EFFECTS OF CONCEPT AND VEE MAPPING STRATEGY ON STUDENTS' MOTIVATION AND ACHIEVEMENT IN BIOLOGY IN SECONDARY SCHOOLS IN UASIN–GISHU DISTRICT, KENYA

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A Thesis submitted to the Graduate School in partial fulfilment of the requirements for the Award of the Degree of Master of Education (Science Education) of Egerton University

EGERTON UNIVERSITY

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DECLARATION AND RECOMMENDATION

DECLARATION

This thesis is my original work and has not been presented for a degree, diploma or other awards in any other University.

Signature…………………….. Date……………………………..

Fred W. Namasaka
EM14/0678/02

RECOMMENDATION

This thesis has been submitted with our approval as University supervisors.

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DEDICATION

This work is dedicated to Linah, Winnie, Ivy, Joseph and Blessings.

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ABSTRACT

Achievement in Biology in the Kenya Certificate of Secondary Education has consistently been low for the period between 2000 and 2006. This would imply that the objectives of Biology teaching have not been achieved. In addition, the performance of girls has often been lower as compared to that of boys. Low achievement in examinations would partly be attributed to lack of effective learning, as a result of ineffective teaching approaches. The expository approach has been the main method used for teaching Biology in secondary schools in Kenya. The stakeholders in education attribute failure of students to adequately master Biology content to the use of expository approach that does not assist learners relate skills, formulae, laws and procedures they learn to previous knowledge and experiences. Concept and Vee mapping strategies have had positive results in other parts of the world such as England, Wales and North America and could probably have a positive impact if used in the teaching of Biology in Kenya. In this study, a hybrid of the two strategies referred as Concept and Vee Mapping Strategy (CVMS) was used. The purpose of the study was to measure the CVMS' effect on students' achievement and motivation in Biology in mixed provincial secondary schools in Uasin Gishu District, Kenya. A Quasi-experimental research based on the Solomon Four group design was used. All students in secondary school in Uasin Gishu District constituted the target population. The accessible population constituted all the form two students. Four mixed schools were sampled and randomly assigned to the experimental and control groups. One form two stream from each school was selected and this gave a total sample size of 144 students. The research instruments used to collect data included the Biology Achievement Test (BAT) and the Students' Motivation Questionnaires (SMQ 1 and SMQ 2). The data was analysed using one-way ANOVA and t-test. Hypotheses were tested at alpha is equal to 0.05 level of significance. The results show that students taught using the CVMS had higher motivation and achievement than students taught using the traditional methods. The results also indicated that students' gender did affect achievement in Biology where girls performed better than boys. It is therefore concluded that CVMS is an effective approach in improving students' performance in Biology in secondary schools as well as reducing the gender disparity in achievement. This study recommends CVMS teaching method for adoption in Kenyan secondary schools.

LIST OF ABBREVIATIONS AND ACRONYMS

AIDS	Acquired Immunity Deficiency Syndrome
ALT	Academic Learning Time
BAT	Biology Achievement Test
BSCS	Biological Science Curriculum Study
FAO	Food and Agricultural Organisation
FAWE	Forum for African Women Educationist
FEMSA	Female Education in Mathematics and Sciences in Africa
HIV	Human Immuno-deficiency Virus
IQ	Intelligence Quotient
KCSE	Kenya Certificate of Secondary Education
KIE	Kenya Institute of Education
KNEC	Kenya National Examinations Council
SMASSE	Strengthening Mathematics and Science in Secondary Education
SMQ	Students' Motivation Questionnaire
SSP	School Science Project
SST	Stimulus Sampling Theory
UNICEF	United Nations International Children's Education Fund

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CHAPTER ONE:

INTRODUCTION

1.1 Background Information

Biological knowledge has made a lot of contribution to the welfare of mankind in various fields. Examples of these contributions are in the industry sector especially in beer brewing, mining, milk processing, bread making as well as waste disposal processes. Biological knowledge has also been widely used in medicine. For example it has made it possible for disease control and organ transplant to be done. In agriculture, biological knowledge has been used in plant breeding to produce high yielding and disease resistant crops and animals. Another area where biological knowledge has made a significant impact is that of population control (UNESCO, 1986; FAO, 1995). Biological knowledge has also enabled man to appreciate the essence of biodiversity and environmental conservation for sustainable development.

Biological knowledge provides students with valuable concepts, life skills and career options. It helps to give learners a greater appreciation for the world and it's inhabitants, problem-solving skills and research skills. Biology education contributes to society's development by helping students develop into more responsible citizens who would help to build a strong economy, contribute to a healthier environment and bring about a brighter future. The study of Biology in Kenya aims at equipping learners with knowledge, attitudes and skills necessary in controlling and preserving the environment. The main objectives for teaching biology in Kenyan secondary schools according to K.I.E. (2002): are to; accumulate biological information in a precise, clear and logical manner; develop an understanding of interrelationships between plants and animals and between humans and their environment; apply the knowledge gained to improve and maintain the health of the individual, family and the community; relate and apply relevant biological knowledge and understanding to social and economic situation in rural and urban settings; observe and identify features of familiar and unfamiliar organisms; record the observation and make deductions about the functions of the parts of organisms; develop positive attitudes and interest towards biology and the relevant practical skills; demonstrate resourcefulness, relevant technical skills and scientific thinking necessary for economic development; design and carry out experiment and project that will enable learners to understand biological concepts; create awareness of the value of co-operation in solving problems; acquire a firm foundation of relevant knowledge, skills and attitudes for further education and for training in related scientific fields.

Expository approaches cannot be relied upon to face the challenge of the new demands and objectives of Biology Education, there is need to consider using new approaches (UNESCO, 1986). Although biological knowledge is very crucial to the welfare of the people, Biology students perform poorly in national examinations in Kenya. Table 1 shows the national performance in Biology in KCSE for the period 2000 to 2006.

The mean score remained low over the period between 2000 and 2006. The best performance was in 2004 with a mean score of 35.26, while 2002 recorded the worst performance with a mean score of 26.46 (KNEC, 2004). Waihenya (2002) attributed low achievement to poor teaching methods, which lead to lack of mastery of the subject by students.

Table 1:

Student's Performance in KCSE Biology (2000-2006)

Year	No. of Candidates	Mean score (%)	Standard Deviation (S.D)
2000	109,414	31.89	18.80
2001	176,954	32.00	21.00
2002	177,251	26.46	18.72
2003	186,403	29.29	19.00
2004	200,797	35.26	17.45
2005	234,975	29.63	18.69
2006	217,675	27.42	20.20

Source: KNEC (2002 - 2007)

Student performance by gender for the same period is presented in Table 2. The results show that girls had a lower achievement in Biology as compared to boys during the same period.

Table 2:

Performance in KCSE Biology by gender

YEAR	MALE		FEMALE	
	No. of candidates	Mean score (%)	No. of candidates	Mean score (%)
2000	59,718	33.57	49,757	30.22
2001	91,525	34.48	85,499	29.52
2002	90,241	28.34	87,141	24.58
2003	95,295	31.35	91,108	27.23
2004	103,156	37.64	97,641	32.91
2005	121,370	32.01	113,605	27.24
2006	109,863	29.84	108,065	25.00

Source: KNEC (2002 - 2007)

Gender disparity in achievement is also supported by a research done by the Forum for African women Educationists (FAWE, 1999), aimed at improving the participation and performance of girls in science and mathematics in primary and secondary schools. The findings of the study revealed that the achievement of girls in science in Kenya was far lower than that of boys. This could be partly attributed to the poor attitude of girls towards science subjects and also to the teaching approaches used.

