EFFECTS OF COLLABORATIVE CONCEPT MAPPING TEACHING APPROACH ON SECONDARY SCHOOL STUDENTS' ACHIEVEMENT AND MOTIVATION TO LEARN BIOLOGY IN NAKURU NORTH SUB-COUNTY, KENYA.

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Egerton University

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DECLARATION AND RECOMMENDATION

Declaration

I declare that this is my original work and has not been presented for award of a Diploma or Degree to this or any other University.

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DEDICATION

This work is dedicated to my family; Paul Mwangi, Carol Wanja, Bilhah Wamahiga and Elizabeth Nyokabi.

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ABSTRACT

Biology is a key science subject in the Kenyan Secondary School Curriculum. However, evidence available indicates that students' achievement in the subject has been poor. One of the factors attributed to this poor achievement is the teaching approaches used by teachers, with teacher-centered approaches being pre-dominant. This study sought to address the problem of ineffective instruction by teachers by investigating effects of Collaborative Concept Mapping Teaching Approach (CCMTA) on secondary school students' achievement and motivation to learn Biology. The study used a Quasi-experimental research design, the Solomon Four Non-Equivalent Control Group Design. The study sample comprised of 202 Form two biology students and four biology teachers in four secondary schools who taught the topic "Gaseous exchange in plants and animals". Purposive sampling technique was used to select the four schools from which a single stream per school was selected by simple random sampling. The streams comprised of 47, 54, 55 and 46 students respectively. The four schools were randomly assigned into two experimental and two control groups and coded as E1 & E2, C1 & C2 respectively. A Biology Achievement Test (BAT) and Students' Motivation Questionnaire (SMQ) were used for data collection. Five educational research experts validated the research instruments. Three experienced biology teachers who are examiners with Kenya National Examination Council (KNEC) were also involved in validation of research instruments. The research instruments were piloted and Cronbach Alpha Coefficient used to estimate their reliability. The achievement test (BAT) yielded a reliability of 0.86 while students' motivation test (SMQ) had a reliability of 0.84. Groups E1 and C1 were pre-tested prior to the treatment. The treatment lasted three weeks after which all groups were post-tested. One-way ANOVA, t-test and ANCOVA were used to analyze the data generated with the aid of the Statistical Package for Social Sciences (SPSS). Kenya Certificate of Primary Education (KCPE) science scores for the sampled groups were used as covariates to adjust for possible pre-existing differences. Four hypotheses were tested at 0.05 α level of significance. The results indicate that there was a statistically significant difference in achievement and motivation to learn biology between the experimental and control groups in favor of experimental groups. Students' gender had no significant effect on achievement and motivation when they are taught through CCMTA. Adoption of CCMTA is recommended as appropriate for the teaching and learning of school Biology. The findings derived from this study provide a basis for improvement of in-service and pre-service biology teacher training programmes. Biology teachers may also benefit from the findings of this study through application of CCMTA to enhance learners' achievement and interest in Biology and subsequent entry into careers that require biological knowledge and skills.

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ABBREVIATIONS AND ACRONYMS

BAT	Biology Achievement Test
CCM	Collaborative Concept Mapping
CCMTA	Collaborative Concept Mapping Teaching Approach
CDE	County Director of Education
DEO	District Education Office
KALRO	Kenya Agricultural and Livestock Research Organization
KCPE	Kenya Certificate of Primary Education
KCSE	Kenya Certificate of Secondary Education
KICD	Kenya Institute of Curriculum Development
KNEC	Kenya National Examinations Council
NACOSTI	National Commission for Science, Technology and Innovation
SMASE	Strengthening of Mathematics and Science in Education
SMQ	Students' Motivation Questionnaire
SPSS	Statistical Package for Social Sciences
TTM	Traditional Teaching Methods
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNSD	United Nations Statistics Division

CHAPTER ONE
INTRODUCTION

1.1 Background Information

Performance of learners in science subjects has implications for the role a country will play in tomorrow's advanced technology sector, and for its general international competitiveness (OECD-PISA, 2003). Science subjects play a critical role in the socio-economic development of a country. A focus on Global achievement in biology reveals a general decline in the sampled studies as presented, thus calling for urgent remedy. In their study on "The effects of 3D computer simulation on biology students' achievement and memory retention", Elangovan and Ismail (2014) reported low achievement in Malaysian secondary school biology examination for the years 2007 to 2011. Learners indicated lack of mastery of concepts and bore misconceptions about biological concepts such as cell division. These learning problems were attributed to improper teaching and learning methods that emphasize mainly teacher centered learning and encourages rote learning among students. In their study on "Learning environment profiles of Turkish secondary biology classrooms", Brok, Telli, Cakiroglu, Taconis, and Tekkaya (2010) indicated that Turkish classrooms were perceived as being low in terms of Teacher Support and high in terms of Task Orientation. They reported low achievement among Turkish high school biology students arising from inadequate teacher support.

In their study on "Academic Achievement in Biology with Suggested Solutions in Selected Secondary Schools in Kano State, Nigeria" Ali, Toriman & Gasim (2014) reported a decline in students' academic achievement in Biology. This was attributed to various factors such as classes being too large and heterogeneous in terms of ability level, ill-equipped laboratories and an overloaded Biology Syllabus.

According to Kenya Institute of Curriculum Development (KICD, 2003), Biology is one of the science subjects that are offered at the secondary school education cycle in Kenya. KICD, the national curriculum development centre in Kenya has identified objectives for the four year biology course at secondary school education cycle. The objectives are that at the end of the four year biology course, learners should be able to; communicate biological information in a precise clear and logical manner, apply the knowledge gained in school to improve and maintain the health of the individual, family and the community, develop positive attitudes towards biology and the relevant practical skills, develop awareness of the value of cooperation in solving problems and acquisition of a firm foundation of relevant knowledge, skills and attitudes for further education and training in related scientific fields (UNESCO, 1975 & Osborne, 1997).

These objectives are a further recognition of the critical role that the knowledge of biology plays in the socio-economic development of a country. The study of biology equips learners with knowledge, skills and attitudes that are necessary for controlling and conserving the environment (KICD, 2002). Biology is a pre-requisite for careers in health sciences, agriculture and environmental science, and is also the precursor of biotechnology which is a tool for industrial and technological development. Biological knowledge lays the foundation for commercial agriculture, the engine for economic growth in Kenya (GoK, 2003). Researchers have used biological knowledge to develop high yielding, disease resistant and fast maturing food crops and animals to meet the food requirements of an ever increasing world population (Burns & Bottino, 1989). The knowledge of genetics which is a branch of biology has revolutionalised determination of paternity disputes and identity of serious crime culprits with precision and certainty through Deoxyribo-Nucleic Acid (DNA) sequencing and profiling (Institute of Biology, 2007). Biological knowledge has contributed towards conservation of the environment and endangered species (Muraya & Kimamo, 2011; UNESCO, 1986).

Although Biology is a key science subject in secondary schools in Kenya, Kenya National Examinations Council indicates low achievement in biology at Kenya Certificate of Secondary Education (KCSE) over the recent years (KNEC Report, 2014). This is an indication that mastery of biological concepts has been faced with challenges. Besides low achievement in biology, there is a worrying gender disparity in favor of boys. In Nakuru North Sub-county, achievement in biology has been lower than the national average. Among the reasons given for this is the application of ineffective teaching approaches by biology teachers, with TTM being pre-dominant. Evidence available in the literature indicates that application of new or a combination of existing approaches in teaching has enhanced academic achievement and interest towards a subject (Novak & Gowin, 1984; Cicognani, 2000; Basque & Lavoie, 2006; Guastello, E. F. Beasley, T. M. & Sinatra, R. C. (2000); Shihusa & Keraro, (2009**);**

Smith, 2010). Table 1 gives a summary of candidates' overall performance in biology per paper for the years 2008 to 2013.

Table 1

Candidates' Overall Performance in KCSE Biology per Paper in the Years 2008-2013

Year	Paper	Candidature	Max. Score	Mean % score	Standard Deviation
2008	1		80	27.8	14.4
	2		80	26.4	11.6
	3		40	43.3	6.8
	Overall	274,215	200	30.3	14.6
2009	1		80	25.2	12.3
	2		80	23	10.3
	3		40	39.7	8.4
	Overall	299,302	200	27.1	28.8
2010	1		80	26.7	13.8
	2		80	23.3	10.8
	3		40	46.1	8.3
	Overall	317,135	200	29.2	30.0
2011	1		80	28.4	12.4
	2		80	29.1	13.0
	3		40	47.1	8.1
	Overall	363,817	200	32.4	31.1
2012	1		80	24.7	12.8
	2		80	25.9	12.1
	3		40	29.9	6.6
	Overall	389,523	200	26.2	29.4
2013	1		80	35.0	14.5
	2		80	28.0	12.7
	3		40	32.2	7.6
	Overall	397,319	200	31.6	32.1

Source: KNEC Report (2014)

Table 1 indicates fluctuating biology percentage mean scores for the sampled years (2008 to 2013). These scores are also below average since they range from 23% to 47.1%, a level that is far lower than 50%. A student who scores 50% is said to be of average achievement and indicates reasonable mastery of biological content and science process skills. Scores that are lower than average are regarded as weak which implies that a student who attains these grades has weak and poor mastery of the subject matter (KNEC, 2012). Such a student is regarded as having failed to attain the expected basic mastery of the subject content and skills. This has implications on future career prospects of students due to the fact that the grades that a student attains in different subjects at KCSE examination determine admission for further education and training at universities and other tertiary institutes (Muraya & Kimamo, 2011).

Paper 3 which tests practical skills has the lowest means scores. This indicates lack of mastery of biological concepts and skills hence raising concern among education stakeholders. Some of the factors contributing to low achievement in sciences at KCSE include: Students' negative attitude towards the subjects which they perceive as difficult; ineffective teaching approaches that are teacher rather than learner-centered; inadequate mastery of subject content and pedagogical skills by teachers; inadequate teaching and learning resources such as text books and laboratory equipment and apparatus (Muraya & Kimamo, 2011). In addition to low attainment in KCSE in general, there is a glaring gender disparity in favor of boys. Table 2 indicates candidates' achievement by gender for the years 2009-2013 KCSE Science Examinations.

Table 2

Candidates' Performance by Gender in the Years 2009- 2013 KCSE Science Examinations

Year	Subject	Female		Male	
		No. sat	Mean %	No. sat	Mean %
2009	Biology	143,359	25.15	155,943	29.08
	Chemistry	149,755	17.56	179,167	20.43
	Physics	29,233	29.93	74,955	31.88
2010	Biology	148,729	26.99	166,334	31.24
	Chemistry	155,725	22.80	191,653	26.62
	Physics	29,964	33.46	79,108	35.76
2011	Biology	170,764	30.07	193,053	34.53
	Chemistry	179,645	21.47	223,462	25.42
	Physics	32,489	34.55	87,604	37.42
2012	Biology	183,595	24.36	205,926	27.86
	Chemistry	193,426	25.95	237,293	29.54
	Physics	32,295	36.22	87,329	38.48
2013	Biology	190,334	30.15	206,980	32.99
	Chemistry	200,735	23.08	239,206	26.30
	Physics	32,703	38.19	87,159	40.82

Source: KNEC Report (2014)

Analysis of candidates' performance in KCSE by gender in the Years 2009 to 2013 indicates poor performance in science subjects. Enrolment in biology suggests that it is a compulsory science subject in most schools, further highlighting its critical role in achieving socio-economic development of a country (OECD-PISA, 2003). Though enrolment for both boys and girls is almost at par in biology, achievement for boys is higher than that of girls. However, the overall achievement in the subject is poor given that the maximum score is 100%. Namasaka (2009) reported that girls attained lower scores in biology than boys at KCSE. He attributed girls' low achievement to their poor attitude towards science subjects and also to the teaching approaches used. According to a study by Forum for African women Educationists (FAWE, 1998), gender disparity in academic achievement is entrenched in primary and secondary schools. The forum is involved in finding ways to improve participation and performance of girls in science and mathematics in primary and secondary schools.

The FAWE report also reveals that teachers tend to give more attention and use positive reinforcement on boys than they do on girls. This tendency has the effect of making girls believe that they are less able and thus erodes their confidence, leading to low achievement. According to KNEC Report (2012), the poor scores are attributed to lack of skills in answering performance-based questions, inadequate understanding of biological concepts and inability to use technical terms in scientific communication. In comparison to the national achievement in biology at KCSE, Nakuru North Sub- County students' performance in biology at KCSE for the years 2008-2013 are presented in table 3.

Table 3

Nakuru North Sub-county biology KCSE results for the years 2008-2013

Year	No. of candidates	Mean performance index	Grade
2008	352	3.97	D (plain)
2009	3350	3.82	D (plain)
2010	2518	4.15	D+ (plus)
2011	2664	4.78	D+ (plus)
2012	2541	4.78	D+ (plus)
2013	3258	4.57	D+ (plus)

Source: Nakuru North Sub-county DQASO Report (KCSE, 2013)

Results in table 3 indicate a slight improvement in mean performance index for the sampled period. This improvement is however not significant since the reported grades are poor given that the maximum mean performance index is 12 with a mean grade of A. Based on marks scored by a candidate in a subject at KCSE, a grade is awarded on a 12 point grading scale: A, A-, B+, B, B-,C+, C, C-, D+, D, D- and E. Grade A is the highest grade scoring 12 points while grade E is the lowest grade, scoring 1 point (KNEC, 2005). In addition, grades A and A- are indicated as good which implies that a student who attains these grades at KCSE has very good mastery of the subject matter (Muraya & Kimamo, 2011). According to Muraya and Kimamo, grades B+, B and B- are indicated as good and likewise a student who attains these grades is regarded as having good mastery of the subject matter. On the other hand, grades D and D- are indicated as being weak while grade E is indicated as poor, which implies that a student who attains these grades has weak and poor mastery of the subject matter, respectively (KNEC, 2005). Students who attain grades D, D- and E are regarded as having failed to attain the expected basic mastery of the subject content. It is, therefore, apparent that achievement in biology in Nakuru North Sub County, just like the National level is wanting and urgent remedial measures need to be taken to remedy the situation. Application of learner-centered teaching approaches has been recommended by most Educational Researchers (Basque & Lavoie, 2006; Keraro, Wachanga & Orora, 2007; Cicognani, 2000; Wachanga, 2002; Christodoulou, 2010; Muraya & Kimamo, 2011; Wambugu, 2011).

Learner-centered teaching approaches promote imaginative, critical and creativity skills resulting in better achievement of instructional objectives (Ministry of Education, 2001). However, teacher-centered Traditional Teaching Methods (TTM) are pre-dominant in teaching school biology. The most widely used TTM is the Lecture Method (Taylor & Francis, 2011). UNESCO (1986) suggested adoption of teaching approaches that have the potential to motivate learners and involve them in active knowledge construction. Collaborative Learning (CL) is one such approach that engages learners in active learning where they work and learn together in small groups to accomplish shared goals (Panitz, 1996). This approach is characterized by group discussions which allow learners' expression and revision of their beliefs in the context of discourse (Sharan & Sharan, 1992; Bereiter & Scardamalia, 1993; Olson & Bruner, 1996). In CL, students explore their ideas, clarify them for themselves and to one another, expand and modify them, and finally make them their own. Collaborative Learning has positive effects on students' discussions in which they elaborate on the subject, challenge and modify one another's ideas, and thus remember these ideas more easily (Cohen, 1984). In small groups, students can share strengths, develop their weaker skills, interpersonal skills and also learn to deal with conflict. When guided by clear objectives, students engage in numerous activities that improve their understanding of a subject explored.

Concept maps are graphical tools for organizing and representing knowledge. They include concepts and relationships between them indicated by a preposition that links two concepts (Ebenezer & Conner, 1998). Concept mapping is the process of organizing concepts in a hierarchical manner from more inclusive to more specific, less inclusive concepts (Novak & Gowin, 1984). To construct a concept map, concepts have to be identified or generated and the interrelationships between them articulated. Concepts are then placed in a hierarchical order with more general concepts at the top and progressively specific concepts at the bottom. Linking a concept to another via a linking word or phrase identifies a relationship leading to a rich connectivity.

Concept mapping has been reported as effective in helping students learn meaningfully by making explicit the links between concepts (Adamczyk, Willson & Williams, 1994; Fisher, Wandersee & Moody, 2000; Novak & Gowin, 1984). This strategy has also been reported to aid collaborative learning (Sizmur & Osbourne, 1997) and to improve students' problem-solving ability (Okebukola, 1992). The Collaborative Concept Mapping Teaching Approach (CCMTA) brings together Collaborative Learning and Concept Mapping Teaching Approaches. It is a hybridized approach of Collaborative Learning and Concept Mapping thus lending itself as a powerful tool for science education. This approach is therefore likely to motivate learners by bringing in the benefits of concept mapping and collaborative learning. A relationship exists between motivation, cognitive engagement and conceptual change thus; learners who are highly motivated engage themselves more actively in learning activities which would also translate to high achievement (Nelson, 2000).

1.2 Statement of the Problem

Studies have shown that Concept mapping and collaborative learning are individually useful for instruction and diagnosis of students' misconceptions by facilitating meaningful learning and enhanced cognitive gain (Kinchin, Hay & Alan, 2000; Novak, 1990; Okebukola, 1992; Sungur, Tekkaya & Geban, 2001; Yılmaz, 1998). However, it is not clear how a hybridized CCMTA would enhance meaningful learning of biology among secondary school students in Nakuru North Sub-county, Kenya. This study aimed at investigating the effects of CCMTA on achievement in biology with a specific interest in the resultant cognitive gain and change of attitude toward biology associated with use of this approach.

