to present their idea map to the class. The instructor will offer closing words.

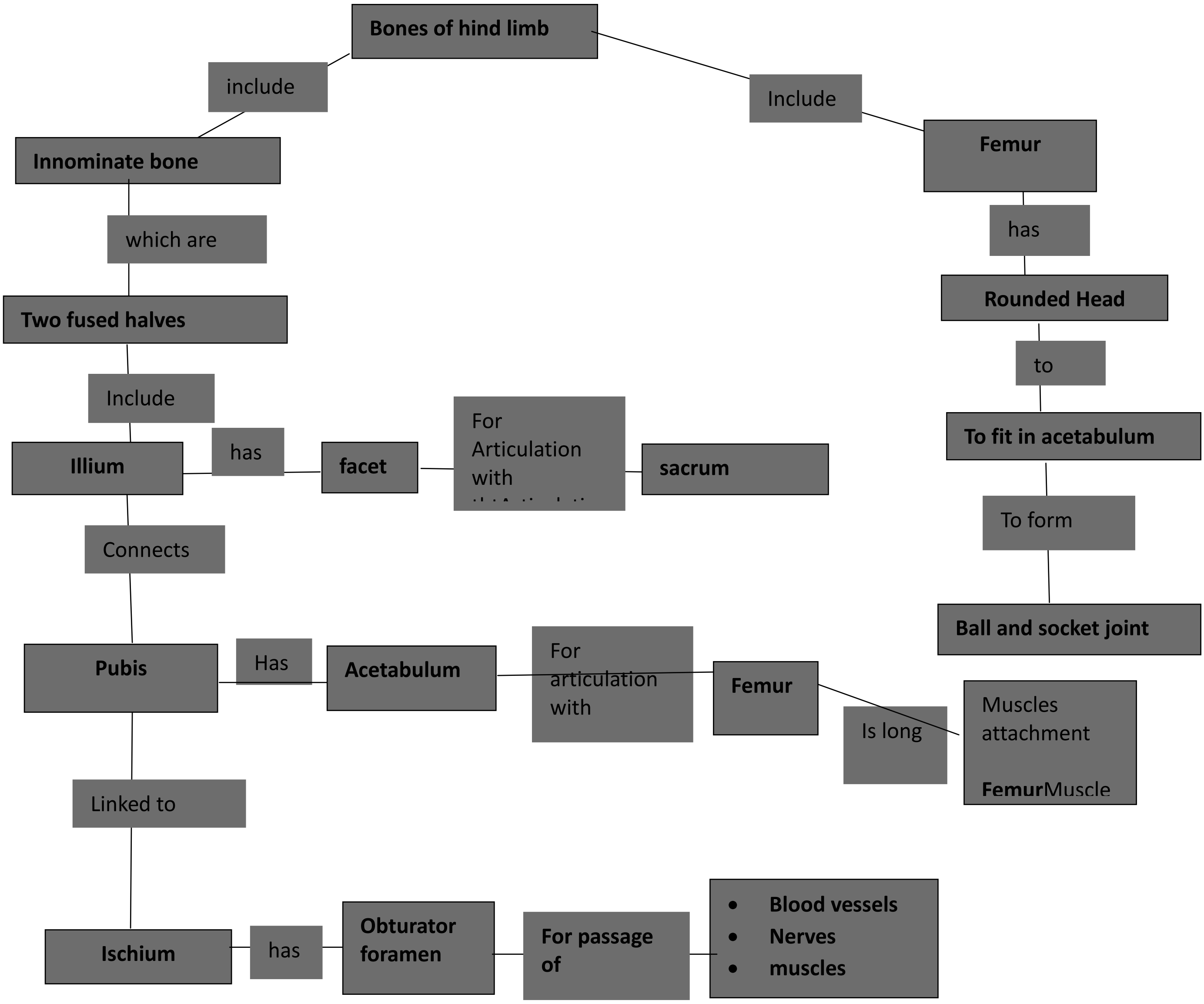
WEEK FIVE

Post-test

Administration of BAT to all groups for a period of 2 hours.