The students' performance at the Kenya Certificate of Secondary Education (KCSE) Biology examination in Uasin Gishu District (2001-2006) shows a drop in performance index from a mean of 5.4 out of 12 in 2001 to 4.9 out of 12 in 2006 as presented in Table 3. The data indicates a downward trend in the student performance within the specified period.

Table 3:

Uasin Gishu District KCSE Biology mean grades (2000-2006)

Year	No of candidates	Mean (Performance index)	Grade
2001	3,212	5.40	C- (minus)
2002	3,448	4.91	D+ (plus)
2003	2,907	4.97	D+ (plus)
2004	3,345	5.35	C-(minus)
2005	3,512	4.90	D+ (plus)
2006	3,462	4.88	D+ (plus)

Source; DEO, U/G District report on K.C.S.E results, 2007

The poor attitudes of girls towards learning of biology are partly due to teaching approaches used, which do not provide a conducive environment for them. Teachers do consciously and unconsciously discourage girls' participation in learning according to the Female Education in Mathematics and Science in Africa (FEMSA, 1997). The FAWE (1999) report also revealed 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 the FAWE (1998), Njuguna (1998) and SMASSE (2003), approaches used in teaching Biology have been identified as one of the factors contributing to poor performance in the subject. There are various teaching approaches that can be used in Biology. They include concept approach, problem-solving approach, inquiry and discovery approaches (UNESCO, 1986). However, most of the teaching approaches used in Kenyan schools are mainly expository and fact oriented. They encourage students to be passive listeners during the teaching-learning process (Kiboss, 1997). Teachers usually act as classroom presenters, exposing students to facts that they copy in their notebooks. Therefore, the role of the learners is to listen, to understand and then remember, for purposes of the examinations (Njuguna, 1998).

Studies on Concept mapping indicate the method can be used to overcome gender disparity in related performance in science (Kinchin & Ian, 2000). It is therefore, hoped that through the use of more interactive methods, teachers can encourage the students to be more motivated to study Biology (Kithaka, 2003). Novak, Gowin and Johansen (1984) investigated the effects of Concept mapping and Vee mapping strategies on achievement of learners in New York. They sought to determine whether Concept mapping and Vee mapping enhanced the learning of Biology. The results showed that there was improved performance and motivation in learning Biology at high school level. The maps were found to be useful in learning because they enhance learners understanding of meanings of concepts and their relationships.

Concept mapping and Vee mapping approaches are associated with meaningful and mastery learning. They enable students to identify the major concepts and relate them to the concepts in their existing knowledge structure (Novak et al, 1983; Kinchin, 2000). The learner therefore plays an active role in knowledge construction, which leads to meaningful learning. Concept mapping is a teaching approach where learners organize concepts and relationships between them in a hierarchical manner from more inclusive concepts to more specific and less inclusive concepts. While using this teaching/ learning approach, students identify major and more inclusive concepts at the top followed by the minor and more specific concepts at the bottom. The major and more inclusive concepts are referred to as super-ordinate concepts while minor and more specific concepts are called subordinate concepts. The super-ordinate and subordinate concepts are placed in ovals and then connected using suitable linking words.

Novak and Gowin (1983) investigated the use of concept mapping in the learning of Biology at high school level in the United States of America. His findings show that concept mapping has tremendous capacity to help learners to adequately cope with demands of learning the various science concepts. Orora, Wachanga and Keraro (2005) investigated the effects of using Cooperative Concept Mapping teaching approach on secondary school students' achievement in Biology. Their findings show that students exposed to CCM approach have significantly higher achievement than those taught through regular methods. In another study, Keraro, Wachanga and Orora (2007) investigated the effects of concept mapping teaching approach on students' motivation in learning Biology. Their findings showed that students exposed to concept mapping teaching approach were highly motivated to learn Biology.

Vee mapping is another teaching approach where students use a V-shaped map to represent key elements (ideas) that are contained in the structure of knowledge. The key elements usually referred to as the Vee heuristics form the point of focus in knowledge creation in the objects or events that learners observe (Gowin, 1977). The Vee map has two sides. The left hand side represents the theory and is referred to as the conceptual side. It outlines the philosophy, theories, principles and concepts that guide learners in selecting or constructing objects or events to be observed in the learning process. The right hand side represents the methodology, often referred to as methodological side. The right side highlights the knowledge and value claims as well as data recording and transforming procedures. Placed in the middle of the Vee map is the focus question and events or objects to be observed in the learning process.

The central idea in using a Vee map is that every element shown is interdependent with every other element on the Vee. The fundamental assumption is that knowledge is not absolute, but rather it is dependent upon the concepts, theories and methodologies by which we view the world. This assumption is supported by several views of epistemology (Toulmin, 1953). Vee maps foster interplay between conceptual and methodological elements and the resultant knowledge or value claims. The knowledge claims are integrated into an individual's cognitive meaning frameworks. Novak (1983) and his team carried out a study on the use of Vee mapping in learning Biology at high school level. The study was done simultaneously with that of concept mapping. The findings of the study revealed that most students were relatively successful in using the Vee maps and that performance improved. This can be attributed to the fact that Vee-mapping helps the students to sort out events or objects under study, key questions being addressed, major claims derived from the records or transformed records and the consistency between concepts, principles, records, events or objects and the stated claims. Therefore, concept mapping and Vee mapping are tools that would aid pedagogy that derives from recent advances in educational theory (Novak, 1977; Gowin, 1979). The advances in other fields require the professional teachers to know the theory underlying the tools in order to employ them most successfully.

Concept and Vee mapping strategy (CVMS) constitutes a composite of two teaching approaches namely concept mapping and vee mapping. Use of CVMS is likely to motivate students and thus improve on their achievement. This study investigated the effect of using Concept mapping and Vee mapping as a teaching approach on students' motivation and achievement in school Biology in selected schools in Uasin Gishu District.

1.2 Statement of the Problem

The overall performance in Biology at the Kenya Certificate of Secondary Education (KCSE) in Kenyan secondary schools has been poor for the period 2000 to 2006. The low achievement has been attributed to teaching methods that are largely expository. Concept mapping and Vee mapping strategy (CVMS) may help improve students' achievement. This study, therefore, was set to investigate the effects of using concept mapping and Vee mapping teaching strategy for teaching on students' achievement and motivation in secondary school Biology in Uasin Gishu district, Kenya.

1.3 Purpose of Study

The purpose of this study was to design a CVMS teaching program and measure its effects on the students' achievement and motivation in Biology in mixed provincial secondary schools in Uasin- Gishu District, Kenya. It also sought to compare boys and girls' achievement and motivation when taught using the Concept and Vee Mapping teaching strategy and the traditional approaches. From the documented literature, the effects of using CVMS on students' achievement and motivation have not been investigated in Kenyan schools and particularly in Uasin-Gishu District.