1.3 Purpose of the Study

The purpose of this study was to find out the effects of CCMTA on students' achievement and motivation to learn biology in public secondary schools. To achieve this, the study compared achievement and motivational gain between students taught using CCMTA and those taught using TTM.

1.4 Objectives of the Study

This study was guided by the following objectives;

i. To compare students' achievement in biology between those taught using CCMTA and those taught using the Traditional Teaching Methods (TTM).
ii. To find out whether there is a gender difference in students' achievement in biology when exposed to CCMTA.
iii. To compare students' motivation to learn biology between those taught using CCMTA and those taught using the TTM.
iv. To find out whether there is a gender difference in students' motivation to learn biology when exposed to CCMTA.

1.5 Hypotheses

The following null hypotheses were tested during the study;

Ho_1: There is no statistically significant difference in secondary school students' achievement in biology between students taught using the CCMTA and those taught using the TTM

Ho_2: There is no statistically significant gender difference in achievement in biology when learners are exposed to CCMTA

Ho_3: There is no statistically significant difference in motivation to learn biology between students taught using CCMTA and those taught using the TTM

Ho_4: There is no statistically significant gender difference in the level of motivation to learn biology among learners exposed to CCMTA.

1.6 Significance of the Study

In view of sustained low achievement in biology at KCSE for the sampled period (2009- 2013), it was thought educationally enriching to find out how application of CCMTA would affect acquisition of biology concepts and motivation towards biology among secondary school students. The findings of this study may provide insights in generating necessary interventions to improve achievement in biology. KICD may use the findings to produce more focused secondary school biology curriculum and teaching materials to enhance the learning of biology.

Science instructional process may benefit through expansion of knowledge related to availability of science teaching approaches in Secondary School Education in Kenya. The findings of this study may inform development of science teacher training programmes aimed at producing teachers who are competent in inculcating capacity to acquire science concepts and skills among learners. The findings may also inform educators in designing appropriate interventions to minimize gender disparity observed in science achievement in KCSE especially those observed in biology.

1.7 Scope of the Study

This study was carried out in Nakuru North Sub-county which is among the regions with a high number of secondary schools in Nakuru County. It involved students of biology in the second year of Secondary School Education aged between 14 and 15 years. Biology is a compulsory subject in all Kenyan secondary schools in forms one and two. The biology content covered was Gaseous exchange in plants and animals. This topic is taught in form two and its applications are useful in relating structural adaptations to functions in both plant and animal systems. Students find this topic difficult due to some abstract ideas that challenge their understanding. Concepts taught in this topic are more of application. Treatment was administered immediately after pre-test and lasted three weeks.

Schools involved in this study were co-educational sub-county schools where boys and girls learn together in the same classroom. At the time of this study, there were 56 secondary schools in this sub-county, 34 of which are private and 22 are public. Out of the 22 public secondary schools, 19 are co-educational. Four public co-educational Secondary Schools were used.

1.8 Limitations and Delimitations of the Study

Quasi-experimental estimates of impact are subject to contamination by confounding variables (Dinardo, 2008). Lack of random assignment in the quasi-experimental design poses many challenges for the researcher in terms of internal validity (Lynda, Harry, Linda & Andrew, 2001). Because randomization is absent, some knowledge about the data can be approximated, but conclusions of causal relationships are difficult to determine due to a variety of extraneous and confounding variables that exist in a social environment. Moreover, even if these threats to internal validity are assessed, causation still cannot be fully established because the experimenter does not have total control over extraneous variables (De Rue, 2012). Study groups may provide weaker evidence because of the lack of randomness. Randomness brings a lot of useful information to a study because it broadens results and therefore gives a better representation of the population as a whole (Morgan, 2000).

Quasi-experimental designs are used when randomization is impractical and/or unethical, hence are typically easier to set up than true experimental designs, which require random assignment of subjects (Seibert, 1999). Additionally, utilizing quasi-experimental designs minimizes threats to external validity as natural environments do not suffer the same problems of artificiality as compared to a well-controlled laboratory setting (Lynda et al, 2001). Since quasi-experiments are natural experiments, findings in one may be applied to other subjects and settings, allowing for some generalizations to be made about the population. Also, this experimentation method is efficient in longitudinal research that involves longer time periods which can be followed up in different environments. Quasi experiments allow a researcher unlimited opportunity to manipulate independent variables. In Natural experiments, the researchers have to let manipulations occur on their own and have no control over them (De Rue, 2012).

1.9 Assumptions of the Study

This study assumed that the learners in both experimental and control groups are of comparable learning abilities because they had equivalent admission criteria for form one. It is also assumed that the learning environment for both experimental and control groups is comparable because the schools from which they were drawn belong to the same category. The study also assumed that the gender of teachers had no effect on learners' acquisition of knowledge and skills.

1.10 Definition of Terms

In this section, definitions of terms are presented as used within the context of this study.

Achievement is the ability to perform tasks in the area of recall, comprehension, application and higher order skills as a result of instruction (Wachanga, 2002). In this study, achievement refers to the score a student attained in BAT.

Co-educational School is a school that is integrated for education of male and female persons in the same institution (Wambugu, 2011). In this study, a co-educational school is an institution between the levels of forms one and four where boys and girls learn together in the same classroom.

Collaborative Concept Mapping Teaching Approach is an interaction between two or more individuals during concept mapping to create a shared understanding of a concept, discipline or area of practice that none had previously possessed or could have come to on their own (Johnson, Johnson & Smith, 1991). In this study, Collaborative Concept Mapping Teaching Approach will involve teacher-guided group tasks in the topic Gaseous exchange in plants and animals, where learners will be required to construct concept maps that relate concepts and ideas in a hierarchical manner.

Concept Map is a schematic device for representing a set of interrelated, interconnected concepts: It is a semantic network showing the relationships among concepts in a hierarchical manner (Ebenezer & Conner, 1998). In this study, concept map constitutes a semantic network showing the relationships among concepts in the topic Gaseous exchange in plants and animals in a hierarchical manner.

Concept mapping is the process of organizing concepts and relationships between concepts in a hierarchical manner from more inclusive concepts to more specific, less inclusive concepts (Novak & Gowin, 1984). In this study, Concept mapping refers to the process of producing interpretable pictorial view of ideas and concepts in the topic Gaseous exchange in plants and animals and how they are related in a hierarchical manner.

Effect denotes a change produced by an action or a cause; a result or an outcome (Oxford Advanced Learners' Dictionary). In this study, Effect denotes the learning outcomes expected after the application of CCMTA on students of biology in Nakuru North Sub-county, Kenya.

Gender refers to the traits or conditions that are usually linked with maleness or femaleness but are culturally- based as opposed to biologically-based (Gentile, 2013). In this study, gender refers to variations in social roles learned by male and female students which may have an effect in learning school biology.

Learning knowles, Holton & Swanson (1998) defines learning as the process of gaining knowledge or expertise. It is a change in behavior as a result of experience (Haggard, 1963). In this study, Learning refers to acquisition of concepts in biology related to the topic "Gaseous exchange in plants and animals".

Motivation is a psychological process by which behavior is activated and directed towards some goal (Keraro, Wachanga & Orora, 2007). In this study motivation refers to the interest, enthusiasm, attention and concentration generated among students of biology when CCMTA is applied to teaching.

Traditional Teaching Methods these are teaching methods that are expository in nature, assigning students the role of passive recipients of knowledge (Keraro et al, 2007). In this study, Traditional Teaching Methods are listed as: lecture, demonstration, class experiment, Question & Answer, Fieldwork and Project Methods.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews literature on; biological knowledge in society, students' achievement in biology, biology teaching approaches, motivation, concept maps, concept mapping and a comparison between cooperative & collaborative learning. Constructivist model of learning, Theoretical and Conceptual frameworks are also discussed.

2.2 Biological knowledge in society

According to the Program for International Student Assessment (PISA) report (OECD-PISA, 2003), science subjects play an important role in the socio-economic development of a country. Biology is one of the subjects offered at the secondary school education cycle in Kenya (KICD, 2002). The knowledge of biology contributes to scientific literacy of citizens so that they can understand the world around them and enable them to make informed choices about their nutrition, health care, exploitation of natural resources, conservation of environment and endangered species, and the society in which they live (Karen, 2008).

Economic activity that is fueled by research and innovation in the biological sciences, the "bioeconomy," is a large and rapidly growing segment of the world economy that provides substantial public benefit (Obama, 2011). From a broad economic perspective, bioeconomy refers to the set of economic activities relating to the invention, development, production and use of biological products and processes. It is an economy based on the use of research and innovation in the biological sciences to create economic activity and public benefit. In his address on National Bioeconomy Blueprint, United States of America (US) President underscored the significant role of bioeconomy due to the tremendous potential for growth as well as the many other societal benefits it offers (Biodesic, 2011). These include: high life expectancy, healthier lives and reduced dependence on oil. It also addresses key environmental challenges, transforms manufacturing processes, and increases the productivity and scope of the agricultural sector while growing new jobs and industries.

It is estimated that by the year 2030, the world population may reach 8.3 billion (World population prospectus, 2010), compounding the need for food. Biotechnology-enabled agriculture has the potential to handle this threat through production of plant and animal food products of improved quality and quantity. Biotechnology advancements combined with breeding techniques are expected in the near future to lead to crops with other desirable traits such as improved nutritional value, enhanced disease resistance, and higher crop yields.

Biological knowledge, skills and attitudes acquired through the study of school biology are the precursor of biotechnology which is a tool for industrial and technological development (KICD, 2002). Biotechnology offers technological solutions for many of the health and resource-based problems facing the world. The Government of Kenya (GoK) takes unwavering policy position on how the biotechnology sector will play a key role towards achievement of the Vision 2030 both in the social and economic pillars (GoK, 2007).Various establishments such as The Bio-safety Greenhouse at the Biotechnology Centre of Kenya Agricultural and Livestock Research Organization (KALRO) and an ultra- modern Biosciences Eastern and Central Africa Hub at the International Livestock Research Institute (ILRI), Nairobi have been established to spearhead research and innovations in agriculture (M'mboyi, 2006).

Kenya enjoys the support of International research institutions like International Centre of Insect Physiology and Ecology (ICIPE), International Maize and Wheat Improvement Centre (IMWIC), African Agricultural Research Foundation (AARF), and Biosciences East and Central Africa (BECA) that have highly skilled scientists involved in genetic engineering-related research. Similarly, international development agencies including USAID, USDA and EU (European Union) funding have expanded research and development programs in Kenya's biotechnology development to a level where adequate threshold of human resource capacity has been achieved (M'mboyi, 2006). In view of the central role of biological knowledge in numerous aspects of human welfare, it was thought educationally enriching to investigate the effect CCMTA would have on learning with a view of engaging remedial interventions to improve achievement and motivation in biology.

2.3 Teaching methods used in biology

Methods of teaching biology refer to all the steps and ways teachers of biology use when presenting lesson content (Maundu, 1986; Wekesa, 2003). Wachanga (2002) identifies teaching effectiveness as a significant variable of students' achievement which may be influenced by the teaching approach that a teacher uses. He identifies methods used by Chemistry educators which constitute Traditional Teaching Methods. These methods are also applicable to teaching of biology. They include; Lecture, Question / Answer, Teacher Demonstration, Project, Field work and Class Experiment method.

2.3.1 Lecture method

Vella (1992) defines a lecture as the formal presentation of content by an educator (as subject matter expert) for the subsequent learning and recall in examinations by students. In this method, a teacher is the central focus of information transfer. This is the most common form of teaching in institutions of higher learning throughout the world, and is likely to continue to be so (Taylor & Francis, 2011). According to Kelly (2014), lectures are a straightforward way to transfer knowledge to students quickly. Instructors also have a greater control over what is being taught in the classroom because they are the sole source of information. Students who prefer learning by hearing find lectures appealing to their learning style. Logistically, a lecture is often easier to develop than other methods of instruction. It is familiar to most teachers because it was typically the way they were taught and because most college courses are lecture-based, students gain experience in this predominant instructional delivery method.

Kelly (2014) observes that students strong in learning styles other than auditory learning find lectures challenging while those who are weak in note-taking skills will have trouble understanding what they should remember from lectures. She observes that some students can find lectures boring causing them to lose interest while others may not be able to ask questions as they arise during lectures. This method limits interaction between learners and a teacher. However, CCMTA is a more interactive teaching approach as learners engage in group work to achieve shared learning goals. Lecture method was applied in this study to represent TTMs.

2.3.2 Question/answer (Q/A)

This method involves verbal interaction between a teacher and students through questions and answers. It leads to correct responses and a summary of the main points (Jekayinfa, 2005). Questioning method gives a student an opportunity to reflect on inquiries and needs for further information. Questions can be used for drill and review; they deepen impressions and embed facts in the mind and memory of the student. Engaging students in Questioning also prompts them to take charge of their own learning.

However, Brown and Atkinson (1994) associated this method with emphasis on lower order learning (mainly recall) and does not involve all learners. There is a tendency for teachers to rush learners into giving answers that confirm their pre-conceived ideas. Application of Q & A method hinders knowledge construction rendering it ineffective for meaningful learning as learners' self expression is inhibited by teachers' pre-conceived ideas on "correct answer". CCMTA engages learners in active knowledge construction during concept mapping activities leading to higher order learning.

2.3.3 Teacher demonstration method

Demonstration is the process of teaching through use of audio-visual aids to explain while laying emphasis on significant points of a process, product or idea (Sola & Ojo, 2007). A demonstration may be used to proof a fact through a combination of visual evidence and associated reasoning. In this method, senses of students are appealed by a teacher which really accelerates the learning process. This method is ideal for teaching a subject in which skills relating to manual dexterity are needed.

According to Kozma, Belle and Williams (1978), demonstrations may fail due to faulty equipment or lack of teacher preparedness. They limit learner participation since an explanation accompanies the actions performed. Audience/ client inputs are limited. Demonstrations require prior preparations hence are time consuming. Due to complexity and structure of different topics in biology, demonstration method may not be appropriate for all topics especially where audio-visual aids are not available. In such topics, students can be engaged in active knowledge construction through use of CCMTA which helps students to discover concepts on their own.

2.3.4 Project method

According to Smith (2010), project is an appealing concrete problem whose solution is planned and executed by learners. He further suggested that project method is a combination of the text book, recitation and laboratory method. In this method, learners are assigned to groups to undertake a given task after which they compile a group report for assessment.

Although project-based learning is considered to be a profitable learning strategy, its implementation faces several challenges (Guzdial & Kehoe, 1998; Means & Olson, 1995; Synteta, 2001; Thomas, 2000; Synteta, 2003). This is because projects are complex endeavors involving many different activities. Students have difficulty to initiate inquiry, have coherent research questions, define a research project, and select good research design plus appropriate methodology. In addition to the difficulty of setting clear goals for various phases, students have trouble relating data, concept and theory. A teacher should intervene and break the project into various phases for viable implementation.

On the other hand, teachers have difficulty in conducting highly demanding pedagogical approaches like Project-based learning (Synteta, 2001). A high degree of competence is required in designing a problem-based course, design projects that support learning of specific concepts and skills. This method also calls for sustained follow up, monitoring of progress, support, assessment and general classroom management (Means & Oslo, 1995). To successfully conduct an effective project, a teacher needs to be highly skilled in pedagogy, knowledgeable, alert and exceptionally gifted. These attributes are lacking in most teachers. CCMTA would provide an ideal alternative since it is easy to learn and apply in all topics in biology. It is also affordable in terms of time and cost thus providing a realistic learner-centered teaching approach that can be accommodated within the time allocated on the timetable.

2.3.5 Fieldwork

This is a teaching procedure that employs trips which students undertake to observe and investigate situations outside the classroom whose technological application of certain topics need to be illustrated (Howarth & Slingsby, 2006). He further points out that Fieldwork is useful in learning since it provides first hand learning experiences, leads to long-lasting meaningful learning and enhances social relationships among students. There is substantial evidence that Fieldwork presents learners with opportunities to develop their own knowledge and skills in ways that add value to their everyday experiences in the classroom (Lock & Dillon, 2002).

Majority of biology teachers lack biological fieldwork planning and implementation expertise besides unavailability of funds to implement the same in most public schools. Fieldwork therefore remains largely impractical in teaching school biology effectively. CCMTA is a practical alternative since it doesn't require special expertise to implement.

2.3.6 Class experiment / Class practical

This method is also referred to as The Laboratory Method. It exposes learners to firsthand experiences with materials or facts emerging from an investigation (Wachanga, 2002). Ozay & Ocak (2009) describe it as a hallmark of learning Science and Technology-based fields. Bayraktar, You, Rotello &Knapp (2006) suggest that this method strengthens theoretical knowledge while learners experience the pleasure of discovery and development of their psycho-motor skills. It increases creative thinking skills, improves gains in scientific working methods and higher order thinking skills. The method requires huge investment of instructional time denying teachers time to cover as much content as they would with other instructional methods. The outlined limitations hamper effective use of experiment method in teaching biology especially in topics like Evolution which have minimal practical activities. CCMTA would be the most appropriate approach as it would use less instructional time and ensure meaningful learning through active engagement of students in group-based task performance.