Appendix D: Concept Map




Bones of hind limb
include
Include
Innominate bone
Femur
which are
has
Two fused halves
Rounded Head
to
Include
To fit in acetabulum
Illium
has
facet
For Articulation with
sacrum
To form
Connects
Ball and socket joint
Pubis
Has
Acetabulum
For articulation with
Femur
Is long
Muscles attachment
Linked to
Ischium
has
Obturator foramen
For passage of
Blood vessels
Nerves
muscles

Appendix E: Teacher Training Instruction Module on Concept Mapping Construction

Introduction to Concept Mapping Construction.

1. Write a list of common items on the whiteboard, such as a desk, chair, computer, pen, and box. Compile a list of verbs that describe common place actions like writing, printing, drawing, storing, and painting. Help educators understand that the names of items are listed in the first list, while events or occurrences are listed in the second.

2. Find out from the students what comes to mind when they hear the terms "book," "table," "computer," "pen," and "box" from the first list. As a result, assist learners in realizing that although we all speak the same language, our thoughts could differ. Every phrase could evoke a different mental image in our minds. Concepts are the mental representations of each word that we have. Students should now be familiarized with the term **concept**. Provide a list of prepositions such as *"of," "to," "in,"* and *"for."* Engage learners in determining whether these words qualify to be categorised as concepts. Guide learners to understand that such words function as connectors rather than actual concepts. To create a coherent sentence, they are employed with concepts.

3. Help learners realize that nouns are names of things, people, events, or even places rather than concept words.

4. On the black board, create a few short sentences using two topic words and linking words. This can help to clarify how individuals utilize concept words and linking words to express information or meaning. For instance, a computer can be used for typing.

5. Identify a topic in form four Biology course book and find a section that explains a given concept. Request the students to read the passage aloud or individually and highlight the main concepts. Remind them to highlight a few less significant concept words and linking words in the text.

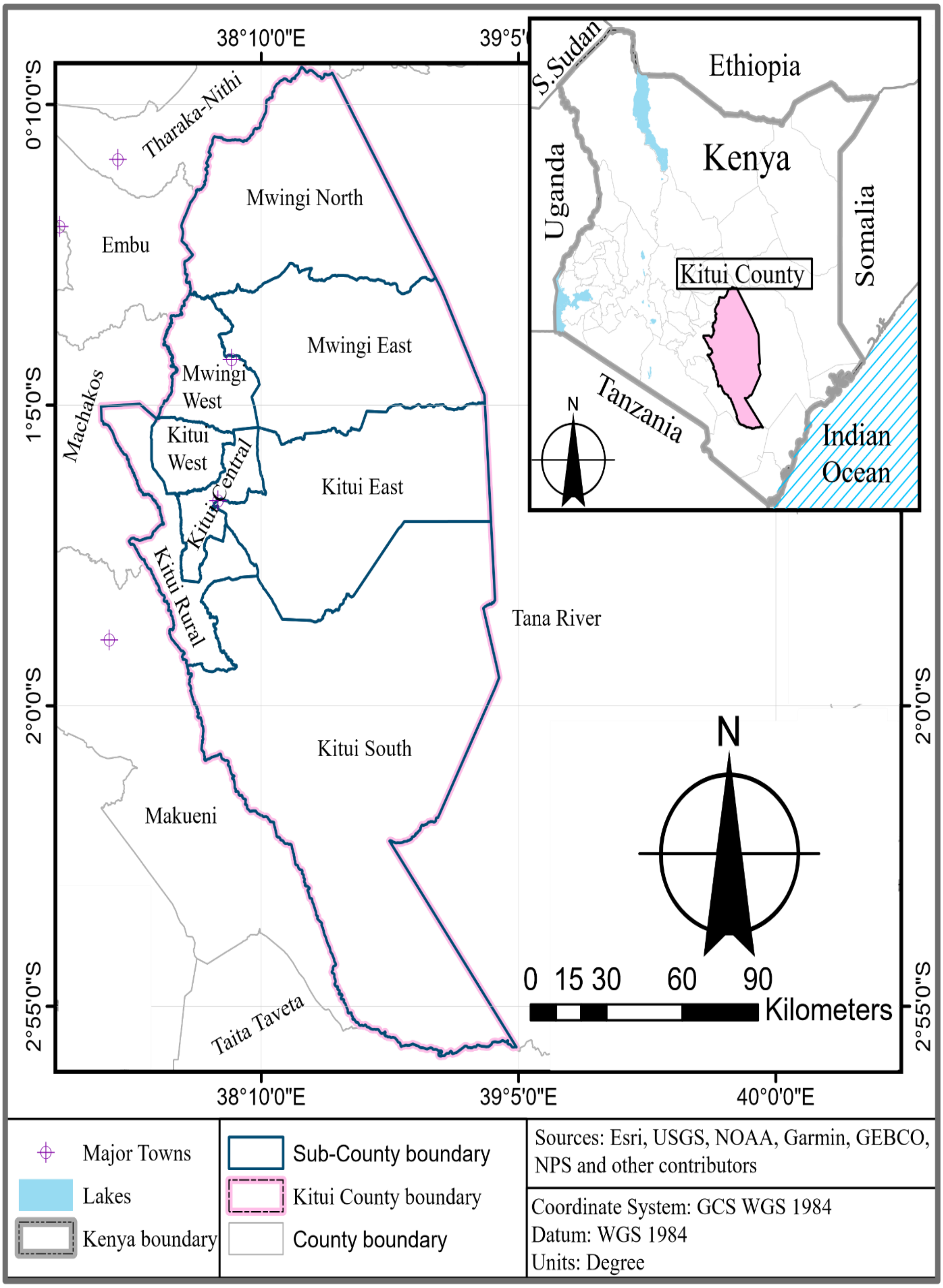
6. Develop a revised, hierarchically ordered list of concepts, starting with the primary concept. Proceed through the first list of concepts, listing the next broadest ones, until all concepts are ranked in order. For instance, in the topic classification I, taxonomic units, the most particular concept, species, is positioned last and is the most specific concept, followed by genus, family, order class, phylum and kingdom as the primary concept.
7. Begin developing a concept map, guided by the ranked list to organize concepts according to their hierarchical relationships. Instruct learners to select appropriate conjunctions to create the prepositions shown on the map by lines.