1.4 Objectives of the Study

The specific objectives of the study were:

1. To compare the effects of traditional teaching methods with Concept and Vee mapping strategy on students' achievement in Biology.
2. To compare the level of motivation of students' taught using Concept and Vee mapping and those taught using the traditional approaches.
3. To determine whether there is gender difference in achievement when students' are taught using the Concept and Vee mapping teaching strategy.
4. To determine whether there is gender difference in motivation when students' are taught using the Concept and Vee mapping teaching strategy

1.5 Hypotheses

The following null hypotheses were tested in this study:

H_O1 There is no statistically significant difference in achievement in Biology between students' taught using the Concept and Vee mapping teaching strategy and those taught using the traditional methods.

H_O2 There is no statistically significant difference in the level of motivation between students' taught using Concept and Vee mapping teaching strategy and those taught using traditional methods.

H_O3 There is no statistically significant gender difference in achievement when students' are taught using Concept and Vee mapping teaching strategy.

H_O4 There is no statistically significant gender difference in motivation to learn biology when students' are taught using Concept and Vee mapping teaching strategy.

1.6 Significance of the Study

It is expected that findings of this study may boost Government efforts directed towards improving Biology education in Kenyan secondary schools. The findings of this study may be useful to the following institutions, and groups of people:- First; The Kenya Institute of Education (KIE) in reviewing and reorganizing the secondary school Biology syllabus. The findings may thus, help in preparing learning materials to support the curriculum. This includes class textbooks, revision books and teacher guides. Secondly, Kenyan Universities and Teachers Training Colleges charged with the task of training and producing effective Biology teachers.The findings may help these institutions develop programs aimed at producing teachers who are capable of making students to be active participants in class instead of being passive recipients of knowledge. Third; it may help teachers in designing and adapting appropriate instructional strategies that will foster learning of biology concepts and science process skills by secondary school learners.

1.7 Scope of the Study

The study focused on Form two students in provincial mixed schools in Uasin Gishu District of the Rift Valley province of Kenya. It focused on the topic 'Respiration' since it is taught at this level of secondary school Biology (KIE, 2002) and it is considered by teachers and learners to be difficult (KNEC, 1996; SMASSE, 2003). Uasin–Gishu District was chosen for the study because it has posted poor results in the subject in the recent past (Ministry of Education, KCSE examination report, 2004). Besides, the area has many schools from which a representative sample for the study was drawn.

1.8 Limitations of the Study

To avoid bias and minimise the sampling error, students were supposed to be randomly assigned to the four groups. However, the schools' administration could not allow such rearrangements. The stream that had recorded the highest mean score in achievement test was chosen for the study from schools that had more than one form two classes.

1.9 Assumptions of the Study

This study assumed that the learners in both experimental and control groups are comparable in terms of learning abilities because they had the same admission criteria. Besides, it was assumed that the school learning environment in both experimental and control groups was comparable because they all (experimental schools) are in the same category. It was also assumed that the stream with the highest meanscore in previous examinations was relatively homogenous.

1.10 Definition of Terms

Achievement means learner's performance as indicated by the scores obtained in the Biology Achievement Test (BAT) on the topic respiration. The test contained questions on the meaning and significance of respiration, respiratory substrates, aerobic and anaerobic respiration, role of enzymes, respiratory quotient and factors affecting respiration.

Concept mapping is a classroom activity, which involves making of a diagrammatic representation of the relationship between the superordinate (major) concept and the subordinate (minor) concepts in hierarchical order.

Traditional teaching approach is the kind of teaching that is characterized by predominance of teacher talk with little or no involvement of students in practical activities. It is a teacher centred approach, where the teacher exposes facts, explains concepts and gives illustrations as in lecture & teacher demonstration. Student participation is limited to listening, answering and asking questions and writing notes as the lesson progresses. This approach includes, lecture, discussion, demonstration, class experiments and field work teaching methods.

Meaningful learning is one in which the information is understood very well by the learner because conceptual meaning of the new information is clear and new knowledge is linked to related concepts already familiar to the learner. It means learning with understanding.

Motivation means built-in desire by the student to want to learn Biology as measured by the scores obtained from the Students Motivation Questionnaire (SMQ). The items on the questionnaire sought to establish the level of student competence, interest, satisfaction and appreciation of Biology.

Vee Mapping is a learning activity that involves making of a V – shaped representation with two sides namely the theoretical (thinking side) on the left and methodological (doing side) on the right. The left hand side outlines the theory, principles, constructs and relevant concepts that constitute the prior knowledge of the learner (what the learner knows). The right hand side outlines value claims, knowledge claims (facts), transformations and records that shows how to carry out a learning task for example an experiment in order to answer the focus question (see Appendix F).

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The previous chapter set out the context of the research problem that was investigated. This chapter reviews literature relevant to the research problem. The literature review focuses on issues in science education and Biology education in society. It also reviews Biology curriculum and the state of Biology teaching in Kenya. It includes literature on research findings on Concept Mapping and Vee Mapping strategies on students' achievement and motivation. Students' performance in science subjects in Kenya, gender disparities in science subjects and the issue of motivation are also discussed. The last section of this chapter discusses the conceptual framework that guided the study.

2.2 Issues in Science Education

Good science education is important for every learner because understanding how science is part of our daily lives can help them have a strong foundation for success in life. Science Education feeds the curiosity of learners and provides them with valuable concepts, life skills, and career options. Science helps to give learners a greater appreciation for the world and it's inhabitants, strong problem-solving skills and research know-how (Nola, 1997). A good science education benefits society by helping students develop into more responsible citizens who would help to build a strong economy, contribute to a healthier environment, and bring about a brighter future for the society. The issue of standards for students learning is therefore crucial because all students deserve to receive high-quality science education. Poor performance of students in national and school examinations provides alarming evidence that most of our students are not being prepared for a world that is shaped by science and technology (Pepin, 1998).

Studies indicate that to learn science effectively, students must compare their own ideas about how things work with experiments and from reading about and discussing, their ideas with their peers and their teachers. But that is not what happens in the classroom (Suchting, 1997). According to Pepin (1998), a good science education encourages students to ask questions, make observations, collect evidence, and develop explanations. It builds on previous knowledge and skills. Therefore, current issues in science education include standards, testing, teacher quality and teaching approaches.

This study aimed at addressing some of these issues using the Concept and Vee Mapping teaching strategy. The strategy is modelled in a way that encourages students' active participation in the learning process by being involved in designing teaching materials.

2.3 Variables affecting students' achievement

Many researchers have tried to put together classroom or school –based models that describe the teaching-learning process. A model is a visual aid or picture, which highlights the main ideas and variables in a process or a system. The models presented in this section include words or diagrams intended to give an understanding of the variables associated with school learning, especially as measured by scores on standardized tests of basic skills. The main models discussed and compared are by Carroll (1963), Proctor (1984), Cruickshank (1985), Gage and Berliner (1992) and Huitt (1995).

The question one would ask is, "Why do some students learn more than others?" Unfortunately the possible answers to this question are enormous. More often than not, research findings and theories of teaching and learning seem to contradict one another. The models described in this chapter have been used extensively in Educational Psychology to help clarify some of the answers that researchers have found that might shed light on such questions as, "How do students learn effectively?" or "What happens in a classroom that facilitates learning better than in another classroom?"

2.3.1 John Carroll's Model

Most current models that categorize the variables or explanations of the many influences on educational processes today stem from Carroll's (1963) article defining the major variables related to school learning. Carroll specialized in language and learning, relating words and their meanings to the cognitive concepts and constructs which they create (Klausmeier & Godwin, 1971).