2.4 Learners' achievement in biology

The Royal Society of United Kingdom points out that many children lose interest in mathematics and science during secondary school (ages 11–16), and that there are too few students doing higher science A-levels (ages 16–19) to secure sufficient transition into undergraduate degree programs in Science, Technology, Engineering and Mathematics (STEM). The US National Center for Education Statistics (2004) reported that students have familiarity with knowledge of a host of concepts, but the depth of their understanding of any given science concept and its connection to broader ideas and principles is extremely limited.

Investigations into students' understanding of biological concepts indicate that students of varying ages possess misconceptions about biology concepts. Educators agree that prevalence of misconceptions among students not only present serious obstacles to learning in biology but also interfere with further learning (Kavramlarinin & Etemeni, 2002). In Kenya, the overall students' performance in science at KCSE has been below average. These results indicate lack of mastery of biological concepts. One of the Millennium Development Goals (MDGs) is to promote gender equality and empower women to eliminate gender disparity in all levels of education by the year 2015 (UNSD, 2007).

According to Wambugu and Changeiywo (2008), one of the factors influencing the quality of education is the competence of teachers and the instructional methods they use in the classroom. Report by biology team in SMASE (SMASE, 2003) reveals weaknesses in teaching biology and attributes poor achievement in secondary school biology to use of teacher centered approaches. It suggests that competence of biology teachers could be improved through improvement of teaching methodology. Adoption of innovative teaching strategies would ultimately cultivate a positive attitude change among learners. This study is further informed by results of four studies (Chiu, Huang, & Chang, 2000; Chung, O'Neil, & Herl, 1999; Depover, Quintin, & De Lièvre, 2004; Sizmur & Osborne, 1997), which show that more interactions and more elaborated, high-level, and complex interactions in the classroom led to better performance when Collaborative Concept Mapping was used.

Collaborative Concept Mapping is a well-researched approach in education hence its application in the teaching of biology is likely to improve achievement and motivation of learners. This would also make biology popular to secondary school learners, especially girls thus reducing the existing gender disparity.

2.5 Motivation

Motivation is a psychological process by which behavior is activated and directed towards some goal (Orora, Wachanga & Keraro, 2007). In a classroom, motivation is observed as students show interest and enthusiasm, and give attention and concentration to learning tasks. Conversely, low levels of motivation are observed in students' apathy and misbehavior (Anderson, 2012).

2.5.1 Categories of motivation

Educational Psychology has identified two basic classifications of motivation; Intrinsic and extrinsic motivation. Intrinsic motivation in education arises from a desire to learn a topic due to its inherent interests, for self-fulfillment, enjoyment and to achieve a mastery of the subject. It is a response to needs within the student, such as curiosity, the need to know, or feelings of competence and growth (Green & Nisbet, 1973; Morgan, 1984).

Extrinsic motivation is motivation to perform and succeed for the sake of accomplishing a specific result or outcome. Students who are very grade-oriented are extrinsically motivated, whereas students who seem to truly embrace their work and take a genuine interest in it are intrinsically motivated. A strategy to motivate students is suggested by Keller (1983). He posits that teachers consider four dimensions of motivation: (a) interest, the extent to which a learner's curiosity is aroused and sustained over time; (b) relevance, a learner's perception that instruction is related to personal needs or goals; (c) expectancy, a learner's perceived likelihood of success through personal control; and (d) satisfaction, a learner's intrinsic motivations and responses to extrinsic rewards.

Research has shown that good everyday teaching practices can do more to counter student apathy than special efforts to attack motivation directly (Barbara, in Ericksen, 1978). This can be achieved by de-emphasizing grades and encouraging students to complete their assignments especially constructing concept maps in biology (Davis, 1993). The CCMTA is likely to succeed as an instructional strategy to motivate students, thereby enhance their achievement in biology. This is because of its inherent nature of learner engagement in active knowledge construction.

2.5.2 The role of a teacher in students' motivation to learn.

The motivational role of teachers encompasses attempts to create conditions within a classroom which will energize, direct and sustain students' performance (Anderson, 2012). This role is important for promoting morale and learning climate. It involves the sustaining of enthusiasm and positive attitudes towards school goals and learning tasks, both those assigned and those self-generated by students. According to Anderson (2012), a teacher creates conditions which will energize and direct students' efforts towards achieving learning goals. He/she seeks to foster classroom climate through a proper sense of student achievement which comes from felt success in achieving school and personal goals. To motivate students, a classroom teacher will seek to ensure commitment of all students to the school mission.

2.6 Concept maps

Concept is a perceived regularity in events or objects, or records of events or objects, designated by a label (Novak & Canas, 2008).Concept maps are graphical tools for organizing and representing knowledge showing the interrelationships among concepts in a hierarchical manner (Ebenezer & Conner, 1998). Concepts/ideas are usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a preposition linking two concepts. Concept maps are a diagrammatic notation used to gather and organize information into a visual form. Words on the line referred to as linking words or linking phrases, specify the relationship between the two concepts. Concept Maps serve to clarify links between prior and new knowledge, and enable learners to externalize those links. They make it easy for a learner to spot central ideas and relationships between them which are hard to follow when using traditional linguistic representations (Brignardello, 2008). The wide range of topics and subtopics in secondary school biology would appear to fit in well with the general structure of a concept map.

The learning of science is essentially an active process (Aslop & Hicks, 2001) that could draw benefits of the visual and verbal nature of concept maps (Faigley & Lester, 2003). Concept maps are powerful instructional tools which assist learners in clarifying their understandings and make connections between concepts explicit (Markow & Lonning, 1998). Educators have found concept maps useful to assess learner's prior knowledge, to identify gaps in learner's knowledge, to enable teacher education students identify key concepts to target in their teaching and as an assessment tool to determine the extent and quality of new connections learners are able to make after instruction (Munson, 1992).

2.6.1 Concept mapping

Concept mapping is the process of organizing concepts and relationships between them in a hierarchical manner from more inclusive concepts to more specific, less inclusive concepts (Novak & Gowin, 1984). Concept mapping is used to develop logical thinking and study skills by revealing connections and helping learners see how individual ideas form a larger whole. The technique of concept mapping was developed by Novak (1970) as a means of representing the emerging scientific knowledge. It organizes knowledge in an understandable visual way and connects prior knowledge with new concepts by utilizing a visual structure for planning and thinking (Christodoulou, 2010). He further posits that the human mind has the ability to organize knowledge in an orderly fashion. Knowledge is organized upon an existing framework or a learner's prior knowledge. When new ideas are presented to a learner, a framework of prior knowledge is constructed for the new ideas to attach to.

2.6.2 Advantages of using concept mapping

According to Weideman & Kritzinge (2003), concept maps possess significant educational values. They include increased efficiency of information retrieval, effective teaching via better course content communication and enhanced collaborative learning. The use of concept maps enhances development of positive attitudes towards learning and improves text comprehension. It increases students' understanding of topics and also brings order to complex tasks. Christodoulou (2010) further suggests that using concept mapping enables students to present previous knowledge on the subject and identify their weak points. A learner is able to use the map to extract relationships between key words because knowledge is broken down into simple and more easily understandable parts. A concept map visually constructs a knowledge structure, organizes and presents information easily using only important keywords. This promotes creative thinking hence self-directed learning. Concept mapping is an important educational technique that provides an excellent means for a learner to externalize knowledge of a particular domain and to get meaningful understanding of new information.

Concept mapping is therefore likely to enhance acquisition of concepts in biology which are considered difficult by students. Both teachers and learners can benefit from the use of concept maps since they assist in identifying and organizing the key concepts on which a learning task is based (Novak & Gowin, 1984). In the light of perceived benefits of using concept maps, this study endeavored to find out the motivational and achievement benefits learners in the second year of secondary school cycle can acquire when CCMTA is applied in teaching the topic " Gaseous exchange in plants and animals".

2.6.3 Cooperative learning and collaborative learning

Cooperative learning refers to instructional methods and techniques in which learners work in small groups and are rewarded for performance as a group rather than as individuals (Slavin, 1987). The approach is more successful when small teams, each with members of mixed academic ability use a variety of learning activities to improve their understanding of subject matter (Sharan, 1980). Johnson & Johnson (1986) suggests that cooperative learning is a tool or didactic means of organizing small-group activities where every member of the group, does his or her own personal task, which is usually given by a teacher.

In a cooperative learning environment, a teacher is the center of authority. He/ She assigns group tasks which are usually more closed-ended and often having specific or predictable answers (Cooper & Robinson, 1997). Group members work together towards achievement of shared learning goals and each has the responsibility of ensuring mastery of content by other team members because the teacher may randomly call upon any learner to answer for the team (Slavin, 1990). Myers (1991) posits that cooperative learning tradition tends to employ quantitative methods which focus on achievement (the product of learning). Cooperative learning develops higher level cognitive skills and creates an environment for active, involving and exploratory learning. It improves the performance of weak learners when grouped together with high achieving learners and addresses learning style differences among learners (Slavin, 2007). In their study on the effects of cooperative learning and feedback on e-learning in statistics, Krauseu, Stark and Mandi (2009) found out that cooperative learning enhanced perceived performance and perceived competence.

On the other hand, Collaborative Learning (CL) refers to an instructional method in which learners of different academic abilities work together in small groups towards a common goal (Gokhale, 1995). Learners engage in complementary learning in which they are responsible for one another's learning as well as their own. Thus, the success of one learner helps other learners to succeed. Proponents of CL claim that the active exchange of ideas within small groups not only increases interest among the participants but also promotes critical thinking. According to Johnson and Johnson (1986), there is persuasive evidence that collaborative teams achieve at higher levels of thought and retain information longer than learners who work individually. The shared learning gives learners an opportunity to engage in discussion, take responsibility for their own learning, and thus become critical thinkers (Totten, Sills, Digby, & Russ, 1991).

The collaborative tradition takes a more qualitative approach, analyzing learner talk in response to a piece of literature or a primary source of history. Unlike cooperative learning, collaboration allows learners autonomy in forming friendship and interest groups (Cooper & Robinson, 1997). They suggest that Collaborative Learning ties into constructivism. Once the group task is set, a teacher transfers all authority to a group. A group task is always open-ended and complex, with no pre-conceived right answer as opposed to Cooperative Learning. Collaborative learning is characterized by discussions which allow learners' explication and revision of their beliefs in the context of discourse (Sharan & Sharan, 1992; Bereiter & Scardamalia, 1993; Olson & Bruner, 1996).

Collaborative learning is preferred to cooperative learning for this study due to its superior features. Learners taught using this approach achieve higher intellectual levels and group diversity in terms of knowledge and experience are enhanced. This approach promotes problem- solving strategies, peer support system which enables learners to internalize both external knowledge and critical thinking skills thereby converting them into tools for intellectual functioning. In CL, shared responsibility reduces anxiety associated with problem-solving. A CL medium provides learners with opportunities to analyze, synthesize, and evaluate ideas collaboratively as the informal setting facilitates discussion and interaction among group members.

2.6.4 Collaborative concept mapping

The learning experience is considered a personal unique process that differs from individual to individual (Cicognani, 2000). It can be enhanced by concept mapping which is regarded as a powerful pedagogical process that fosters social creativity. Davidson (1998) posits that when a learner constructs a concept map, the learning experience is promoted and becomes more effective when constructed collaboratively. Concept mapping engages the benefits from the interactions with others by blending their thoughts and experiences while trying to achieve understanding of a common concept of interest.

In concept mapping, collaboration is achieved in various phases. For example, in a brainstorming session, all participants collectively agree on the focus question. They contribute in the creation of a list of keywords that later will be used to give birth to the concept map (Cicognani, 2000). Collaboration is also achieved among the group through evaluation, questioning, discussion and debate with others. CCMTA is likely to be an effective summative assessment technique that engenders rich discussions amongst learners who have already individually engaged with the concept mapping activity.

2.6.5 Collaborative concept mapping and constructivist learning

Constructivism is a theory of learning and an approach to education that lays emphasis on ways that allow a learner to experience an environment first-hand thereby giving the learner reliable trustworthy knowledge (Glaserfeld, 1989). It is based on observation and scientific study about how people construct meaning and knowledge (Baker, McGaw & Peterson, 2007). According to this theory, people construct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences (Mestre, 1994). When an individual encounters something new, it has to be reconciled with previous ideas and experiences. This may change what one believes or discard the new information as irrelevant (Piaget, 1965). Social constructivism encourages a learner to arrive at his or her version of the truth, influenced by his or her background, culture or embedded worldview.

In a constructivist classroom, the focus shifts from a teacher to learners. Both a teacher and learners think of knowledge not as inert facts to be memorized but as dynamic, ever-changing view of the world and the ability to successfully stretch and explore that view. Jonassen (1997) proposes that constructivist learning environments support collaborative construction of knowledge. This is achieved through social negotiation and not competition for recognition among learners. Besides, the process of knowledge construction has a social dimension. It uses language in negotiation and shaping of knowledge within social groups including classrooms (Edward & Mercer, 1987). Driver (1989) is of the opinion that teaching is not a “transmission” of knowledge but the negotiation of meanings. It involves the organization of situations in the classroom and the control of tasks in a way which promotes intended learning outcomes.

Collaborative learning is consistent with constructivist approaches to learning in its characteristic group autonomy and social dimension to meaningful learning. This is because learners engage in open-ended tasks that encourage knowledge construction.

Cooper and Robinson (2002) describe the classroom as no longer a place where a teacher (expert) pours knowledge into passive learners, who wait like empty vessels to be filled. A teacher functions as a facilitator who coaches, mediates, prompts and helps develop and assess learners' understanding hence their learning (Grasserfield, 2009).

2.6.6 Key features of constructivism

Taber (2006) analyses core ideas of constructivist's theorists who suggest that knowledge is actively constructed by a learner, not passively from the outside. Learners come to the learning situation with existing ideas about many phenomena. They have their own individual ideas about the world but there are also many similarities and common patterns in their ideas. These ideas are often at odds with accepted scientific ideas and some of them may be persistent and hard to change. Knowledge is represented in the brain as conceptual structures, and it is possible to model and describe these in some detail. Teachers have to take learner's existing ideas seriously if they want to change or challenge them. Constructivists also suggest that although knowledge in a sense is personal, learners construct knowledge through interaction with the physical world, collaboratively in social settings and in a cultural and linguistic environment.

The outlined features of constructivism informed this study as learners engage in active construction of knowledge in collaborative groups. The ensuing discussions and negotiations provide for modification of concepts previously held by learners. This is likely to enhance conceptual change thus motivate learners to learn biology.

2.7 Theoretical framework

This study was conducted within an interpretive paradigm with a constructivist view of learning. Formalization of constructivism as a theory of learning is generally attributed to Jean Piaget who articulated mechanisms by which learners generate knowledge and internalize it. He suggested that knowledge is constructed from interaction between experiences and mental ideas. Learners construct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences. Among educators, philosophers, psychologists and sociologists who added new perspectives to constructivist learning and practice are: Lev Vygotsky, Jerome Brunner and David Ausubel (Piaget, 1965). Modern educators, who studied, wrote about and practiced constructivist approaches to education include: John Dewey, Ernst Von Glasersfeld, Eleanor Bukkworlt, George Forman, Roger Schank, Jackueline Grennon Brooks and Martin G. Brooks.

According to Piaget, construction of new knowledge from experiences is achieved through processes of assimilation and accommodation (Piaget, 1965). Assimilation occurs when individuals incorporate new experiences into their own pre-existing mental representation of worldview without changing that framework. This leads to active learning or learning by doing (Piaget, 1965). Accommodation occurs when new experiences fail to make sense leading to individual's mental representation being reframed to accommodate the new experience. In a constructivist classroom, a teacher encourages students to use active techniques to create more knowledge and then reflect on and talk about what they are doing and how their understanding is changing. This way, students become expert learners.

Students' ideas gain complexity and power through continuous reflection on their previous experiences leading to greater abilities to integrate new information. Rather than dismiss the active role of a teacher or value for expert knowledge, constructivism modifies that role to that of a facilitator who coaches, mediates, prompts and helps students develop and assess their understanding hence their learning. The teacher's role is interactive and rooted in negotiation in continuous dialogue with the learners. Constructivism transforms a student from a passive recipient of information to an active participant in the learning process. In constructivist classroom learning is interactive as students work primarily in groups, building on what they already know as opposed to learning by repetition in a traditional classroom where students work primarily alone.

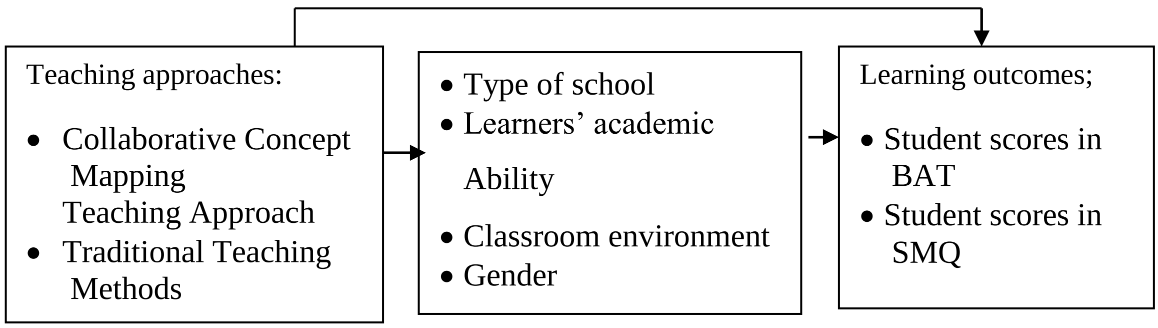
This study is therefore built on constructivism in terms of emphasis on active and interactive knowledge construction, facilitative role of a teacher, dynamic nature of knowledge with ever changing experiences and emphasis on group work. The CCMTA, a hybridized approach combines features of concept mapping and collaborative learning to provide opportunities for learners to practice scientific skills in hands-on activities and make discoveries for themselves as they construct new knowledge (Good & Brophy, 2003). In a collaborative setting, teachers encourage group work and use of peers as resource persons thereby heavily leaning on constructivism.