8. Identify relationships between concepts located in different parts of the concept map or branches of the concept "tree of concepts. Involve learners in choosing suitable connecting terms for the cross-links.

9. The majority of maps created for the first time lack symmetry or have certain concepts positioned incorrectly in relation to other concepts that are more closely connected. As a result, it might be required to reconstruct the maps, as you mention to the teachers that a good depiction requires at least one, two, or three attempts at reconstruction.

10. Teachers can use manila papers to display their created maps to the class. Other learners in the class should be able to fully comprehend the text's meaning as interpreted by the map reader through discussion of the concept map.

Appendix F: Map of Study Location



Appendix G: Research Licence

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NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 454076

Date of Issue: 15/December/2023

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This is to Certify that Mr.. Benedict MBALUKA MWAMBUA of Egerton University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Kitui on the topic: Effects of concept mapping on secondary school students achievement and motivation to learn Biology in kitui county kenya for the period ending : 15/December/2024.

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Appendix H: Abstract Section Of The Published Research Paper

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Original Paper

Effects of Concept Mapping Teaching Approach on Secondary School Students' Achievement in Biology in Kitui County, Kenya

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Abstract

This study investigated the impact of the Concept Mapping Teaching Approach (CMTA) on Biology achievement among year four students in selected secondary schools in Kitui County, Kenya. The Solomon Four Non-Equivalent Control Group design was used. The target population included all secondary school Biology students, while the accessible population comprised Form Four students from co-educational secondary schools in the county. A purposive sample of four secondary co-educational Sub County schools was selected. Two schools were randomly assigned as experimental groups and the remaining two schools served as control groups. The study sample comprised 173 Form four Biology students. Biology Achievement Test (BAT) was used to collect data. The BAT was validated by five experts. The reliability of BAT was estimated using Cronbach's alpha coefficient formula. This yielded a reliability coefficient of 0.78. One-way ANOVA, ANCOVA and t-tests were used to analyze data at 0.05 level of significance. Results indicated that students exposed to CMTA showed significant improvements in their biology performance. Additionally, the study findings indicate that CTMA bridged the gender disparity in achievement.

Keywords

Concept Mapping Teaching Approach (CMTA), biology achievement, secondary school student, learning biology

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