In this model, Carroll states that time is the most important variable to school learning. A simple equation for Carroll's Model is:

School learning = f(time spent/time needed). Carroll explains that time spent is the result of opportunity and perseverance. Opportunity in Carroll's Model is determined by the classroom teacher; the specific measure is called allotted or allocated time. That means time allocated for learning by classroom teachers. Perseverance is the student's involvement with academic content during that allocated time. Carroll proposed that perseverance be measured as the percentage of the allocated time that students are actually involved in the learning process and was labelled engagement rate. Allocated time multiplied by engagement rate produced the variable Carroll proposed as a measure of time spent, which came to be called engaged time or time-on-task.

Carroll (1963) proposed that the time needed by students to learn academic content is contingent upon aptitude (the extent to which they possessed pre-requisite knowledge), and the quality of instructions students receive in the learning process. Carroll proposed that these specific teacher and student behaviours and students' characteristics were the only variables needed to predict school learning. The author did not include the influence of family, community, society and the world that other authors discussed below have included.

The principles of this model can be seen in Bloom's (1976) Mastery learning model. Bloom, a colleague of Carroll, observed that in traditional schooling, a student's aptitude for learning academic material (IQ) is one of the best predictors of school achievement. His research demonstrated that if time is not held constant for all learners (as it is in traditional schooling) then a student's mastery of the prerequisite skills, rather than aptitude, is a better predictor of school learning. Mastery learning's best principle is that almost all students can pass examinations with grade A if they are given enough time to learn normal information taught in school and are provided quality instruction. By quality instructions Bloom meant that teachers should:-

1. Organize subject matter into manageable learning units.
2. Develop specific learning objectives for each unit.
3. Develop appropriate formative and summative assessment measures, and
4. Plan and implement group-teaching strategies, with sufficient time allocations, practice opportunities, and corrective re-instruction for all students to reach the desired level of mastery.

The John Carroll's Model emphasises the importance of time allocation and management for effective learning. This study recognises the importance of time management and allocates time appropriately for the teacher to introduce the topic, having a discussion session, involving students in developing concepts and vee maps and presenting the same before the entire class. Each of these sessions is given specific time.

2.3.2 Proctor's Model

Prior to the sixties the research on important school and classroom related variables was directed toward the best traits or characteristics of teachers in an attempt to identify good teaching and the important characteristics of schools and communities that support good teaching. Proctor (1984) provides a model that updates this view including important teacher and student behaviours as determinants or predictors of student achievement. It is derived from other teacher and classroom based models but it is redesigned to emphasize teacher expectations. Proctor states that it is possible for a self-fulfilling prophesy (as researched by Rosenthal & Jacobson, 1968) to be an institutional phenomenon and the climate of a school can have an effect on the achievement of it's learners. The attitudes, the norms and the values of the school and staff can make a difference in achievement test scores. The paradigm most influencing Proctor's Model is that of a social nature and not of a teacher/student, one-on-one relationship. The other models include the variables that provide the focus for this model, but show these variables in a more subordinate manner.

Proctor's (1984) Model begins with the factor of the school's social climate. Some of the variables included in this would be attitudes, norms, beliefs and prejudices. This school climate is influenced by a number of factors, including such student characteristics as gender, economic level, race and past academic performance.

The student characteristics also influence teacher attitudes and efficacy. Latter studies support Proctor's (1984) position that student self-image and behaviour are affected by teacher efficacy (Ashton, 1984; Woolfolk & Hoy, 1990).

The next category of variables is the interaction among the individuals involved in the schooling process. This includes the inputs of the administrators as well as that of teachers and students. If expectations of learning are high (that is, the school has good, qualified teachers and students who can learn) and there is high quality instructional input, corrective feedback, and good communication among students, parents and educators, then the intermediate outcomes of student learning and student self-expectation goes up. On the other hand, adverse or negative attitudes on the part of instructors and administrators will cause student self-esteem, and consequently, student achievement to drop.

The interactions in Proctor's (1984) Model include the school's overall policy on allowing time for children to learn or promoting other forms of student-based help when needed. This could include the school's overall policy on allowing time for children to learn or promoting other forms of student-based help when needed. This could include quality of teaching (Carroll, 1963) or teacher classroom behaviours (Cruickshank, 1985) models. These behaviours have an effect on student classroom performance (especially academic learning time and curriculum coverage) and self-expectations.

Finally, the student's achievement level in Proctor's (1984) Model is an outcome of all previous factors and variables. It is hypothesized that there is a cyclical relationship among the variables. In Proctor's Model, the main concept is that achievement in a specific classroom during a particular school year is not an end in itself. It is re-filtered into the social climate of the school image and the entire process begins all over again. Proctor's Model implies that change can be made at any point along the way. These changes will affect school achievement, which will continue to affect the social climate of the school.

One major aspect that this study borrows from the Proctor's model is the importance of teacher student interaction in the learning process. The Concept and Vee Mapping strategy ensures that teachers interact fully through discussion and development of Concept and Vee maps.

2.3.3 Cruickshank's Model

The model by Cruickshank (1985) is more classroom and teacher-based. Models created by Mitzel and Biddle (1964) heavily influenced him. The models contributed the concept of classifying variables as "product, process, or presage" (Cruickshank, 1985). Product is learning on the part of the student (change in behaviour or behaviour potential) while process involves interaction between student and teacher. Presage is the teacher's intelligence, level of experience, success and other teacher characteristics. Presage is supposed to affect process and then, of course, process will affect the product.

Biddle and Ellena (1964), showed a relationship between specific learning activities and teacher effects. In his model, Biddle offers seven categories of variables related to schooling and student achievement. These variables include school and community contents, formative experiences, classroom situations, teacher properties, teacher behaviours, intermediate effects and long-term consequences.

Biddle also contributed a model of the transactional process of the classroom by analysing the structure and function of the communication process. This provides the foundation for Cruickshank's model of 1985.

This study's approach, Concept and Vee Mapping, fits within the product, process and presage stages of learning recommended by Cruickshank's model. At the discussion and development of Concept and Vee maps, the student actively interacts with the teacher. This would be likened to the process stage of the Cruickshank's model. After the concept and vee maps are developed and presented by the students the teacher makes concluding remarks akin to the presage stage of the Cruickshank's model.

2.3.4 Gage and Berliner's Model

Gage and Berliner (1992) developed a model of the instructional process that focuses on these variables that must be considered by the classroom teacher as he/she designs and delivers instructions to students. This model attempts to define more precisely what is meant by "Quality teaching" and presents five tasks associated with the teaching/learning process. In this model, a teacher begins with objectives and ends with an evaluation. Instruction connects objectives and evaluation and is based on the teacher's knowledge of the students' characteristics and how best to motivate them. If the evaluations do not demonstrate that the desired results have been achieved, the teacher re-teaches the material and starts the process all over again. Gage and Berliner suggest that the teacher should use research and principles from educational psychology to develop proper teaching procedures to obtain optimal results.

In the Concept and Vee Mapping Strategy used in this study, the teacher listens to the students' presentations of the Concept and Vee Mapping. Upon his evaluation of how the students have mastered the subject, he makes concluding remarks.