The social constructivism view of learning is the theoretical model that informed this study. Vygotsky (1978) formulated social constructivism which suggests that knowledge is first constructed in a social context and is then taken up by individuals (Guba & Lincoln, 1994, Eggan & Kauchak, 2004). According to social constructivists, the process of sharing each person's point of view, called collaborative elaboration (Meter & Stevens, 2000), results in learners building understanding together that wouldn't be possible alone (Greeno, Collins & Resnick, 1996). The internal construction of knowledge is viewed as being driven primarily by social interaction (Wertsch, 1985). In constructivist learning, learners are seen as constructing meaning from input by processing it through existing cognitive structures and then retaining it in long-term memory (Okere, 1996). Collaborative Concept Mapping Teaching Approach was found to be consistent with social constructivism in its dimension of learning as learners engaged in active knowledge construction through social negotiation rather than competition for recognition.

2.8 Conceptual framework

Figure 1 indicates the effect of CCMTA on learners' achievement and motivation to learn biology in secondary schools in Nakuru North Sub-county. However, there were intervening variables that could have affected both the independent and the dependent variables as indicated.

Independent Variables **Dependent Variables**



Intervening variables

Fig.1: Conceptual Framework on Effect of CCMTA on Student's Achievement and Motivation to learn Biology.

Figure 1 indicates independent variables as Collaborative Concept Mapping Teaching Approach and the Traditional Teaching Methods. The dependent variables are learner Achievement and Motivation to learn biology. In an ideal situation, the teaching method may affect learners' achievement and motivation to learn. However, various intervening variables such as class room environment, type of school and learners' academic ability may affect the expected outcome.

Gender was built into the study as a moderating variable that affects the association between independent and dependent variables (Baron & Kenny, 1986). To control for classroom environment, the study involved co-educational schools where boys and girls learn together in the same classroom. Type of school was controlled by involving Sub-county secondary schools because they enroll learners of comparable academic ability.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents a description and justification of the research methodology that was used in this study. It includes the research design, location of the study, target and accessible population, sample size and sampling procedures, instrumentation, validation and estimation of reliability of research instruments. Development and use of instructional materials, data collection procedures and data analysis are also discussed.

3.2 Research design

The study adopted the Solomon's Four Non-Equivalent Control Group design. This is a quasi-experimental design that is considered sufficiently rigorous and appropriate for quasi-experimental studies (Fraenkel & Wallen, 2000). It assesses the plausibility of pretest sensitization effects, that is, whether the mere act of taking a pretest influences scores on subsequent test administration (Clark & Elen, 2006). It also ensures the administration of pre-test to two groups and post-test to all the four groups (Gall, Borg & Gall, 1996; Wachanga & Mwangi, 2004).

Quasi-experimental design was considered ideal for this study because participants were already constituted into intact classes hence it was not ethical to randomly select them individually for experimental purposes (Gall *et al*, 1996; Trochim, 2006). Besides, school administrators normally do not allow breaking of classes for random assignment of learners into groups for experimental purposes. An important component of the quasi-experimental study is the use of pre-testing or the analysis of prior achievement to establish group equivalence. The Solomon Four Non-equivalent Control Groups Design is represented in Figure 2.

Group I (E1)	O1	X	O2
Group II (C1)	O3	C	O4
Group III (E2)	-	X	O5
Group IV (C2)	-	C	O6

Figure 2: Solomon Four Non-Equivalent Control Group Design (Source: Best & Kahn, 2003).

Solomon Four Non-Equivalent Control Group Design has been used successfully in studies to determine the effect of teaching approaches on student achievement in Kenya (Wambugu & Changeiywo 2008; Wachanga & Mwangi, 2004; Keraro, Wachanga & Orora 2007). In this study, the symbols proposed by Wiersma (2000) were adopted. Groups I, II, III and IV were co-educational schools randomly assigned to experimental and control groups. O1 and O3 were pre-tests while O2, O4, O5 and O6 were post-tests.

Both pre-test and post-test were the Biology Achievement Test (BAT) constructed by the researcher for the purpose of this study. X represents the treatment variable which in this study was the Collaborative Concept Mapping Teaching Approach, while C represents the control condition which in this study was Lecture Method. The dotted line between groups 1, 2, 3 and 4 indicates that the groups used in this study existed as intact groups and therefore there was no randomization of students when establishing the treatment and control groups. Groups I and III were the experimental groups that received treatment (X) while group II and IV were the control groups that were kept under the control condition (C). Groups I and II were pre-tested (O1 and O3) while groups III and IV were not pre-tested. All the four groups were then post tested (O2, O4, O5 and O6) at the end of the three weeks treatment period.

Solomon Four Non-Equivalent Control Group Design is designed to deal with a potential testing threat which occurs when the act of taking a test affects how people score on a retest or post tests (Trochim, 2006). The treatment and control groups were situated in different schools to avoid contamination hence control reactive effects of experimentation since learners were less aware of being subjected to experimental treatment (Koul, 1984).

3.3 Location of the study

This study was carried out in Secondary Schools in Nakuru North Sub County. Nakuru Count**y** is located in the former Rift Valley Province of Kenya, about 165 km to the North of Nairobi. It borders 7 (seven) Counties namely: Laikipia to the North east, Kericho to the West, Narok to the South West, Kajiado to the South, Baringo to the North, Nyandarua to the East and Bomet to the West. The approximate area of Nakuru County is 7,496.5 km^2. It is easily accessible from Nairobi by road, a journey that takes about three hours. Nakuru North Sub County is one of the eleven sub counties that constitute Nakuru County. These include; Nakuru Town East, Nakuru Town West, Bahati, Rongai, Subukia, Kuresoi North, Kuresoi South, Gilgil, Naivasha, Njoro and Molo.

This study location was purposely selected because the Sub County has consistently posted poor results in KCSE science, especially biology. There is also a clear gender disparity in achievement in favor of boys in the Sub County. The Sub County is cosmopolitan with a large number of public secondary schools attended by most students.

3.4 Target and accessible population

The target population in this study was secondary school students in Nakuru North Sub County, Kenya while the accessible population was Form Two Biology students in the sub county. Form two students were considered appropriate for this study because they have been exposed to the secondary school science curriculum for one year hence are considered to be adjusted to secondary school curriculum. Biology is offered as a compulsory subject in form one and two in Kenyan public secondary schools.

3.5 Sample size and sampling procedure

The sampling unit was the secondary schools and not individual students since secondary school learners operate as intact groups (Gall *et al*, 1996). Each School was therefore treated as a group. The study used Sub County secondary schools because a majority of students attend these schools. A list of 56 Nakuru North Sub County secondary schools was obtained from the Sub-County's Director of Education Office and used as a sampling frame. Out of the 56 schools, 19 were co-educational. Purposive sampling technique was used to select four co-educational schools that offer biology. This technique allowed application of the researcher's own expert judgment based on prior experience to select the participants with desirable information (Mugenda & Mugenda, 2003).

A total of 4 biology teachers and 202 form two students were involved in this study. The total number of students per stream was 47, 54, 55 and 46 respectively. In schools that had more than one form two stream, simple random sampling was used to pick one stream to provide the four groups for the study. The four schools were randomly assigned to treatment and control groups to control for interaction between selection and maturation (Best and Kahn, 2003). However, biology teachers in the experimental schools were encouraged to expose all the students in form two to CCMTA for ethical reasons, but only data from the sampled class was analyzed in this study.

3.6 Instrumentation

Two instruments were used in this study. These were the Biology Achievement Test (BAT) and the Students' Motivation Questionnaire (SMQ). The instruments were developed by the researcher and used for data collection in both piloting and treatment period.

3.6.1 Biology Achievement Test (BAT)

A Biology Achievement Test adapted from KNEC past examination papers was availed and used to measure students' achievement in biology. It consisted of forty structured short answer questions based on "Gaseous exchange in plants and animals" with a maximum score of 100. The short answer item format was modeled on the KNEC Biology Paper One and modified in length of test items and level of difficulty to suit form two learners. The format was considered appropriate as it is familiar to form two learners at secondary school level in Kenya (KNEC, 2005). The forty test items were set and categorized into three cognitive ability levels of knowledge, comprehension and application adapted from the Blooms Taxonomy of Educational Objectives in the Cognitive Domain (Bloom, 1956).This classification enabled the researcher to determine the effect of CCMTA on student achievement in different cognitive abilities.

There were 16 items on knowledge cognitive level with a total score of 40 that required students to memorize and recall information. Items based on comprehension required students to demonstrate understanding of concepts and there were 12 items in this category with a total score of 28. The items based on application required students to use prior information to solve unfamiliar problems and in this category were 12 items with a total score of 32. A table of specification was used to sample both the content in Gaseous Exchange in Plants and Animals and the three cognitive levels during the construction of the test items. As an assessment, BAT had two components; a task that students performed to demonstrate and record their knowledge, and a scoring system which was used to evaluate students' knowledge.

An incorrect response scored zero mark while correct responses was awarded a range of marks ranging from 1 to 5 based on the structure of each test item.

3.6.2 Students' Motivation Questionnaire (SMQ)

The instrument used in assessing students' motivation and interest to learn biology was adapted from Keller's ARCS motivation theory and was modified to suit this study (Hohn, 1995; Kiboss, 1997). It contained 50 five point likert- type items designed to find out students' opinion and perception of Biology and the strategies used for instruction. The SMQ was used to measure students' motivation and interest towards Biology when they were taught using CCMTA. Students' motivation is a good indicator of effort and devotion in studying the subject and it is an important factor in determining achievement (Nitcher, 1984). The 50 five point likert- type items that were used to generate data on students' motivation to learn biology were scored as follows; SD (1), D (2), U (3), A (4), SA (5). A higher number on the scale represented agreement with the item on the scale and a more favorable disposition of that item. Such scale scoring was consistent with typical scale interpretations in Kenya's education system where, in normal ranking or in rating candidates on achievement measures, larger numbers represent higher and desirable achievement and smaller numbers represent poorer and undesirable achievement (Namasaka, 2009).

In this study, motivation was taken to be a measure along a continuum ranging from strongly negative effect to strongly positive effect. In analyzing the data, an item such as "learning biology course by applying the concepts learnt to real life situation made me feel as if I was wasting time" had the scores reversed since "strongly disagree" would reflect a high positive effect toward Biology. The SMQ was pilot-tested in the same school as BAT in order to determine its reliability coefficient. It was validated by five experts in educational research and three experienced teachers of secondary school biology. The SMQ had two sections; section 1 captured students' bio data while section 2 contained items for measuring motivation. Student's admission number, gender, age and study group constituted bio data. Since students' names were omitted for confidentiality, admission numbers were used to match pre- and post-test scores during data analysis.

3.6.3 Validation of research instruments

Before pre-test, BAT and SMQ plus their scoring keys were validated by five experts in educational research. Three experienced biology teachers who are examiners with Kenya National Examination Council (KNEC) were also involved. Experts' opinion was used to improve research items before intervention. To ensure comparable results between pre-test and post-test, BAT test items were re-organized and administered to all the groups as post-test.

3.6.4 Reliability of research instruments

To estimate their reliability, both the BAT and SMQ were pilot tested in two secondary schools that were not part of the study but with similar characteristics as the sampled schools. Pilot schools were drawn from the neighboring Nakuru East Sub-County to minimize chances of contamination during treatment period. The reliability coefficient for BAT was estimated using the Cronbach's alpha coefficient formula (α). This was considered appropriate because the research instruments used consisted of items on which different scoring weights are assigned to different responses (Wiersma & Jurs, 2009).The tool was administered only once. Cronbach's alpha coefficient is represented as;

$$A = \frac{K}{K-1}\left[1 - \frac{\sum S_i^2}{S_x^2}\right]$$

The Cronbach's alpha coefficient formula

Where K = number of items on the test

S_i^2 = Variance of the total test

$\sum S^2_x$ = the sum of the variances of the individual items

Cronbach's alpha Coefficient was also used to estimate reliability of SMQ (Popham, 1990). Gall *et al*, (1996) consider this technique appropriate for rating scale items on which different scoring weights are assigned to different responses (SMQ scores range from 1-5). Test items in SMQ yield a range of scores and the tool was administered only once. For both BAT and SMQ, α value of 0.86 and 0.84 respectively were obtained. These values were considered suitable to make group inferences that were accurate enough (Fraenkel & Wallen, 2000).

3.7 Instructional Materials

3.7.1 Development and use of instructional materials

The instructional materials used in this study were based on the KIE approved biology syllabus (KICD, 2003). They include; CCMTA teacher's manual, a form two biology teachers' guide, lesson plans on topic "Gaseous exchange in plants and animals" and a marking scheme for the BAT.

3.7.2 CCMTA teacher's manual and teacher's guide

A CCMTA teacher's manual was developed based on the revised KIE biology syllabus for secondary schools, and used throughout treatment period. Teachers of experimental groups were trained on skills of collaborative concept mapping for one week. They taught sampled groups using CCMTA on a different topic other than Gaseous exchange in plants and animals for one week to enable them master the skills. After this, pre-test was administered to groups E1 and CI. Control groups were taught using TTM. Soon after intervention period, post-test was administered to all the groups.

For ethical reasons, all form two streams in experimental schools were taught using CCMTA and only data from the sampled class considered for analysis. Form two biology teachers' guide was used to guide teachers on recommended style of content delivery and students' learning activities. It also indicated the scope of content coverage to ensure compliance with the Revised Secondary School biology syllabus (KICD, 2003).

3.8 Data collection procedures

The researcher obtained an introductory letter from Graduate School of Egerton University to the National Commission for Science, Technology and Innovation (NACOSTI). The NACOSTI granted a research permit to conduct this study copied to; the County Commissioner and the County Director of Education, Nakuru North Sub-County. NACOSTI is a government agency in the Ministry of Education in Kenya. Once granted a permit, the target schools and respondents were contacted through the Sub County Director of Education (SDE) and Sub- County Quality Assurance & Standards Officer (SQASO). Before commencement of the study, a visit to the Nakuru North Sub County Education Office and to the four sampled schools was conducted to determine the workability of scheduled activities. The visit aimed at determining biology syllabus coverage in form two, allocation of biology lessons on the master time table, and the schools' calendar of events for the year.

In the respective schools, the researcher sought cooperation and explained to respondents the aim of the research. Preliminary information on the schools was obtained from Nakuru County Director's Office and used for sampling process to identify the four schools for this study. All the teachers involved in this study were trained on CCMTA prior to the commencement of the study. After this, the teachers trained students in the treatment groups on the use of CCMTA for one week. Data was collected from pilot schools using BAT and SMQ with assistance of biology teachers. These research instruments were then applied to sampled schools to collect data which was scored quantitatively. Prior to intervention, BAT and SMQ were applied as pre tests to groups E1 and C1 with the assistance of biology teachers of sampled groups. At the end of three weeks treatment period, all the four groups were post-tested and the scores obtained analysed.

3.9 Data analysis

This study generated quantitative data hence quantitative methods of data analysis were applied. Data was coded, keyed into a computer and analyzed using of Statistical Package for Social Sciences (SPSS). BAT achievement scores and students' motivation ratings were generated in this study. To test null hypotheses 1 and 3, one-way ANOVA statistical technique was used to determine differences between the four means of post test scores. T-test was used to test null hypotheses 2 and 4 due to its superior power to detect differences between two means. Where significant differences were found in pre-tests and post-test scores, ANCOVA statistical technique was used to test null hypotheses 1, 2, 3 and 4 respectively. This is because of its superior power to compensate for lack of equivalence (Gall *et al*, 1996). For all the statistical techniques applied, tests of significance was performed at significant level of $\alpha = 0.05$.

Table 4 gives a summary of statistical methods that were applied for hypotheses testing.