2.3.5 Huitt's Model

Huitt (1995) identifies the major categories of variables that have been related to school achievement. The model is not only school–classroom–teacher and student-based, but includes additional contextual influences as well. Huitt's Model attempts to categorize and organize all the variables that might be used to answer the question "why do some students learn more than other students?" This is a revision of a model by squires, Huitt and Segars (1983), which focused only on those variables thought to be under the control of teachers. This earlier model focused on school and classroom level processes that predicted school learning as measured on standardized tests of basic skills. One important addition in this Model is the redefinition of Academic learning time. It had long been recognized that Carroll's conceptualisation of time spent measured the quality of time engaged in academics, but was lacking in terms of the quality of that time. As discussed in Proctor's (1984) Model, Fisher and his colleagues (1978) had added the concept of success as an important component of quality of time spent and coined the term Academic Learning Time (ALT) that they defined as "engaged in academic learning at a high success rate." Brady, Clinton, Sweeney, Peterson and Poynor (1977) added another quality component, the extent to which content covered in the classroom overlaps the content tested, which they called content overlap. A more inclusive definition of ALT was proposed by Caldwell, Huitt and Graeber (1982) – "the amount of time students are successfully engaged on content that will be tested.

Huitt (1995) advocates that important context variables must be considered because our society is rapidly changing from an agricultural/industrial base to an information base. From this perspective, children are members of a multi-faceted society, which influences and modifies the way they process learning as well as defines the important knowledge and skills that must be acquired to be successful in that society. Huitt's Model shows a relationship among the categories of context (family, home, school and community environments, input (measures of learning done outside of the classroom process), classroom processes (what is going on in the classroom) and output (measures of learning done outside of the classroom). This model shows input and output as the beginning and end of the teaching/learning process. Huitt believes that teachers must first identify or propose an end result (as stated by Gage and Berliner, 1992) because how you identify and measure the end product (output) will influence the selection of important predictor variables. Once the outcome measures are selected, teachers can begin to focus on those variables that can explain fluctuation or variability in those measures. Changing specific objectives may change the predictor variables from each of the other three categories. Thus the output or outcome category is the most important and the focus of Huitt's Model.

In Kenya, the most often cited output measures are scores on standardized tests of basic skills. However, student achievement in basic skills is not the only desired outcome of the Kenyan education. The student is also expected to obtain important skills that would be used in his daily life after school.

Huitt (1995) supports Proctor's (1984) position that intermediate outcomes or more specifically Academic Learning Time (ALT) is one of the best classroom process predictors of student achievement. Accordingly, if an objective or topic is not taught, it is not likely to be learned and therefore a teacher cannot expect students to do well on measures of it's content. In fact, to the extent content is not specifically taught, the test becomes an intelligence task rather than an achievement test. The fact that many teachers do not connect instructional objectives to specific objectives that will be tested (Braddy et al, 1977) is one reason that academic aptitude or IQ is such a good predictor of scores on standardized tests. Both tests measure the same construct: the amount of general knowledge an individual has obtained that is not necessarily taught in a structured learning setting.

The second component of ALT is student involvement. If the students are not provided enough time to learn material or are not actively involved while teachers are teaching, the students are not likely to do well on measures of school achievement. The last element is that of success, defined as "the percentage of class work that students complete with a high degree of accuracy.   Thus, if a student is not successful on classroom academic tasks, that student will likely not demonstrate success on the achievement measures.

Huitt (1995) proposes that these three components of Academic Learning Time should be considered as the "vital signs" of a classroom. What teachers and students do in the classroom will depend to some extent on the characteristics or qualities they bring to the teaching-learning process. If a teacher believes that, in general, students can learn the knowledge or skills, and that, specifically he can teach them, then that teacher is more likely to use the knowledge and skills he has and the students are more likely to learn.

A second subcategory of input is student characteristics. This includes all the descriptions of students that might have an influence on the teaching learning process and student outcome. These include; study habits; learning styles; age; sex/gender; race/ethnicity; motivation; and moral, socio-emotional, cognitive and character development. All the factors are important in the relationship of classroom processes and school achievement (Huitt, 1995). However, student aptitude and/or pre-requisite skills are probably the best student characteristic predictors (Bloom, 1971). This supports the idea that the teacher can arrange teaching-learning process and modify each student's experience. This results in different outcomes, which in turn becomes the input for the next learning cycle.

Finally, Huitt (1995) includes the category of context that includes such sub-categories as school processes and characteristics, family, community, the state, media and the global environment. For example, research shows that student achievement is impacted by class size (Bracey, 1995) and school size (Fowler, 1995). Mother's education and family expectations for student's achievement have been shown to be excellent predictors of student achievement (Campbell, 1991).

In conclusion, each of the models discussed identifies important factors related to school learning and contribute important information concerning why students learn more than others. Over a period of years, the models have been examined, reviewed, revised and edited to fit into today's modern society. Beginning with Carroll (1963) and ending (at least as far as their review is concerned) with Huitt (1995), it is clear that teachers and school systems, families, communities and entire countries having an influence on students' school learning. None of these variables appears influential that we need to pay attention to that particular factor in order to produce the kinds of educational changes we desire.

Understanding all the variables and relationships among each other and how they influence learners' success may be more than we can expect of any teacher. The significance of the entire process may never be fully grasped but we can make every effort to understand as much as possible as we develop appropriate teaching/learning methods. We can also identify the most important variables within a category or subcategory and make certain we attend to a wide variety of variables across the model. Models are useful tools to better understand not only the learning process of students, but also useful for teachers. These models have been carefully studied and provide useful inputs the Concept and Vee Mapping strategy that was development and tested in this study.

2.4 Theories of Learning

Learning is the process by which a relatively lasting change in potential behaviour occurs as a result of practice or experience. Three models are currently widely used to explain changes in learned behaviours. While two emphasize the establishment of relations between stimulus and response, the third emphasizes the establishment of cognitive structures. Bandura (1977) maintained that learning occurs through observation of others or models. The learning models are consistent with the theories that attempt to explain the occurrence of learning phenomena. In this literature review a few learning theories have been considered which includes the following:

2.4.1 Stimulus Sampling Theory (SST)

The Stimulus Sampling Theory (SST), first proposed by Estes in 1950, was an attempt to develop a statistical explanation for learning phenomena. The theory suggested that a particular stimulus-response association is learned on a single trial. However, the overall learning process is a continuous one consisting of the accumulations of discrete stimulus-response (S-R) pairings. On any given learning trial, a number of different responses can be made but only the portion that are effective (rewarded) form associations. Thus, learned responses are a sample of all possible stimulus elements experienced. Variations in stimulus elements are due to environmental factors or changes in the learner (Norman, 1982). Most research on SST was conducted using probability or verbal learning experiments, limiting it’s application to other types of learning. Furthermore, SST did not really take into account cognitive strategies used by participants in these experiments, which could affect the results. According to this theory, the overall learning process is gradual and cumulative. Fluctuations in environmental and internal factors will cause variability in learning progress.

2.4.2 Modes of Learning

Rumelhart & Norman (1978) proposed that there are three modes: accretion, structuring and tuning. Accretion is the addition of new knowledge to existing memory. Structuring involves the formation of new conceptual structures or schema. Tuning is the adjustment of knowledge to a specific task usually through practice. Rumelhart and Norman later extended their model to include analogical process: a new schema is created by modelling it on an existing schema and then modifying it based upon experiences. Rumelhart & Norman further suggested that teaching should be designed to accommodate different modes of learning, concluding that practice activities affect the refinements of skills but not necessarily the initial acquisition of knowledge. A number of learning theories emphasize the importance of learning strategies (Ausubel, 1968). This refers to methods that students use to learn. This ranges from techniques for improved memory to better studying or test-taking strategies.