Table 4

Summary of Methods used to Test Hypotheses

Hypotheses	Independent variables	Dependent variables	Statistical tests
Ho1: There is no statistically significant difference in secondary school Students' achievement in biology between students taught using CCMTA and those taught using the TTM.	Instructional approaches; • CCMTA • TTM	Post-test scores in BAT for four groups	• One-way ANOVA • ANCOVA
Ho2: There is no statistically significant gender difference in achievement in biology when learners are exposed to CCMTA.	• CCMTA	Post-test scores in the BAT for four groups	• t-test • ANCOVA
Ho3: There is no statistically significant difference in Motivation to learn biology between students taught using CCMTA and those taught using the TTM.	• CCMTA • TTM	• Post-test • Motivation score in SMQ	• One-way ANOVA • ANCOVA
Ho4: There is no statistically significant gender difference in the level of motivation to learn biology among students exposed to CCMTA.	• CCMTA	Motivation scores in SMQ	• t-test • ANCOVA

CHAPTER FOUR
RESULTS, INTERPRETATION AND DISCUSSION

4.1 Introduction

This chapter presents the results obtained, interpretation and discussions. The results are presented in tables. To test the four hypotheses of the study, ANOVA, ANCOVA, t-test and Bonferroni Post-Hoc Pair wise Multiple Comparisons test were used. This chapter is organized into the following sub-headings;

i. Pre-test Results
ii. Effects of CCMTA on students' achievement in biology
iii. Achievement of boys and girls exposed to CCMTA
iv. Effects of CCMTA on students' motivation to learn biology
v. Motivation of boys and girls exposed to CCMTA

4.2 Pre-test results

Solomon Four Non-equivalent Control Group Design was used in this study. This design enabled the researcher to have two groups sit for the pre-test. To establish homogeneity of experimental and control groups, a BAT pre-test was administered to Form Two students in groups E1& C1 prior to the experiment. Group E1 and group C1 were used as experimental and control groups respectively. The mean scores for the two groups were compared using an independent sample t-test statistic to establish if there were any statistically significant differences in their achievement. Solomon Four Non-equivalent Control Group Design requires that sample groups are as homogenous as possible at the beginning of the study (Gall *et al*, 1996). Pre-tests therefore enabled the researcher to;

a) Assess the effect of pre-test relative to no pre-test
b) Determine the interaction between the pre-test and the CCMTA treatment
c) Determine whether there was a practice effect
d) Determine the similarity of the groups before treatment

Table 5 shows students' pre-test BAT mean scores

Table 5

Students' pre-test BAT mean scores

	Group	N	Mean	SD
	E1	46	17.48	12.36
	C1	54	13.85	7.39
Gender	Male	44	17.14	12.19
	Female	56	13.25	7.98

Results in Table 5 reveal that the experimental group E_1 had a higher mean score (M=17.48, SD=12.36) than of their counterparts in control group C1 (M=13.85, SD=7.39). The results also reveal that boys had a slightly higher mean score (M=17.4, SD=12.19) than girls (M=13.25, SD=7.98). An independent sample t-test was carried out to determine if the differences were statistically significant. The results are presented in table 6.

Table 6

Pre-test BAT means scores' independent samples t-test results

Group E1, N= 46; Group C1, N= 54		Male= 44;		Female= 56		
Variable	Group	Mean	SD	df	t-value	p-value
Teaching approach	E_1	17.48	12.36	98	1.810	0.073
	C_1	13.85	7.39			
Gender	Male	17.14	12.19	98	1.426	0.157
	Female	13.25	7.98			

Results in Table 6 reveal that the mean scores of groups E_1 and C_1 were not statistically significantly different at 0.05 level since t (98) =1.810, p>0.05. Therefore, the groups used in this study exhibited comparable characteristics and were considered suitable for the study. The results further reveal that the difference between means scores by gender was not statistically significant at 0.05 level since t (98) =1.426, P=0.157. Therefore, achievement in biology of male students was comparable to that of female students.

These results show that at the point of entry, E1 and C1 were similar on BAT. The groups were therefore considered suitable for the study. The entry behavior of students on SMQ was also analyzed. Comparison of the mean scores of groups E1 & C1 using the t-test was done and the results are presented in Table 7.

Table 7

Independent sample t-test of pre-test scores on SMQ

Group E1, N=52; Group C1, N=50, Male=44; Female=56						
Variable	Group	Mean	SD	df	t-value	p-value
Teaching approach	E1	3.16	0.50	100	0.563	0.574
	C1	3.22	0.55			
Gender	Male	3.23	0.53	98	0.820	0.414
	Female	3.14	0.52			

Results in Table 7 reveal that the mean score of E1 (M=3.16, SD=0.50) was lower than that of C1 (M=3.22, SD=0.55). However, the difference between the two means was not statistically significant at 0.05 level since t (100) = 0.563, $p>0.05$. This implies that the two groups exhibited comparable characteristics as measured by SMQ and were thus considered suitable for the study.

Results in table 7 also reveal that the mean score of male students (M= 3.23, SD= 0.53) was slightly higher than that of their female counterparts (M=3.14, SD=0.52). The difference between the means by gender was, however, not statistically significant at the 0.05 level since t (98) =0.820, P=0.414. This implies that motivation of male students towards biology was comparable to that of their female counterparts. These results show that E1 and C1 were similar on SMQ at the point of entry. The groups were therefore considered suitable for the study.

4.3 Effects of CCMTA on students' achievement in biology

Hypothesis one (Ho1) of the study sought to find out whether there were statistically significant differences in secondary school students' achievement in biology between those taught using CCMTA and those taught using TTM. To determine the effects of CCMTA on students' achievement in biology, analysis of post-test BAT mean scores was carried out. Mean scores of the four groups are presented in Table 8.

Table 8

Students' post-test BAT mean scores

Group	N	Mean	SD
E1	47	27.68	15.13
C1	54	21.59	10.22
E2	55	30.22	4.77
C2	46	15.35	8.53

Results in table 8 reveal that the mean scores of experimental groups E1 (M= 27.68, SD=15.13) and E2 (M= 30.22, SD= 4.77) were higher than those of the control groups C1 (M=21.59, SD= 10.22) and C2 (M= 15.35, SD= 8.53). These shows that experimental groups performed better than control groups in the BAT post-test. In order to establish whether the differences among the mean scores of the groups were statistically significant, ANOVA was conducted and the results are presented in Table 9.

Table 9

Post-test BAT ANOVA results

Scale	Sum of squares	df	mean squares	F-ratio	p-value
Between groups	6519.097	3	2173.032	20.928	0.000*
Within groups	20559.066	198	103.834		
Total	27078.163	201			

Result in Table 9 reveal that the difference in E1, C1, E2 & C2 was statistically significant at 0.05 level since F (3, 198)=20.928, p= 0.000. Result however did not reveal where the difference occurred. This necessitated the use of Bonferroni Post Hoc pair wise multiple comparisons test to pinpoint the observed significant differences among the group means. Bonferroni test is considered ideal for making multiple comparisons since it is flexible for use with any set of statistical tests (Howel, 2002). The observed differences in the four groups were revealed by the Bonferroni test. The results are presented in Table 10.

Table 10

Post-Hoc pair wise Multiple Comparisons test Results of the Post-test BAT Mean Scores for the Four groups

	Group (I)	Group (J)	Mean difference (I-J)	p- value
Bonferroni	E1	C1	6.09	0.032*
	E1	E2	-2.54	0.666
	E1	C2	12.33	0.000*
	E2	C2	14.87	0.000*
	C1	E2	-8.63	0.000*
	C1	C2	6.24	0.067

The mean difference is significant at $p< 0.05$

Results in Table 10 reveal that there were significant differences between group pairs E1 and C1 (p= 0.032), E1 and C2 (p= 0.000), E2 &C2 (p= 0.000) and E2 & C1 (p= 0.000). However, there was no statistically significant difference between the mean scores of E1 & E2 (p= 0.666) and C1 & C2 (p= 0.067). It is also observed that the difference between the mean scores of experimental and control groups is statistically significant in favor of experimental groups. This difference is attributed to the intervention where CCMTA was used.

Though pre-test results suggested insignificant difference between groups E1 and C1, it was considered prudent to carry out further analysis using ANCOVA since it has features that levels out initial differences by making compensating adjustments to the post-test means of the groups. The ANCOVA test was conducted using students' KCPE science scores as covariates and the adjusted BAT post-test mean scores presented in Table 11.

Table 11

Adjusted BAT post-test mean scores for ANCOVA using KCPE science scores as covariate

Group	N	Adjusted BAT Mean score	Std. Error
E1	47	28.91	1.84
C1	54	21.69	1.39
E2	55	29.37	1.57
C2	46	15.00	1.53

Results of table 11 reveal that the adjusted mean scores of experimental groups E1 (M= 28.91) and E2 (M = 29.37) were still higher than those of control groups C1 (M = 21.69) and C2 (M = 15.00). The ANCOVA test was conducted to establish whether the scores were statistically significantly different at level 0.05. The results are presented in table 12.

Table 12

Comparison of BAT post-test Mean scores using ANCOVA

Scale	sum of squares	df	mean squares	F-ratio	P-value
Contrast	6623.538	3	2207.846	21.293	0.000*
Error	20426.323	197	103.687		

Results in table 12 show that the differences among mean scores of groups E1, C1, E2 and C2 were statistically significant at level 0.05 level, $F(3, 197)= 21.293$, $p<0.05$. K.C.P.E science scores were found ideal for use as covariate since it correlates reasonably well with BAT. It is also a mandatory assessment taken by all students in the sampled groups. Further tests, the Bonferroni Post Hoc pair wise Multiple comparisons test based on ANCOVA was carried out to reveal where the mean score differences were and the results are presented in Table 13.

Table 13

ANCOVA Post hoc Pair wise Multiple Comparisons results of BAT post-test Mean Scores for the four groups

Group (I)	Group (J)	Mean differences (I-J)	p-value
E1	C1	7.23	0.002*
E1	E2	-0.45	0.870
E1	C2	13.92	0.000*
C1	E2	-7.68	0.000*
C1	C2	6.69	0.082
E2	C2	14.37	0.000*

The mean difference is significant at $p< 0.05$

The results in Table 13 reveal that there were significant differences between the means of groups E1 & C1 (p= 0.002), E1 & C2 (P= 0.000), C1 & E2 (p=0.000) and E2 & C2 (p= 0.000). However, the difference between E1 & E2 (p= 0.870) and C1 & C2 (p=0.082) was not statistically significant. This confirms the ANOVA results to be correct and indicates the following:

i. There was no significant interaction between BAT pre-test and the treatment conditions. Otherwise pre-tested groups would have obtained significantly different results from those who did not take the pre-test.

ii. Undertaking the pre-test did not affect students' learning of biology content. This is supported by the fact that the groups which undertook pre-test and those that didn't had results that were not statistically different.

iii. Application of CCMTA resulted in higher student achievement than the TTM that was used to teach control groups since groups E1 and E2 obtained scores that were significantly higher than those of other groups.

These results indicate that the Collaborative Concept Mapping Teaching Approach used to teach experimental groups had significant effect on achievement as compared to the approach used on control groups hence, hypothesis $H0_1$ is rejected.

4.4 Achievement of boys and girls exposed to CCMTA

To find out whether there was gender difference in achievement when students were exposed to CCMTA, the BAT post-test mean scores for boys and girls exposed to CCMTA were analyzed and compared to determine whether there was a significant difference between them. The BAT post-test mean scores for boys and girls exposed to the treatment are shown in Table 14.

Table 14

T-test results of Post-test BAT Mean Scores for Boys and Girls Exposed to CCMTA

Gender	N	Mean	SD	df	t-value	p-value
Male	40	30.15	13.10	100	0.821	0.414
Female	62	28.34	9.19			

The results in Table 14 reveal that male students had a slightly higher mean score (M=30.15, SD= 13.10) than female students (M= 28.34, SD = 9.19). However, the mean scores of male and female students were not statistically different at 0.05 level; t (100) =0.821, $p>0.05$. The findings indicate that gender had no influence on learners' achievement since both boys and girls benefited equally when CCMTA was used. Based on these findings, the second hypothesis of the study was accepted.

4.5 Effects of CCMTA on student's motivation to learn biology

The aim of hypothesis three (Ho_3) of the study was to examine the effect of CCMTA on students' motivation to learn biology. The hypothesis stated that there was no statistically significant difference in motivation to learn biology between students taught using CCMTA and those taught using the TTM. The post-test SMQ mean scores were obtained through administration of motivation questionnaires. These scores were analyzed and used to find out the effects of CCMTA on students' motivation to learn biology.

4.5.1 Results of SMQ post-test mean score analysis

The SMQ post-test mean scores were analyzed to determine the relative effects of CCMTA on students' motivation to learn biology. This was done using one-way ANOVA and post hoc multiple comparisons test. The results are presented in Tables 15 & 16 respectively.

Table 15

SMQ Post-test Group Mean Scores Analysis

Group	N	Mean score	SD
E1	52	3.82	0.71
C1	49	3.48	0.50
E2	51	3.78	0.25
C2	47	3.38	0.67

The results in Table 15 indicate that the mean scores of treatment groups E1 (M= 3.82, SD=0.71) and E2 (M= 3.78, SD= 0.25) were higher than those of the control groups C1 (M= 3.48, SD=0.50) and C2 (M=3.38, SD=0.67). To establish whether the differences among the mean scores of the groups were significant, ANOVA test was conducted and results presented in Table 16.

Table 16

ANOVA Results of the post-test scores on SMQ

Scale	Sum of squares	df	mean squares	F-ratio	p-value
Between groups	7.019	3	2.340	7.427	0.000*
Within groups	61.428	195	0.315		
Total	68.447	198			

The results in Table 15 reveal that the difference in SMQ post-test mean scores among the four groups is significant since F(3, 195)= 7.427; p< 0.05. The Bonferroni post hoc multiple comparisons test was done to determine between which means significant differences occurred. The results are shown in Table 17.

Table 17

The Post hoc Pair wise multiple comparisons test on SMQ post-test mean scores

	(I) Group	(J) Group	Mean difference (I-J)	p- value
Bonferroni	E1	C1	0.34	0.028*
	E1	E2	0.41	0.987
	E1	C2	0.44	0.002*
	E2	C2	0.40	0.008*
	C1	E2	0.30	0.032*
	C1	C2	0.10	0.862

The results in Table 17 reveal that there were significant differences between the group pairs; E1 &C1 (p= 0.028), E1& C2 (p= 0.002), E2 & C2 (p= 0.008) and E2 & C1 (0.032). No significant differences were found between groups E1 & E2 (p= 0.987) and C1& C2 (p= 0.862). There is no statistically significant difference when one treatment group is compared to another treatment group or when one control group is compared to another control group. This observation is attributed to positive effect that CCMTA has on learner motivation.

The ANCOVA test was conducted to establish whether adjusted SMQ post-test mean scores were significantly different at the 0.05 level. Results of this analysis are shown in Table 18.

Table 18

ANCOVA Results of SMQ post-test mean scores

Scale	sum of squares	df	Mean square	F-ratio	P-value
Contrast	6.267	3	2.089	6.654	0.000*
Error	59.334	189	0.314		

The results in Table 18 show that the differences among mean scores of the E1, C1, E2 and C2 were statistically significant at the 0.05 level, $F(3,189) = 6.654$, $P<0.05$. To establish where the differences were, Bonferroni Post hoc pair wise multiple comparisons test was carried out and the results are presented in Table 19.

Table 19

Bonferroni Post-hoc Pair wise Multiple Comparisons test results of the Post-test SMQ Mean scores of the four groups

Group (I)	Group (J)	Mean difference (I-J)	P-values
E1	C1	0.22	0.036*
E1	E2	-0.19	0.231
E1	C2	0.27	0.043*
C1	E2	0.41	0.001*
C1	C2	0.05	0.690
E2	C2	0.46	0.000*

The results in Table 19 reveal that there were statistically significant differences between groups E1 & C1 (0.036), E1 & C2 (0.043), C1 & E2 (P=0.001) and E2 & C2 (P=0.000) at 0.05 level. However the differences between E1 & E2 (p=0.231), and C1 & C2 (P>0.05) were not significant. This confirms that CCMTA has superior qualities which affect learner motivation positively as opposed to TTM applied to control groups.

These results indicate that,

i. The SMQ pre-test did not interact significantly with treatment conditions. This is because there was no significant difference in SMQ mean scores between Group E1 and C1, both of which took the pre-test.
ii. The use of CCMTA resulted in higher students' motivation than the conventional teaching approaches since Group E1 and E2 obtained scores that were significantly higher than the other groups on SMQ. Hypothesis Ho3 is therefore rejected; there exists statistically significant difference in motivation between students who are exposed to CCMTA and those exposed to conventional teaching methods.

4.5.2 Results of SMQ gain analysis

A gain analysis was conducted to establish which of the two groups E1 and C1 that were pre-tested and post-tested attained higher motivation. The gains of the two groups are summarized in Table 20.

Table 20

Results of SMQ pre-test and SMQ post-test mean scores

		E1	C1
Pre-test	N	52	50
	Mean	3.16	3.22
	SD	0.50	0.55
Post-test	N	52	49
	Mean	3.82	3.48
	SD	0.71	0.50
Mean gain		0.66	0.36

Results in Table 20 reveal that the mean gain of the experiment group E1 (M=0.66) was higher than that of the control group C1 (M=0.36). After treatment, it is observed that the SMQ post-test mean scores were higher. This means that CCMTA led to enhanced motivation of students to learn biology, more than TTM did. Group E1 was found to be superior in terms of motivation as enhanced by CCMTA.

4.6 Motivation of boys and girls exposed to CCMTA

The SMQ mean scores for boys and girls were analyzed and compared to find out if there was significant difference between them. Table 21 shows the post-test SMQ mean scores for boys and girls exposed to CCMTA.

Table 21

Post–test SMQ Mean Scores for Boys and Girls Exposed to CCMTA

Gender	N	Mean	Std. Deviation
Boys	39	3.72	0.59
Girls	62	3.83	0.49

Results in Table 21 reveal that girls attained a slightly higher mean score (M=3.83, SD=0.49) than boys (M=3.72, SD=0.59). An independent sample t-test was conducted to find out whether the observed difference was significant. The results are represented in Table 22.

Table 22

T-test results of Post-test SMQ Mean Scores for Boys and Girls Exposed to CCMTA

Gender	N	Mean	SD	df	t-value	p-value
Male	39	3.72	0.59	99	1.027	0.307
Female	62	3.83	0.49			

Results of Table 22 indicates that there is no significant gender difference in motivation when students are exposed to CCMTA, t (99) = 1.027, p > 0.05. This indicates that the difference in SMQ post-test means is not statistically significant. Therefore, both boys and girls were motivated to the same level by the teaching approach. Hypothesis Ho4 is therefore accepted; there is no statistically significant gender difference in the level of motivation when students are exposed to CCMTA.

4.7 Discussion

A great difference is expected in post-test scores between Groups E1 and E2 than between groups C1and C2 where the pre-test interacts with treatment conditions. This would be due to sensitization effect such that the pre-test facilitates the learning of experimental group but not the control group. No such interaction was indicated by post-test achievement and motivation results as having occurred between the pre-test and CCMTA treatment in this study.

A comparison of groups E1 and C1 pre-test BAT mean scores reveal no significant differences t (98) =1.810, p> 0.05. These results indicate that the groups were equivalent before the intervention. Results of pre-test SMQ means scores also reveal non-significant differences t (100) = 0.563, p>0.05. This implies that groups E1 and C1 exhibited comparable characteristics hence considered suitable for the study.

4.7.1 The effects of CCMTA on students' achievement in biology

The results of this study reveal that students who were taught using CCMTA achieved significantly higher scores in BAT than those taught using the conventional approaches. The findings are in line with those of Keraro, Wachanga and Orora (2007). Their findings revealed that secondary school students exposed to Cooperative Concept Mapping Teaching approach performed better in biology than their counterparts taught using the traditional teaching methods. The results are also consistent with those of Wambugu (2011) which showed that Experiential Cooperative Concept Mapping instructional approach enhances secondary school students' achievement in physics.

An earlier study conducted by Muraya and Kimamo (2011) to determine the Effect of Cooperative Learning Approach on Mean Achievement Scores in Biology found significant differences. Students who were taught using Cooperative Learning Approach attained significantly higher mean achievement scores compared to those taught using regular teaching approach. Namasaka (2009) studied the Effects of Concept and Vee Mapping Strategy (CVMS) on Students' Motivation and Achievement in Biology and found out that students taught using the CVMS exhibited improved achievement in secondary school biology. His results also indicated reduced gender disparity in achievement.

In his study on Which Strategy Best Suits Biology Teaching, Ajaja (2013) observed that students taught using Cooperative Learning and Learning Cycle scored significantly higher than those taught using lecture method on achievement tests. There was no significant gender difference in achievement tests; Students in learning cycle and cooperative learning groups did not significantly differ on achievement tests. Non significant interaction effect between gender and method of instruction on achievements was reported. Kinchin (2000a) observed a significant impact of Concept Mapping on Achievement when used for instructing secondary school biology students.

This study reveals that CCMTA offers students opportunity to construct knowledge and yield the best results when students work in small groups made up of members of mixed abilities. The CCMTA was found to be more effective in enhancing learners' achievement than the conventional teaching approaches. However, CCMTA is ineffective where there is individualism and where students of comparable abilities are put in the same group.

4.7.2 The effects of CCMTA on students' motivation in biology

The results of this study indicate that CCMTA resulted in higher student motivation than the conventional teaching approaches. This is probably because the approach emphasized active participation of learners in the learning process. This may have led to meaningful understanding of concepts in biology arising from enhanced thought process triggered by the procedures involved in CCMTA. Enhanced achievement in tasks as learners engaged in group activities may have increased their confidence and motivation in knowledge construction as they solved problems in biology.

These findings are consistent with those of previous researchers such as Keraro, Wachanga & Orora (2007). In their study on Effects of Cooperative Concept Mapping Teaching Approach on Motivation of students in biology, they reported significantly higher motivation among students exposed to CCM than those taught through regular methods. Their results further indicate that there is no statistically significant gender difference in motivation towards the learning of biology among secondary school students exposed to CCM. In this study, boys and girls of mixed abilities were placed together in different groups and all were treated equally by their teachers. Every student was given an equal chance to contribute during the biology lessons. When students exchange ideas with one another in the group, new concept become clearer, are retained in memory and connected to what the learner already knows. This enhances achievement and motivation to learn (Ajaja, 2013).

An earlier study by Slavin (1997) reported that provision of group goals based on the individual learning of all group members might affect cognitive processes directly, by motivating students to engage in peer modeling, cognitive elaboration, and/or practice with one another. Group goals may also lead to group cohesiveness, increasing caring and concern among group members, making them feel responsible for one another's achievement, thereby motivating students to engage in cognitive processes which enhance learning. Group goals may motivate students to take responsibility for one another independent of the teacher, thereby solving important classroom organization problems and providing increased opportunities for cognitively appropriate learning activities.

In contrast, regular teaching approaches such as lecture method assumes that a teacher is the source of knowledge and reduces learners to passive recipients of this knowledge. A teacher takes charge of the learning process while learners compete for grades, taking no responsibility over each other’s learning. In such situations, slow learners are disadvantaged as a teacher is tempted to move at the pace of fast learners. CCMTA offers learners a chance to apply knowledge gained in real life situations through emphasis on hands-on experience in knowledge construction in collaborative groups. Since the major objective of science instruction is to enable students learn effectively, the most appropriate approaches for teaching and learning biology should be those that enhance learner achievement and motivation, such as CCMTA. These approaches will however be most effective only if the laboratory facilities for science teaching and learning are available in schools. Where laboratory facilities for biology teaching and learning are not available, a better alternative to the lecture method remains concept mapping since the method does not essentially demand the use of laboratories for practice (Ajaja, 2013).

However, before the adoption of the method as an appropriate instructional approach, both teachers and students should be well trained to acquire the skills necessary for its use. The efficient acquisition of the skills necessary for its use both by biology teachers and students will reduce the limitations associated with the approach. The findings of this study and reviewed literature indicate that the use of Concept Mapping Teaching Approach combined with other approaches leads to enhanced learner motivation.

4.7.3 Effect of gender on achievement of students taught using CCMTA

The results of this study indicate that there is no statistically significant difference between the achievement of boys and girls exposed to CCMTA. The results also show that boys and girls taught using CCMTA achieved significantly higher scores than those taught using the regular teaching methods. A classroom environment that seems to favor boys tends to discourage girls' participation in learning. Teachers who give more attention to boys at the expense of girls during instruction discourage girls and negatively affect their self confidence (Kelly, 1998). In their study on Using Advance Organizers to Enhance Students' Motivation in Learning Biology, Keraro and Shihusa (2009) found significantly higher level of motivation among boys than their female counterparts. However, CCMTA enabled both boys and girls to participate equally hence acquired comparable motivation.

Girls have been found to exhibit low levels of self esteem and underestimate their abilities. This attitude leads to low motivation levels and poor performance especially in science subjects as they are deemed a male domain. The use of CCMTA gives contrary findings. When boys and girls are subjected to the same learning environment, they reflect significantly comparable achievement in biology. This is a strong indicator of gender parity that ensures access to prestigious careers. Given the same educational opportunities and a gender positive teaching approach, girls are likely to perform at par with boys. CCMTA provides opportunities for students to interact, share knowledge and apply acquired knowledge to real life situations. Activities related to CCMTA generate intrinsic motivation and self-directed learning as students take full responsibility of their own learning and that of their peers during knowledge construction.

4.7.4 Effect of gender on motivation of students taught using CCMTA

The results of this study indicate that there is no statistically significant gender difference in the level of motivation to learn biology among boys and girls exposed to CCMTA. This indicates that both girls and boys were equally motivated to learn biology during the treatment period. An earlier study by Keraro, Wachanga and Orora (2007) found no significant difference in motivation to learn biology among secondary school students exposed to Cooperative Concept Mapping Instructional Approach. In their study on Effects of Cooperative Mastery Learning Approach on Student's Motivation to Learn Chemistry, Keter, Barchok and Ng'eno (2014) found no significant gender difference in motivation to learn chemistry. The above findings concur with this study and imply enhanced academic abilities in girls especially in science subjects that were previously viewed as a domain of male students.

Previous study by Changeiywo, Wambugu and Wachanga (2009) indicate that students exposed to Mastery Learning Approach (MLA) have significantly higher motivation than those taught through regular methods. Gender has no significant influence on their motivation to learn physics. The researchers conclude that MLA is an effective teaching method in motivating students. However, results of earlier study by Shihusa and Keraro (2009) on Use of Advance Organizers to Enhance Students' Motivation in Learning Biology indicate significant gender difference in motivation to learn biology in favor of boys. This seems to contradict earlier studies that show girls having more positive attitudes towards biology hence have higher motivation to learn. One of possible reasons for this scenario is the preferential treatment teachers give boys as opposed to girls and which end up de-motivating girls and curtailing their learning (Wachanga, 2002).

Since motivation is an important predictor of achievement in science, measures need to be taken to develop and implement novel teaching approaches that eliminate gender bias and enhance positive teacher characteristics that will promote teaching of science subjects. This will eliminate perception of science subjects as being difficult especially to the girls. In this study, all students were actively engaged in group activities that involved construction of concept maps during which concepts were discussed and elaborated among the group members. This enhanced mastery of content leading to meaningful learning. The new method (CCMTA) enhanced girls' confidence in learning biology especially in co-educational schools.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents summary of findings, conclusions drawn from the study, implications of the findings and recommendations. Suggestions on possible areas for further research are also presented.

5.2 Summary of findings

The findings of this study indicate that CCMTA is superior to regular teaching methods since it exerted positive influence on students' achievements in biology. This approach also enhanced learners' motivation, which is an important predictor of science achievement. As indicated by the findings, both boys and girls seem to draw equal benefits in terms of achievement and motivation to learn when CCMTA is applied.

5.3 Conclusions

The findings of this study provide the evidence that CCMTA is a viable strategy to enhance learners' achievement and motivation to learn biology. This section presents conclusions drawn from findings of this study;

i. Students who are taught Biology through CCMTA acquire higher achievement than those who are taught through TTM.
ii. Gender does not affect student's achievement when they are taught Biology through CCMTA.
iii. Students who are taught Biology through CCMTA acquire higher motivation than those who are taught through TTM.
iv. Gender does not affect student's motivation when they are taught Biology through CCMTA.

5.4 Implications of the findings

The evidence elicited by findings of this study implies that gender has no effect on the positive influence that CCMTA has on achievement and motivation to learn biology. The approach is therefore likely to assist in improving the achievement of girls which has been low as compared to that of boys at KCSE. Their improved performance would lead to better representation of girls in science based occupations. This would go a long way in assisting Kenya achieve the goals of vision 2030. CCMTA can make girls to be equally motivated towards learning biology as boys thereby assist them overcome their negative attitude towards science subjects. The superiority of CCMTA over the regular teaching method can be attributed to the fact that it is an integration of two learning approaches (collaborative learning and concept mapping). The strength of CCMTA is in the elements of collaborative learning that make students develop a positive attitude towards self and learning in general. As learners work in collaborative groups, they teach one another and also learn to be responsible for one another.

In concept mapping, learners engage in knowledge consultation and discover new ways of linking concepts thus enhancing their cognitive abilities. This improves learner confidence and determination which in turn enhances their motivation to learn biology. CCMTA may therefore assist in enhancing the objectives of teaching biology in Kenyan secondary schools. The Ministry of Education should encourage biology teachers to use CCMTA for more effective teaching that enhances understanding of concepts and discourages rote learning.

The use of CCMTA is however quite demanding on both teachers and students. CCMTA requires that students assume greater responsibility in negotiating and shaping knowledge within social groups by engaging in rich discussions amongst themselves. They have to be involved in organization of learning situations, setting instructional objectives, gathering content and are individually engaged with the concept mapping activity. Teachers on the other hand require ample time to prepare for lessons. They act as facilitators to coach, mediate, prompt and help students in understanding content. They also assess the level of understanding of learners.

5.5 Recommendations

Competence in the application of effective teaching methods stands as a major challenge in teaching of biology. Teachers require skills to enhance both theoretical and practical teaching of biology so as to motivate learners and impart skills and attitudes for use in everyday life. The findings of this study strongly suggest that CCMTA should be introduced in both teacher education and in teaching of secondary school biology to supplement existing approaches. This will assist in overcoming challenges that lead to low achievement in biology at KCSE. This approach has been proved useful in addressing gender disparity in secondary school course since both boys and girls seem to draw equal benefits in terms of achievement and motivation. Based on the findings of this study, the following recommendations have been made;

i. CCMTA has shown that it can enhance students' achievement and motivation in biology. It should therefore be adopted to supplement existing approaches to improve the teaching of biology.
ii. Students should be encouraged to practice use of CCMTA through contests, symposia, science club activities and science congress with the aim of inculcating science process skills in order to improve achievement at KCSE. This approach has superior qualities that would reduce gender disparity in achievement in school biology.
iii. Teachers should incorporate CCMTA in their teaching. This is because it enhances understanding of abstract concepts through active involvement of learners in group activities and application in real life situations. This would lead to motivational gains in learning biology.
iv. Practicing biology teachers should be trained in the use of CCMTA through in-service courses, seminars, workshops and symposia. This would go a long way in minimizing gender motivational disparities among students as they play an active role in acquisition of biological knowledge.

5.6 Recommendation for further research

The findings of this study indicate that CCMTA is effective in improving the teaching of biology. However, there are areas that require further investigations. They include the following;

i. A study on how CCMTA can be incorporated in ICT to enhance learning of biology.
ii. A study on effectiveness of CCMTA in other subjects such as chemistry and physics to further confirm the effectiveness of this approach in Kenyan context.
iii. A study on effectiveness of CCMTA in other dimensions such as social development to enhance social cohesion especially in Africa where ethnic tensions are prevalent.
iv. A study to determine the effect of CCMTA on acquisition of science concepts at primary school level to gather more evidence on the effectiveness of this approach.

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APPENDICES

APPENDIX A

TRAINING MANUAL ON COLLABORATIVE CONCEPT MAPPING

The purpose of this manual is to assist biology teachers in this study to plan and implement the Collaborative Concept Mapping Teaching Approach (CCMTA) in the topic Gaseous exchange in plants and animals taught to form two students. Collaborative learning practitioners are inclined to assume that students are responsible participants who already use social skills in undertaking and completing tasks. Therefore the teacher will be expected to help students to form and work in groups to produce interpretable pictorial views of ideas and concepts in the topic Gaseous exchange in plants and animals indicating their relationship in a hierarchical manner. CCMTA improves learner's participation in lessons as it makes learning more interesting to students and can be used to cover a large amount of material quickly.

The aim of this manual is to minimize variability among teachers when they teach the topic Gaseous exchange in plants and animals using CCMTA. This approach is based on Collaborative learning instructional approach where learners of different skills and ability collaborate in tasks and discussion to arrive at a shared understanding in a specific field of study.

Instructional objectives

Instructional objectives are the end results in a lesson stated in the terms of intended changes of learner's behavior due to the instruction received. Behavior includes mental (cognitive), emotional (affective) and physical (psychomotor) reactions. Instructional objectives are stated in terms of learning outcomes because emphasis is on the product of learning rather than on the process of learning.

Reasons for having instructional objectives

i. They provide direction to the teaching process.
ii. They set the stage for the evaluation of student's learning

Domains of instructional objectives

i. **Cognitive domain**. Objectives in this domain relate to the intellectual abilities and skills. The objectives in this domain can be group into six classes;
   - Knowledge- the objectives measure recall with the use of words like list, state, enumerate
   - Comprehension- the objectives measure understanding with use of words like classify, convert, describe, explain
   - Application-the objectives measure relevance of learnt material to other situations with the use of words like apply, using, compute
   - Analysis-the objectives use words like analyze, differentiate, compare and contrast
   - Synthesis-the objectives use words like compose, arrange
   - Evaluation-the objectives use words like assess, evaluate, criticize, appraise

ii. **Affective domain.** Objectives in this domain relate to attitudes, interests, beliefs and values. Objectives in this area are common in the curriculum because they relate to issues and topics that are relevant to the youth such as HIV/AIDS, abortion. Objectives in this domain are categorized into five classes;
   - Receiving- objectives in this domain use words such as choose, listen
   - Responding-the objectives use words such as discuss, responding
   - Valuing- the objectives use words such as accept, argue about, complete
   - Organization-the objectives use words such as organize, relate, and modify
   - Characterization by value-the objectives use words such as propose, oppose and verify

iii. **Psychomotor domain.** Objectives in psychomotor domain reflect motor skills. They have a place in teaching of science especially in the laboratory. The terms used in writing objectives in this area include; build, construct, calibrate, display & measure. objectives in this domain are grouped into 6 classes;

- Reflex action
- Perception abilities-interprets various stimuli
- Physical abilities- physical strength and stamina required for sustained effort
- Skilled movements- refer to efficiency and skills in performing complex tasks e.g. swimming, driving
- Non-discursive communication. This is communication without producing sound (gesture, facial expression).
- Basic fundamental movement-includes walking, gripping, finger manipulation.