2.4.3 Repair Theory

Repair Theory is an attempt to explain how students learn procedural skills with particular attention to how and why they make mistakes. It was proposed by Vanlehn (1990), who suggests that once the errors associated with a particular task are known, they can be used to improve student performance and the examples used to teach the procedure. The theory assumes that people primarily learn procedural tasks by induction and that errors occur because of biases that are introduced in the examples provided or feedback received during practice. The implication of this theory is that mistakes are often introduced when students try to extend procedures beyond the initial examples provided. Repair theory applies to any procedural knowledge.

However, the learning theories so far discussed do not make assumptions about the nature of memory but do specify how information should be organized for optimal learning. The constructivist theory attempts to fill that gap hence need to briefly discuss it.

2.4.5 The Constructivist Theory of Learning

Constructivism is undoubtedly a major theoretical influence in contemporary science education. Although constructivism began as a theory of learning, it has progressively expanded its dominion, becoming a theory of teaching, education, origin of ideas and a theory of both personal and scientific knowledge. According to Bell (1991) constructivism holds a promise of educational objectives other than those associated exclusively with cognitive development. It is a postmodern theory of knowledge.

Constructivism is thought to be a superior position to its rivals in learning theory and pedagogy. It offers teachers a moral imperative for deconstructing traditional objectivist conceptions of the nature of science and knowledge, and for reconstructing their personal epistemologies, teaching practices and educative relationships with students' (Lorsbach &

Tobin, 1992). Learning science is identified with ‘constructing personal meaning’. In fact, there is a widespread sense that constructivism will lead teachers, students and researchers out of the wilderness and into the educational promised land. It attempts to give scientific guidance on human learning and the process of knowledge production; and philosophical guidance about the epistemological status of what is being learned, especially the nature of scientific knowledge claims (Kilpatrick, 1987). According to Mathews (1998), constructivism is meant to connect with the reality of human cognitive processes and thus guide affective teaching and learning across the curriculum in science and even other subjects.

The constructivist epistemology asserts that the only tools available to a learner are the senses. It is only through seeing, hearing, touching, smelling and testing that an individual interacts with the environment. With these messages from the senses the individual builds a picture of the world. Therefore, constructivism asserts that knowledge resides in individuals (Lorsbach & Tobin, 1992). Osborne and Freyberg (1985) argue that knowledge is acquired not by the internalization of some outside given facts but is constructed from within. The role of the teacher therefore is to help students learn how to learn (Glasersfeld, 1995). This can be achieved by the teacher being a learner too, ensuring equity for all students, creating a friendly, supportive learning environment, providing learning opportunities, listening to students, using students’ ideas, experiences and interests, challenging sensitively the ideas of students, providing resources to help students learn, ensuring students communicate in a variety of modes, identifying and nurturing the scientific talent and interest of all students. This includes all things that the teacher needs to do besides knowing the subject matter to be taught, and being able to teach it in a clear, engaging and understandable manner. Some prominent constructivist, argued that ‘although the research on alternative conceptions has sparked interest in content, it has not yielded clear advice about how to teach different topics (Fensham, Gunstone & White, 1994). Many science educators are interested in finding out how, on constructivist principles, one teaches a body of scientific knowledge that is abstract and not experiential and has no connection with prior conceptions. Researchers such as Richard White asserts that teaching a body of knowledge involves not just teaching the concepts but also the method. Learners need to be given access not only to physical experiences but also to the concepts and models of traditional science (Driver et’al, 1994). According to Driver et al, the challenge for teachers lies in helping learners to construct these models for themselves, to appreciate their domains of applicability and, within such domains, to use them. It can thus be concluded that teaching is meant to lead learners towards traditional science and the teachers intervention is essential, both through providing appropriate experiential evidence and making theoretical ideas and conventions available to students.

However, a practical and significant consideration is that science teachers are overwhelmed by challenges such as students' lack of interest in science, teachers' inadequate knowledge of science, schools' lack of resources and society's lack of interest in education. Constructivism has done a service to science education: by alerting teachers to the function of prior conceptions in the process of learning new material, by stressing the importance of understanding as a goal of science instruction and by fostering students' engagement in lessons. Given the influence of constructivism on education reform, teacher education, curriculum development and pedagogy, it is important to understand the epistemological commitments of constructivism and the relationship of these commitments to classroom practice. Therefore, the theoretical framework of this research was based on the constructivist theory of learning.

2.5 Biology Education in Society

Biology is the field of science that deals with the study of living things and how they relate to each other and with their environment. The history of Biology is as old as the history of man. Early man must have had some knowledge of the animals and plants around him. His very survival depended upon the accurate recognition of non-poisonous food plants and upon an understanding of the habitats of dangerous predators (Starr, 1991). According to Starr, the history of Biology begins at the time when man had not begun to write and to keep records.

Biological knowledge has had a wide range of applications throughout the centuries aimed at addressing welfare of the human race. It was used in the ancient Chinese civilization (5,700 – 3,600BC) in the battle against disease (Starr, 1991). The ancient Chinese not only utilized the silkworm, *Bombyx mori*, to produce silk for commerce but also understood the principle of biological control, employing one type of insect, an entomophagous (insect–eating) to destroy insects that bored into trees (Huff, 1995; Toulmin, 1953). In the Mesopotamia civilization (2,000 – 1595 BC) the Babylonians had good knowledge of anatomy and physiology. They also had knowledge of surgery and even performed delicate eye operations. Biological knowledge was utilized in the ancient Egyptian civilization (3,000 –

1,000 BC) to advance medical practices such as surgery, production of therapeutic drugs and preservation of dead bodies (Huff, 1995).

Many centuries passed before the Greek philosophers established the science of Biology around 600 BC (Encyclopaedia Britannica, 1998). They also developed Biological nomenclature until the 12th century AD when Botany was developed from the study of plants and similarly zoology was developed from veterinary medicine. According to the Encyclopaedia (1998), further advances in Biology came during the period of Renaissance (1400 – 1500 AD) and included the development of botanical nomenclature and discovery of homologous structures. Advances in Biology in the 20th century included the establishment of scientific societies for dissemination of ideas in addition to progress in the development of the microscope that has had far reaching effects in the advancement of Biology.

Today, Biological knowledge is applied in various fields such as health and nutrition. Biological knowledge has been used widely in medicine to control disease and pests. In environmental conservation, it has enabled man to appreciate the essence of biodiversity for sustainable development. It has been used in agriculture in plant and animal breeding in order to produce high yielding and disease resistant crop varieties and animal breeds respectively. Another important area is industry where Biological knowledge has been applied in processes such as mining, bread making, beer brewing, milk processing as well as waste disposal. Biology has also been useful in the fields of forensic science and population control (Brown, 1995). This indeed, partly justifies the inclusion of biology as one of the core science subjects of secondary school curriculum in Kenya (Cheloti, 1996).