Teaching biology

The teaching of biology in schools aims at imparting certain skills to the learner that make him/her equipped to exploit resources without causing destruction. The teacher must understand that he/she must develop scientific skills among learners to enable them make use of biological knowledge in their day to day life. These skills are;

i. Observing
ii. Classifying
iii. Communicating
iv. Measuring
v. Predicting
vi. Inferring
vii. Identifying and controlling variables
viii. Formulating and testing hypotheses
ix. Defining
x. Interpreting data
xi. Experimenting
xii. Constructing models

Teaching methodology

The teacher is advised to always prepare in advance on the topic or sub-topic to be taught. In this regard, the teacher should:

i. Study all the objectives and suggested activities
ii. Make notes on the topic or sub-topics to be taught

iii. Arrange and try out practical activities before involving students
iv. Prepare all the teaching resources
v. Arrange all the demonstration materials or organize visits where necessary
vi. Prepare likely precise evaluation questions

Instructional objectives for the topic Gaseous exchange in plants and animals (36 lessons)

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

1. Explain the need for gaseous exchange in living organisms
2. Explain the mechanism of gaseous exchange in plants
3. Compare the internal structures of aquatic and terrestrial roots, stems and leaves
4. Examine various types of respiratory structures in animals and relate them to their functions
5. State the characteristics of respiratory surfaces
6. Describe the mechanisms of gaseous exchange in protozoa, insects, fish, frog and mammal
7. Describe the factors which control the rate of breathing in humans
8. State the causes, symptoms and preventive measures of respiratory diseases.

Content to cover:

i. The necessity of gaseous exchange in living organisms
ii. Gaseous exchange in plants-mechanisms of opening and closing of stomata; the process of gaseous exchange in root, stem and leaves of both aquatic and terrestrial plants
iii. Gaseous exchange in animals-Types and characteristics of gaseous exchange surfaces such as cell membrane, gills, buccal cavity, skin and lungs; mechanism of gaseous exchange in protozoa (amoeba), insect (grasshopper), Fish (bony fish), Amphibia (frog), mammal (human)
iv. Factors affecting rate of breathing in humans
v. Respiratory diseases; Asthma, bronchitis, pulmonary tuberculosis, pneumonia and whooping cough.

Practical activities

i. Observe permanent/temporary slides of cross sections of aerial and aquatic leaves and stems
ii. To investigate the release of carbon(IV)oxide in plants
iii. To investigate the release of oxygen by plants
iv. Examine the distribution of spiracles in insects such as grasshoppers
v. Examine the gills of a bony fish
vi. Dissect a small mammal and identify the structures of the respiratory system
(Demonstration)
vii. Construct and use models to demonstrate breathing mechanisms in a mammal (Human)
viii. Demonstrate the effect of exercise on the rate of breathing

Resources:

- Permanent/ temporary slides of cross-sections of aerial and aquatic leaves and stems
- Model of guard cells- constructed from two balloons, strings and masking tape
- Grasshoppers
- Gills of fish
- Dissecting kits
- Small mammals e.g. rat/rabbit
- Stationary

THE PROCESS OF CONCEPT MAPPING

What is a concept map?

It is a graphical tool for visualizing, organizing and representing knowledge. It presents the relationships among a set of connected concepts and ideas. A concept map is a tangible way to display how the mind "sees" a particular topic. In a Concept Map, the concepts are represented by single words enclosed in a rectangle (box) or a circle. Relationships between concepts are then indicated by a connecting line (arrow) linking two concepts. A word or brief phrase, referred to as linking phrase/word(s) is written on the arrow to define the relationship between the connected concepts. Major concept boxes will have lines to and from several other concept boxes generating a network.

What is Concept Mapping?

It is a teaching strategy that consists of a procedure where concepts, generated from a particular knowledge domain, are organized in a hierarchical fashion and connected through a series of links to form particular knowledge propositions. This strategy enables learners to learn and teachers to organize learning material. The application of concept mapping to learning environments has been extensive, varied and successful.

Collaborative Concept Mapping Teaching Approach (CCMTA)

CCMTA is an interaction between two or more individuals during concept mapping to create a shared understanding of a concept, discipline or area of practice that none had previously possessed or could have come to on their own. Students of different academic abilities work together in small groups towards a common goal. Students engage in complementary learning in which they are responsible for one another's learning as well as their own. Thus, the success of one student helps other students to be successful.

The teacher should divide learners into groups during whose formation and operation, the following elements should be observed;

- Group heterogeneity. Groups should be limited to five students and be as heterogeneous as possible in terms of gender and academic ability.
- Group's goal. Each group member must work hard in order to assist the group achieve maximum score in continuous assessment tests.
- Promote interaction. Techniques such as peer tutoring and mutual encouragement will be used to promote interaction within the group.
- Individual accountability. Each group member must make a significant contribution to the group goal.
- Interpersonal skills. Group members should work closely together by having face to face interactions. They should communicate clearly with one another and be able to resolve conflicts.
- Equal opportunity for success. Each group should be as the other and students should be allowed to contribute in their own way.
- Team competition. Competition should be inter-group and should not be frequent.

Role of a teacher in CCMTA

The role of a teacher in this model is;

i. To divide students into autonomous groups of mixed gender and ability
ii. Appoint a group leader per group and divide the lesson into tasks
iii. Assign group tasks and initiate discussion on lesson topic
iv. Create conditions within a classroom which will energize, direct and sustain students' performance (Motivate). This role is important for promoting morale and learning climate.

Steps for creating and teaching Concept Maps

The class should be divided into groups of mixed academic ability and gender (approx. 5-7 members). It is advisable to retain these groups throughout the study.

i. Pre-concept mapping activity

1. Make two lists on the board using familiar words for objects and another list for events.
2. Ask students to describe what they think of when they hear each word. Help them recognize that the mental images we have about each word are our concepts.
3. List the words: are, where, the, is, then, with and ask students what comes to their minds when they hear each of these words. Emphasize that these are not concept words but linking words. When put with concepts they form sentences that have meaning.
4. Have students practice using two concepts words and linking word(s) to construct a few short sentences.

i. Concept mapping activity

a. Brainstorming Phase:

Select a particularly meaningful paragraph or two from a text or other printed material. Have the students read the text and select the key concepts (facts, terms and ideas) for understanding the meaning of the text. Concepts can also be drawn from memory. List these concepts (may be a single word or a short phrase) then discuss which concept is the most important, most inclusive idea in the text.

NB: Since this is a brainstorming phase, students should write down everything that anybody in the group thinks is important and avoid discussing how important the item is. Don't worry about redundancy, relative importance, or relationships at this point. The objective here is to generate the largest possible list of concepts. Concepts may be written on small cards or pieces of paper (post-it notes) so that they can be moved around.

b. **Organizing Phase:** Spread out your concepts (Post-It notes) on a flat surface so that all can be read easily and, together, create groups and sub-groups of related items. Try to group items to emphasize hierarchies. Identify terms that represent those higher categories and add them. Feel free to rearrange items and introduce new items that you omitted initially. Note that some concepts will fall into multiple groupings.

c. **Layout Phase:** On a large sheet of paper (e.g. manila paper), try to come up with an arrangement (layout) that best represents your collective understanding of the interrelationships and connections among groupings. Feel free to rearrange things at any time during this phase. Use a consistent hierarchy in which the most important concepts are in the center or at the top. Within sub-grouping, place closely related items near to each other. Think in terms of connecting the items in a simple sentence that shows the relationship between them. Do not expect your layout to be like that of other groups. It may be advisable to meet outside of class to work on this assignment and plan for its completion.

   Put the most inclusive concept at the head of a new list of rank-ordered concepts. List the next most general, most inclusive concepts, working through the first list until all concepts are rank-ordered. It is sometimes difficult to identify the broadest, most inclusive concept. It is helpful to be aware of the context of the concepts you are dealing with or to have some idea of the situation for which these concepts are arranged.

d. **Linking Phase:** Now begin constructing a concept map, using the rank-ordered list as a guide in building the concept hierarchy. Use label lines with arrows to connect and show the hierarchical relationships between connected items. Write action or linking words/ short phrase by each arrow to define the relationship between the two concepts so that it reads as a true statement, or proposition. The connection creates meaning. When a large number of related ideas are held together, one can see the structure of meaning for a given subject area. Many arrows can originate or terminate on particularly important concepts.

e. **Finalizing the Concept Map:** After group members have agreed on an arrangement of items that coveys their understanding, they need to convert their concept map into a permanent form that others can view and discuss. Learners need to be creative in a constructive way through the use of colors, fonts, shapes, border thickness, etc. to communicate group's understanding. Give your concept map a title.

NB: The first Concept map may have poor symmetry or some concept clusters poorly located relative to other more closely related concepts or clusters. It may take several reconstructions to show a good representation of propositional meanings

In reviewing a concept map, the following attributes are considered:

- **Accuracy and Thoroughness**. Are the concepts and relationships correct? Are important concepts missing? Are any misconceptions apparent?
- **Organization**. Was the concept map laid out in a way that higher order relationships are apparent and easy to follow? Does it have a title?
- **Appearance**. Was the assignment done with care showing attention to details such as spelling and penmanship? Is it neat and orderly or is it chaotic and messy?
- **Creativity**. Are there unusual elements that aid communication or stimulate interest without being distracting?

Breathing system of an insect

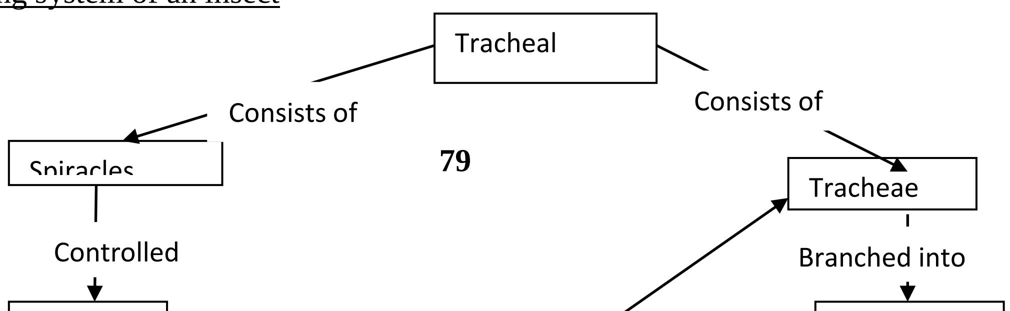


Fig 3.Illustration of a good Concept Map

APPENDIX B

BIOLOGY ACHIEVEMENT TEST (BAT)

School Name…………………………………………………………………………………

Admission No……………………………………………………………………………….

Gender………………………………………………………………………………………

Age…………………………………………………………………………………………..

Study group………………………………………………………………………….....

Instructions:

This test consists of **forty** questions. You are required to read each question carefully before writing your answers in the spaces provided. Answer **all** the questions.

1. What is the role of aerenchyma tissue in aquatic plants? (2marks). K
2. How is aerenchyma tissue adapted to its function? (2 marks) A
3. State two ways in which floating leaves of aquatic plants are adapted to gaseous exchange. (2 marks) K
4. Name 3 gaseous exchange surfaces in aquatic plants. (3 marks) K
5. Differentiate between stomatal and cuticular gaseous exchange. (2 marks)C
6. State four characteristics of gaseous exchange surfaces. (4 marks).K
7. State three adaptations of a respiratory surface. (3marks). C
8. Apart from lungs, name two other gaseous exchange surfaces in a frog. (2 marks)C
9. Illustrate the mechanism of gaseous exchange in a named unicellular organism. (3marks). A
10. State the differences in content of oxygen and carbon (IV) oxide in the air that enters and leaves the human lungs. (2marks) K
11. Name the causative agent for pneumonia. (1mark). K
12. Explain how each of the following parts of the gill is suited to its function ;(2marks) A
    a. Gill bar
    b. Gill filaments
13. State factors that make alveolus adapted to its function. (4marks) K
14. Explain how alveoli are ventilated. (2marks) A
15. Explain why water logging of the soil may lead to death in plants. (2marks) C

16. Write two advantages of breathing through the nose than through the mouth. (2marks)A

17. State and explain two adaptations of leaves for gaseous exchange.(2marks) C

18. Name three gaseous constituents involved in gaseous exchange in plants. (3marks)K

19. Name the sites of gaseous exchange in; (2marks) K

    i). Mammals

    ii). Fish

20. Name the physiological process by which gas exchange takes place at the respiratory surface of plants and animals. (1Mark).K

21. State the differences between guard cells and other epidermal cells. (3marks).C

22. How does photosynthetic theory explain the opening and closing of stomata? (3marks).A

23. Explain the mechanism of gaseous exchange in insects. (3marks).C

24. State the role of the following in the nasal cavity of mammals; (2marks) A

    i). Blood capillaries

    ii). Goblet cells

25. Explain why smokers are more prone to respiratory tract infections than non-smokers. (2marks). A

26. Explain the terms; (2marks). K

    i). Tidal volume

    ii). Vital capacity

27. The table below shows percentage composition by volume of inhaled and exhaled air.

Gas	Inhaled air (%)	Exhaled air (%)
Oxygen	21	16
Carbon (IV) oxide	0.04	4.0
Nitrogen	79	79
Water vapor	0.2	1.0

a). By what percentage is the carbon (IV) oxide concentration in exhaled air higher than in inhaled air (1mark).A

b). Explain the difference in the composition of gases between inhaled and exhaled air. (2marks). A

28. Name three respiratory diseases and state their causes. (2marks). K

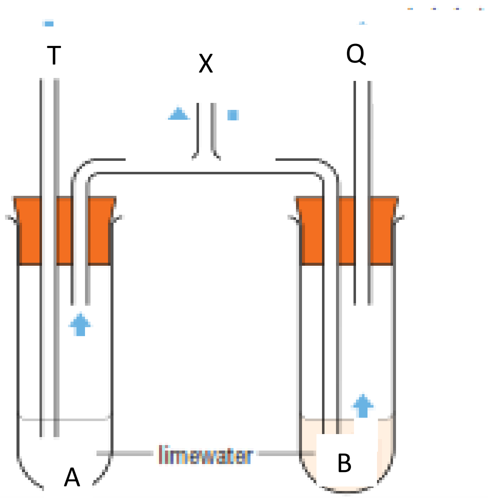
29. Explain why;

a). A fish dies when kept out of water (2marks) A

b). It is dangerous to sleep in a poorly ventilated room with a charcoal jiko on. (2marks). A

30. Explain the mechanism of exhalation in a named mammal. (3marks). C

31. A form two student set up the experiment below to investigate a certain aspect of gaseous exchange.

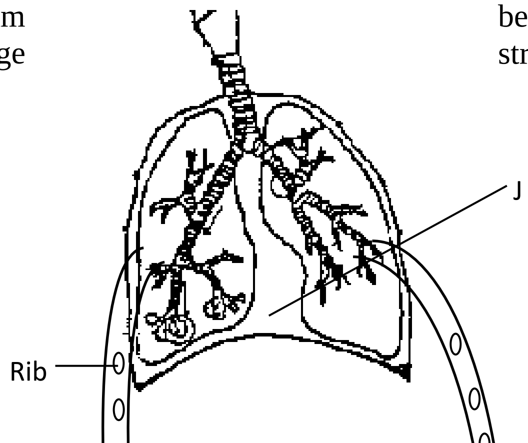


The student breathed in and out at point X using the mouth.

a) Using arrows indicate the direction of movement of air along tubes T and Q on the diagram during the experiment. (1mark). A

b) State the results expected after some time. Give reasons for your answer.(2mark). A

32. The diagram below represents some gaseous exchange structures in humans.



a). Name the structures labeled K, L and M. (3marks). K

b). How is the structure labeled J suited to its functions? (2marks) A

33. Discuss the role of intercostal muscles in breathing in mammals. (2marks). C

34. How does temperature affect the rate of breathing in man; (2marks) A

35. Outline the significance of gaseous exchange in living organisms. (2marks). C

36. How are tracheal tubes of insects ventilated? (2marks). K

37. Name the components of the breathing system of mammals. (2marks). K

38. Discuss the process of gaseous exchange across alveolar wall. (2marks). C

39. Outline the role of the following in mammalian breathing system; (4marks). K

i). Pleural fluid

ii).Diaphragm muscle

40. What is the role of a ribcage in mammalian breathing system? (2marks). C

APPENDIX C

STUDENT'S MOTIVATION QUESTIONNAIRE (SMQ)

School

Name…………………………………………………………………………………

Admission

No…………………………………………………………………………………

Gender………………………………………………………………………………………

Questionnaire

This questionnaire is designed to find out your attitude towards the biology course. Please indicate your opinion on each item by encircling your preferred response. Information given in this questionnaire will be treated with strict confidence and only used for the purpose of this study. Ask for assistance from your biology teacher if any of the items is not clear to you. Do not write your name anywhere in this questionnaire.

Instructions:

Read each of the items carefully before selecting your preferred response. Encircle the letter that truly represents your opinion. Study the key below to help you understand the choices you make.

SD = Strongly Disagree D = Disagree

SA = Strongly Agree A = Agree

U = Undecided

Example: I find Biology lessons very interesting

SD D U (A) SA

If you agree with the above statement you encircle A as above.

ITEMS

A. Learning biology course was;

	1	2	3	4	5
1. Interesting	SD	D	U	A	SA
2. Satisfying	SD	D	U	A	SA
3. Informative	SD	D	U	A	SA
4. Exciting	SD	D	U	A	SA
5. Rewarding	SD	D	U	A	SA
6. Fulfilling	SD	D	U	A	SA
7. Useful	SD	D	U	A	SA
8. Boring	SD	D	U	A	SA
9. Stressful	SD	D	U	A	SA
10. Demanding	SD	D	U	A	SA

B. Learning biology course by applying the concepts learnt to real life situation made me;

1. Look forward to learn biology course SD D U A SA
2. Learn biology with greater interest SD D U A SA
3. Eager to apply biological knowledge to solve practical problems SD D U A SA
4. Comprehend the content learnt SD D U A SA
5. Enjoy biology lessons SD D U A SA
6. Participate in learning activities SD D U A SA
7. Feel as if I didn't know anything SD D U A SA
8. Feel discouraged SD D U A SA
9. Feel as if I was wasting time SD D U A SA
10. Doubt my ability to learn biology SD D U A SA

C. The biology lesson and assignment during the course topic Gaseous exchange in plants and animals was;

1. Easy SD D U A SA
2. Helpful SD D U A SA
3. Insightful SD D U A SA
4. Stimulating SD D U A SA
5. Fun SD D U A SA
6. Meaningful SD D U A SA
7. Not interesting SD D U A SA
8. Difficult SD D U A SA
9. Time consuming SD D U A SA
10. Discouraging SD D U A SA

D. Learning biology course through concept mapping in groups and applying the knowledge to real life situation made me;

1. Look forward to learn biology course SD D U A SA
2. Learn biology with greater interest SD D U A SA
3. Eager to apply biological knowledge to solve practical problems SD D U A SA
4. Comprehend the content learnt SD D U A SA
5. Enjoy biology lessons SD D U A SA
6. Participate in learning activities SD D U A SA

7. Feel as if I didn't know anything	SD	D	U	A	SA
8. Feel discouraged	SD	D	U	A	SA
9. Feel as if I was wasting time	SD	D	U	A	SA
10. Doubt my ability to learn biology	SD	D	U	A	SA

E. The biology lessons I attended were;

1. Enjoyable	SD	D	U	A	SA
2. Exciting	SD	D	U	A	SA
3. Involving	SD	D	U	A	SA
4. Easy	SD	D	U	A	SA
5. Helpful	SD	D	U	A	SA
6. Involving	SD	D	U	A	SA
7. Satisfying	SD	D	U	A	SA
8. Scaring	SD	D	U	A	SA
9. Discouraging	SD	D	U	A	SA
10. Difficult	SD	D	U	A	SA

APPENDIX D

TEACHING MODULE USING COLLABORATIVE CONCEPT MAPPING TEACHING APPROACH IN THE TOPIC GASEOUS EXCHANGE IN PLANTS AND ANIMALS TO FORM TWO BIOLOGY STUDENTS

Class: Form 2

Sub-topics:

i. The necessity for gaseous exchange in living organisms

ii. Gaseous exchange in Plants- gaseous exchange surfaces.

iii. Gaseous exchange in animals

Objectives of the lesson:

By the end of the lesson, the learner should be able to;

- Explain the need for gaseous exchange in living organisms
- State gaseous exchange surfaces in plants
- Explain the photosynthetic theory of opening and closing of stomata

Week I: Four lessons per week for 160 minutes (two single and one double lesson)

Lesson 1	**Teaching Activities**	**Learning Activities**
Introduction 5 min	Teacher presents the lesson topic and invites learners to comment on it	Learners respond by stating the meaning of gaseous exchange based on knowledge gained in form one topic characteristics of living things
Lesson development 10 min	a. Teacher introduces objectives of the three weeks' lessons b. Teacher explains the concept of gaseous exchange in living organisms c. Formation of heterogeneous groups and appointment of group leaders	a. A learner take notes and seek clarification where content is not clear. b. Learners choose groups to belong to based on guidance provided by the teacher
Lesson development 10 min	Teacher initiates a discussion on the significance of gaseous exchange in living organisms.	Group members discuss types of gaseous exchange surfaces in plants and write down their points
Introduction of concept mapping 10min	a. Steps for creating a concept map b. Teacher makes two lists on the chalk board; one using familiar words for objects and another list for events c. Teacher helps learners to recognize that mental images they form about each word are concepts d. Teacher lists words; are, where, the, is, then, with and helps learners understand that these are not concepts but linking words	a. Learners copy the words in their notebooks. b. Learners explore and discuss among their groups to understand the difference between concepts and linking words

	e. Teacher helps learners practice using two concept words and linking word(s) to construct a few short sentences	
Conclusion. 5 min	a. Teacher picks a few words from lesson topic and asks learners to connect them with linking words to form meaningful sentences b. Teacher alerts learners to prepare for a test to be administered during prep time (BAT- Pretest)	Learners construct a few meaningful sentences using the words given by their teacher
Lesson 2 & 3 Introduction 5 min	Teacher highlights the points emphasized in the previous lesson and allows learners time to ask for clarification in areas that were not clear	Learners seek clarification Learners ask questions and note important points on teacher's clarification.
Lesson development 20 min	Gaseous exchange surfaces: a. Teacher involves learners in highlighting gaseous exchange surfaces in plants i.e. cuticles, lenticels and stomata. b. Teacher explains meaning of Stomatal gaseous exchange and the theories of stomatal opening and closing.	Learners take notes and seek clarification among group members and from the teacher
Practical activity 20 min	a. Teacher avails materials and equipment for use during the practical activity and provides procedures to be followed by learners. b. Teacher moves from group to group to assist students	a. Learners, working in their groups make Transverse sections of aerial & aquatic leaves, stems and roots to observe under the microscope. They compare their temporary slides with permanent slides of the same specimens to identify special features that facilitate effective gaseous exchange. b. Learners draw neat diagrams of the specimens under observation
Group presentation 20 min	Teacher summarises the practical by emphasizing on the main adaptations of plants in various habitats to gaseous exchange.	A representative from each group highlights their findings in the practical activity.
Lesson development . 10 min	**Gaseous exchange in animals**. a. Teacher reminds learners about the relationship	Learners actively participate in their groups and take notes

	between surface area to volume ratio and the need for a specialized gaseous exchange mechanism in multi cellular animals. b. Teacher discusses types and characteristics of gaseous exchange surfaces	
Conclusion 5 min.	Teacher poses questions to learners on the main points covered in the lesson and gives them an assignment- list main concepts discussed under gaseous exchange in plants and possible linking words	Learners respond to the question and note down the assignment
Lesson 4 Introduction 10min	Teacher asks a member from each group to list the words given as an assignment the previous lesson, on the chalk board. Using the words, the class in involved in constructing simple concept maps on the chalk board	a. A member of each group lists their words on the chalk board. b. Learners participate in constructing concept maps on the chalk board. c. Learners copy these concept maps in their note books
Lesson development 15min	Gaseous exchange in animals. a. Teacher involves learners in highlighting gaseous exchange surfaces in animals. b. Teacher discusses gaseous exchange in protozoa. c. Gaseous exchange in insects. Teacher draws a relationship between the need for complex gaseous exchange mechanism and surface area to volume ratio	Learners engage in group discussion as the teacher occasionally directs Note taking
Lesson development 10min	Teacher leads learners to highlight the main lesson points and asks them to construct concept maps in their respective groups based on Gaseous exchange in protozoa & Gaseous exchange in insects.	Learners take notes and also engage in group discussion as they construct concept maps
Conclusion 5min	Teacher summarizes the lesson by highlighting main points of the lesson	Learners may seek clarification on areas they think are difficult

WEEK II

Lesson 1	Teaching activities	Learning activities
Introduction	Teacher reviews previous lesson by	Learners respond to the

5min	asking questions on main points of the lesson	questions as they consult among group members
Lesson development 20 min	Mechanism of gaseous exchange in the tracheole system of an insect. a. Teacher displays a chart showing the tracheole system of a grasshopper b. Teacher highlights the adaptations of tracheole system to gaseous exchange and the mechanism of gaseous exchange in an insect	a. Learners explore and draw the displayed diagram. b. Note taking. c. Learners seek clarification where necessary
Lesson development 10min	Teacher leads learners in listing main points and construct concept maps in their respective groups.	Learners list main points and engage group members in constructing a simple concept map
Conclusion 5min	Teacher summarises the lesson by highlighting main points of the lesson	Learners contribute in lesson summary
Lesson 2&3 Introduction 10min	Practical activity. a. Teacher introduces lesson and involves group leaders in distributing materials for the practical. b. Teacher issues practical Manuals	Learners assemble lesson materials And collect practical manuals
Lesson development 20min	Teacher guides learners in dissecting a grasshopper to display the tracheole system.	a. Learners work in turns in their respective groups to dissect their grasshopper. b. Learners discuss findings and compare with displayed chart
Lesson development 10min	Teacher concludes the practical by highlighting features of the tracheole system	Note taking. Learners seek clarification where necessary. Learners clear the table and get ready for next part of the lesson.
Lesson development 20min	Gaseous exchange in fish. a. Teacher asks learners to name gaseous exchange surfaces in fish, introduces gill structure. b. Teacher issues preserved gills to various groups for examination and discussion	Learners respond to questions. Observe and draw gill structure.
Lesson development 15min	Teacher leads learners in discussion on adaptations of gills to gaseous exchange	Learners discuss adaptations of gills to their functions. Draw and label gill structure
Conclusion 5min	Lesson summary by question & answer method	Learners give answers to teacher's questions

Lesson 4 Introduction 5min	Teacher reviews previous lesson by highlighting the main points	Learners make contributions during lesson review
Lesson development 15min	Mechanism of gaseous exchange in amphibians. a. Teacher enumerates gaseous exchange surfaces in amphibians. b. Teacher involves learners in discussion on adaptations of amphibian gaseous exchange surfaces	a. Note taking. b. Learners discuss adaptations of amphibian gaseous exchange surfaces.
Lesson development 15min.	Mechanism of gaseous exchange in mammals. a. Teacher asks learners to name parts of the human breathing system. b. Teacher displays a chart showing human breathing system for learners to study.	a. Learners respond to questions asked by the teacher. b. Learners study and draw structure of mammalian breathing system. c. Note taking
Lesson conclusion 5min	a. Teacher involves learners in identifying main concepts on human breathing system. b. Teacher gives an assignment to learners to use these concepts to construct a hierarchical concept map	a. Learners make contributions to identify main concepts on human breathing system. b. Learners note the concepts in their c. notebooks

WEEK III

Lesson I	Teaching activities	Learning activities
Introduction 5min	Review of previous lesson. A member of one group presents their concept maps for plenary assessment	Learners participate in lesson review by giving their individual contributions
Lesson development 15min	Demonstration of breathing mechanism in man. a. Teacher guides learners in demonstration of breathing movements. b. Teacher explains the difference between inhalation and exhalation. c. Teacher displays chart showing complete breathing system in man.	a. Learners work in pairs to feel ribcage movements during inhalation and exhalation of their partners. b. Note taking.
Lesson development 15min	Teacher introduces a model to demonstrate ribcage action during breathing and relates	a. Learners study and draw the breathing system of man.

	this to lesson content.	b. Learners explore the model in their respective groups and relate it to breathing system in man
Lesson Conclusion 5min	a. Teacher concludes the lesson by a quick review of the main lesson points using question & answer method. b. Teacher gives an assignment to construct hierarchical concept maps in their groups to summarize main points on gaseous exchange in man.	a. Learners respond to review questions b .Learners note the assignment in their notebooks
Lesson 2&3 Introduction 80min	Post-test a. Teacher ensures that learners are well distributed in class to take the test. b. Teacher distributes test materials and actively invigilates to ensure no cheating takes place	Learners arrange themselves well in class and take the test
Lesson 4 Introduction 10min	Review of previous lesson. Teacher appoints a volunteer to present their group's concept map for class discussion	Learners participate in lesson review
Lesson development 15min	Exchange of gases in alveolus. a. Teacher displays a chart showing the structure of an alveolus. b. Teacher explains mechanism of gaseous exchange in alveolus	a. Learners study the chart, listen to the teacher and take notes b. Learners draw the displayed structure of alveolus
Lesson development **10min**	a. Teacher highlights the adaptations of alveolus to gaseous exchange b. Teacher explains regulation of breathing in man	Learners take notes, may seek clarification where content is not clear
Lesson conclusion. 5min	Teacher concludes the lesson and gives an assignment on; a. Factors affecting rate of breathing in humans b. Diseases of the respiratory	Learners note the assignment in their exercise books

	system	

Teaching activity:

a. Practical activity; to compare the amount of carbon (IV) oxide in inhaled and exhaled air.

b. Teacher takes learners through the requirements of the experiment and safety measures.

c. Teacher uses group leaders to distribute practical equipment and practical manuals.

d. Teacher visits the groups in turns to ensure they are doing the right thing and guides them to make correct observations

e. Teacher leads learners to conclude the practical by discussing findings for each group.

f. Teacher draws the set up on the chalkboard for learners to copy.

g. Teacher concludes the practical and asks learners to clear their benches.

Learning activity:

a. Learners note down important points and get ready for the practical.

b. Learners set up the experiment and follow the procedure to make appropriate observations.

c. Learners engage in group discussion to explore findings and take notes. Draw the set up in their books.

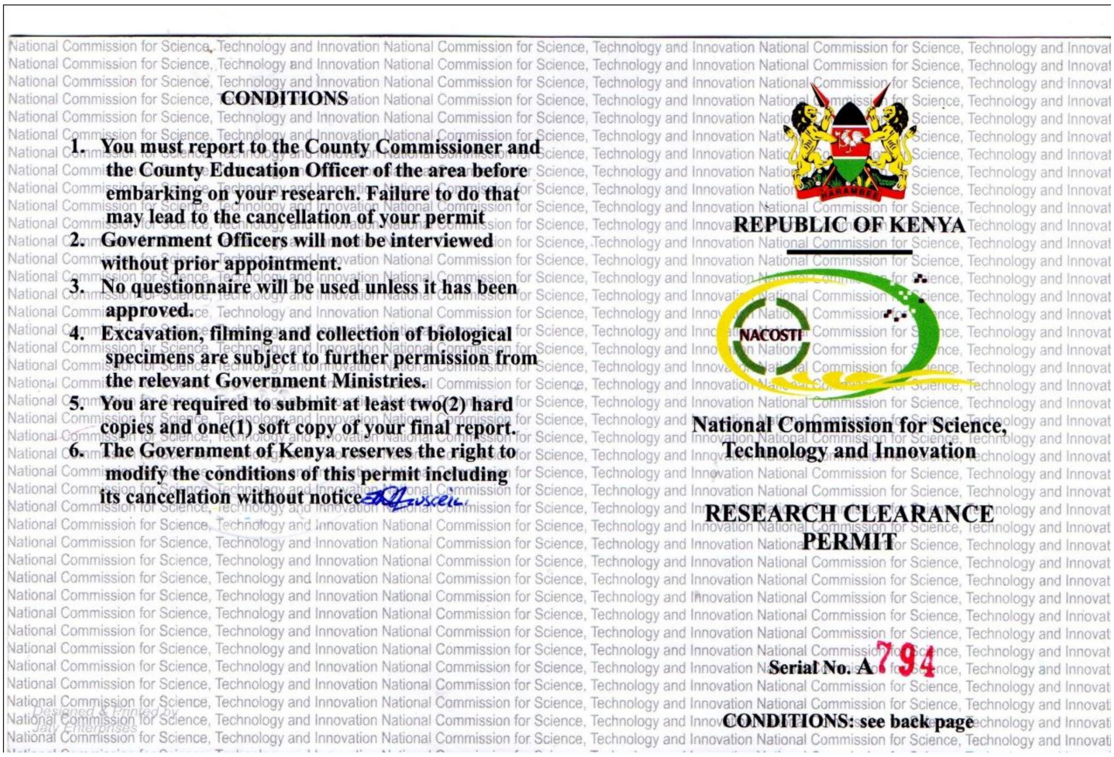
d. Learners clean their working stations.

APPENDIX E

Location Map of Nakuru County

APPENDIX F

Research Certificate (NACOSTI)



CONDITIONS

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit
2. Government Officers will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2) hard copies and one(1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No. A 794

CONDITIONS: see back page

PAGE 2

THIS IS TO CERTIFY THAT:
Prof./Dr./Mr./Mrs./Miss/Institution
Rahab Wamucii Githae
of (Address) Egerton University
P.O.Box 536-20115, Egerton.
has been permitted to conduct research in

Location
District
Nakuru County

On the topic: Effects of collaborative concept Mapping teaching mapping teaching approach on secondary school students' achievement and motivation to learn Biology in Nakuru North District, Nakuru County, Kenya.

for a period ending: 31st December, 2014.

PAGE 3

Research Permit No. *NACOSTI/RCD/14/013/1770*
Date of issue *3rd January, 2014*
Fee received *KSHS. 1000*

....
Applicant's Signature

....
For: Secretary
National Commission for Science Technology & Innovation

APPENDIX G

Research Authorization (NACOSTI)

NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471, 2241349, 310571, 2219420
Fax: +254-20-318245, 318249
Email: secretary@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

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

Ref: No.

Date:

3rd January, 2014

NACOSTI/RCD/14/013/1770

Rahab Wamucii Githae
Egerton University
P.O.Box 536 - 20115
EGERTON.

RE: RESEARCH AUTHORIZATION

Following your application dated ***13th November, 2013*** for authority to carry out research on ***"Effects of collaborative concept mapping teaching***