2.6 Biology Curriculum in Kenya

Biology enables the learner to appreciate humans as part of the broader community of living organisms. It is a precursor of biotechnology, which is a tool for industrial and technological development. The content of Biology syllabus has been organized to ensure that the required concept and skills are realized (KIE, 2002). Sufficient practical activities have been suggested for teaching alongside the respective content rather than being treated as a separate entity. Also incorporated are contemporary issues such as HIV/AIDS, Sexually Transmitted Diseases, drug abuse and environmental pollution, which have an impact on the learners' lives. The syllabus is expected to be adequately covered within a period of four years, based on the guideline on time allocation per topic, to help the teacher in lesson planning. Finally, KIE (2002) recommended that to achieve the objectives of the subject, the teachers should use methods, which enhance active participation of learners in the teaching process.

2.7 State of Biology teaching in Kenya

Educationists all over the world have been struggling to develop methods that can optimise the attainment of teaching and learning objectives (Kithaka, 2003). In order to enhance teaching/learning, a teacher must make use of effective teaching strategies and methods (Kerlinger, 1983). Teaching methods may be defined as a way of carrying out actual teaching in the classroom. They are the means by which the teacher attempts to impart the desired learning or experience (Cheloti, 1996).

The goal of teaching Biology is that the students may gain knowledge, skills, deepening of understanding, and development of problem solving ability or change of perception, attitudes, values and behaviours K.I.E (2002). A variety of teaching methods and strategies can be used in the teaching of Biology. Teaching methods are grouped into three major categories namely; learner centred, teacher centred and teacher-learner centred (Ondiek, 1986; Shiundu & Omulando, 1992). The traditional teacher centred methods are the commonly used in secondary schools in Kenya (Waihenya, 2002). They include lectures, teacher demonstration, discussion, fieldwork, practical work and project work.

Strengthening Mathematics and Science in Secondary Education (SMASSE) project was conceived as an intervention measure to enhance the learning of mathematics and sciences. In order to identify the root cause of poor performance, a survey was carried out in 1998 in nine pilot districts in Kenya with the aim of identifying and determining the needs of Biology education in secondary schools (SMASSE, 2003). The purpose of the survey was to obtain information on; teachers and students attitude towards Biology, approaches and methods used in teaching, topics and sub-topics that were considered difficult to teach/learn and management of learning resources in the teaching of Biology. The results of the project revealed weaknesses, which included: use of teacher centred approaches and methods in teaching of biology; certain topics in the syllabus that teachers found difficult to teach and learners found difficult to comprehend were identified. Some of the topics were respiration, evolution and ecology among others. Poor planning and/ or lack of planning for the lessons was evident from the way teaching was being carried out.

One reason given to explain why some topics were difficult to teach /learn, was the minimal opportunity the learners had to relate what they learn in the classroom to real life situation. Therefore, on the basis of this survey, the SMASSE Biology team saw the need to enhance competence of Biology teachers through improvement of teaching methodology. Achievement in biology subject could improve if Biology teachers adopt innovative teaching strategies, which would ultimately cultivate a positive attitude change among the learners (Kithaka, 2003). A brief summary of the teacher centred methods is as follows:

2.7.1 The Demonstration Method

The purpose of a demonstration is to provide a means by which the teacher can explain or clarify certain parts of the content quickly and economically. For example, it can be demonstrated that seedlings exposed to unilateral source of light bend towards the light (Cheloti, 1996). Cheloti further suggests that students can get actively involved through questioning as the demonstration progresses, recording observations and discussing the results. Teacher demonstrations can be used to explain an experimental set before the students begin to set up their own apparatus for individual or group activities. According to Ondiek (1986), this method is especially useful when the apparatus and materials to be used are not enough for the whole class or when the materials are too dangerous or the equipment is too delicate to be entrusted to the students. It is also good for verification of observed phenomena or trend of data. However, the major disadvantage of this method is that it cannot be effective if the teacher does not involve pupils appropriately during the demonstration (Shiundu & Omulando, 1992).

2.7.2 Lecture Method

This involves giving factual information with very little or lack of participation from the learners. This method is considered outmoded due to a number of reasons that include failure to offer training for the attainment of scientific skills, content taught is quickly forgotten, and boring especially if lengthy and if the teacher lacks appropriate communication skills.

However, this method is most effective for transmission of large amounts of subject matter. In spite of this criticism, this method is still very useful as an instructional technique as long as it is used appropriately (Oluoch, 1982). Oluoch argues that it is an economic way of transmitting information to a large number of pupils because it does not need a lot of facilities. It also enables the teacher to present information in a logical and coherent order in a short time.

2.7.3 Discussion Method

This method allows students to share their ideas. The role of the teacher is to guide the discussion. It can be used at the beginning of a topic to ascertain students' preconceived notions of the subject matter or towards the end of a topic by presenting students with a new situation and asking them to explain it in terms of what they have just learned. However, discussion in groups might not have much value unless it is followed by presentation of reports (Cheloti, 1996).

Discussion can be done in small manageable groups or as a whole class. If discussion is done in small groups then there is need for a group leader to guide the discussion and one to write the main points to be presented in a report. The topic of discussion should be made clear to the group members or class prior to the sessions. To make the discussions meaningful, students should be encouraged to present their work in a plenary session.

Discussion as a method is accredited for among other merits; widening the learners thinking, building self-confidence, providing feedback, ensures active participation of the learners and develops communication skills. It also creates class cohesiveness and develops students' independence from the teacher. However, discussion as a method is known to discourage weak students and encourage laziness in subject teachers. It is also time consuming.

2.7.4 Practical Work (Class experiment) Method

This involves teaching/learning activities conducted by the students under the guidance/supervision of the teacher (Bennet , Foreman & Higgins, 1996). The teacher provides the students, either singly or in groups, with the materials and apparatus as well as the instructions to be followed in performing the activities. According to Hohn (1995), two basic skills are required in order for students to carry out practical work safely and successfully. They include ability to read instruments such as thermometers accurately and correct use of equipment and apparatus such as microscope and bunsen burners. Hohn further suggests that successful practical work requires the following: Preparation before practical period, trying out of activities to make sure that the materials used will give expected results, clarity of the instructions (simple and clear language), effective guidance and supervision by the teacher, the teacher to establish a link between the practical work and the concept to be learnt, the teacher to brief learners on any precautions to be taken to ensure their safety and that of the equipment.

Although this method is expensive, lack of laboratory facilities should not be taken as an excuse to limit practical work (Jenkin, 1989; Shiundu & Omulando, 1992; Wachanga, 2002) since some facilities can be improvised.

2.7.5 Fieldwork (Excursion)

Fieldwork results from a need to illustrate the natural development or technological application of certain topics dealt with in the classroom. It provides students with first hand evidence of scientific phenomena and how they impact on everyday life (Biehler, 1978). Students learn to appreciate Biology not only as a subject in curriculum but also as part of the real world where Biology is applied in seeking solutions to human problems and explaining natural phenomena (Vaidya, 2001). Students may also get an opportunity to interact with experts in particular aspects of Biology. Some of the places where fieldwork/excursion can be done include, National parks and game reserves; rivers, lakes & seashores, ponds, forests and other natural ecosystems; museums, herbaria and botanical gardens; factories and plantations; research laboratories; Weather monitoring and forecasting stations; and mines and quarries.

According to Killerman (1996), fieldwork is difficult to organize, but if well planned, it can be an effective method of teaching and learning some aspects of Biology. He says that the immediate environment of the school may offer unique opportunities for students to conduct field studies, which may help reinforce what is learned in the classroom. To avoid a situation where students reduce a field trip to sightseeing, the teacher needs to plan well by specifying the objectives, learning activities, evaluation and follow up activities. The teacher needs to prepare a detailed worksheet or questionnaire and give clear instructions to students before hand in order for them to focus on key areas of the study (Oyaya & Njuguna, 2000).

2.7.6 Project Work

The value of project work in the learning of Biology cannot be over emphasized. Project work enables learners to practically involve themselves in Biological investigation on an aspect of their own interest and thus learn to appreciate the basic steps involved in the scientific method (Vaidya, 2001). Killerman (1996), outlines a combination of the following steps and science process skills in project work; observation, identification of a problem, discussion, formulation of a hypothesis, design of the investigation, data gathering, data analysis, making deductions, report writing and presentation.

Contrary to popular belief, project work need not consume a lot of time and resources allocated to the subject. There are many opportunities for students to learn Biology through individual or group project work (Ralph, 1998). Ralph suggests that the problems to be investigated may arise from the students' own interest but they may also be given by the teacher. Besides, he argues that whatever the case, the teacher should make sure that students have sufficient background information before they embark on project work. Teacher supervision and guidance are important pre-requisites for successful project work.

Since a variety of methods can be used in teaching, the main issue is how teachers should organize their teaching in order to maximize learning. Many critics of education insist that the most important goal of a school is to teach children how to think and solve problems. Construction of knowledge is a process that surpasses simple memory explanations (Lorayne, 1989; Silva, 1992; Killerman, 1996). Therefore, the important question is whether it should be a must for Biology teachers to ensure high students' achievement and positive attitude towards Biology as a subject. The answers to this question can be sought in learning theories, which provide useful insights that can ease the task of teaching (Vaidya, 2001). The Concept mapping and Vee mapping strategies are based on the constructivist theory of learning (Novak & Gowin, 1984). The constructivist theory takes cognisance of the fact that by the time learners enter formal education, they have already interacted with their environment and have developed ideas and concepts in relation to their experiences (Driver & Erickson, 1993). Accordingly, the child grows up, continuously encountering new knowledge, which requires explanations. The learnt knowledge may not necessarily be scientifically correct, but the learner may accept it as truth.

Learning should, therefore, be built on the learner's experiences while at the same time correcting any misconceptions or learner's alternative frameworks (Lawless, 1998). According to Piaget (1969), an individual interprets reality via intellectual structures that change as one grows. An individual therefore tries to attain a state of cognitive equilibrium by frequently altering the intellectual structures to make it consistent with new experience. The role of the teacher, therefore, is to provide guidance by giving students challenges that will help to change their conceptions and enable them to draw correct scientific concepts (George, 1999). It involves the teacher helping students to learn Biology by modifying their pre-existing ideas in the light of the new insights and constructing their understanding of the scientific or Biological concepts. It is on this premise that George (1999) reaffirms constructivism as the basis for reforming education and improving “thinking skills”. Various studies on Concept mapping and Vee mapping strategies, based on the constructivist theory of learning, have shown positive results on learners’ achievement and motivation (Driver & Erickson, 1993; Horton, 1993; Lawless, 1998; Novak, 1986). There is, therefore, need to find out whether CVMS can have the same effect on learners in Kenya.

2.8 Motivation

Motivation refers to the initiation, direction, intensity and persistence of behaviour. It means having the encouragement to do something. A motivated student can be reaching for a long-term goal such as becoming a professional writer or a more short-term goal like learning how to spell a particular word. Trying to teach students who seem to have lost interest in learning and are displaying no motivation to learn in school or who are defeated or turned off to school for any number of reasons, is a frustrating and all too common experience for teachers in today’s classroom and schools (Deci & Ryan, 1985).

Teachers tend to believe that when students are motivated to perform competently on academic tasks, they will learn in accordance with their academic abilities. For this reason alone, working to enhance students academic motivation is worthwhile. But in addition to maximising student learning, another beneficial by-product of having highly motivated students in class is that they make the teachers job of managing the instructional programme simpler. Academically motivated students tend not to disrupt the instructional environment; they infrequently need to be disciplined; they listen when listening is appropriate because they are interested in what is being said. They discuss when discussion is appropriate because they want to share their thoughts with others. When students are academically motivated, their teachers often become professionally motivated, working hard to provide students with worthwhile educational experiences and finding more satisfaction in doing so (Cheryl, 1992).

According to Deci & Ryan (1985), there are three motivational orientations. Learners can be intrinsically motivated or extrinsically motivated. Learners tend to be intrinsically motivated when they perceive themselves as being both competent and self-determining. The behaviour of students who are intrinsically motivated is internally regulated, meaning that those learners do not let other people or external events unduly influence them. For example, if a student is intrinsically motivated to read novels, he reads them simply because he finds pleasure in the process. He does not read novels because his mother is proud of him when he reads one or because he is afraid of what will happen to him if he does not read. He reads novels because they satisfy his desire to experience, vicariously other lives lived in other places at other times. Intrinsically motivated students set and work towards their own goals, undertaking tasks that they find both interesting and personally satisfying. They do not have to be pressured or coerced into completing their freely chosen tasks.

On the other hand, Deci and Ryan (1985) argue that extrinsically motivated students do not perceive themselves as being competent or self-determining. Their behaviour is externally regulated, meaning that other people and external events play a large role in determining their decisions and behaviour. For example, when students feel incompetent, their attention is often turned outward towards those individuals they perceive as being more competent than they are. Thus rather than focussing on the task at hand and the satisfaction inherent in doing a good job on it, externally motivated students focus on what their teacher will think of them if they do not do a good job, how they can get help from the person sitting next to them, what sort of reward will be available if they do a good job, how they can make the student who always gets A grades look bad and what sort of punishment will be delivered if they do not do a good job.

Deci and Ryan (1985) give another motivational orientation as amotivated student. Amotivated students do not see any relationship between their own academic behaviour and what happens to them in school. If their teacher calls on them in class and they answer a question correctly, they are likely to attribute that success to luck or the easiness of the question and when they do poorly on an exam or quiz, they see no connection between the fact that they did not study and their grade on the test. In the eyes of these amotivated students, the results of the examination or quiz were predetermined; it was something that no amount of studying could have changed. They believe that their school successes are attributable to external, uncontrollable factors like easy test or lucky guess and thus, no reason to put out any effort or energy.

Deci and Ryan (1985) three motivational orientations are best viewed as being at least somewhat situationally determined according to Cheryl (1992). That is, individuals are not always intrinsically motivated or always extrinsically motivated. Some individuals are amotivated in school environment but highly motivated, albeit extrinsically, in work environments where they can earn money for their efforts. Teachers should be careful not to make sweeping orientations as flexible and fluid psychological structures, influenced by environmental factors; there is room for teachers to have an effect for good or bad on their students academic motivation.

Cheryl (1992) suggests that promoting intrinsic interest in learning is much more complicated because when students do not perceive themselves as being competent in a given academic environment, opportunities to be self-determining lead only to decrements in their motivation. This means that intrinsic motivation results when perceived competency and perceived control come together simultaneously.

The teachers' goal is to increase their students' intrinsic motivation in academic environments. However, intrinsic motivation is a situationally determined psychological state and as such no student can be in perpetual state of intrinsic motivation (Cheryl, 1992). As situations change from day to day or even from minute to minute, so will students perception of self-determination and competence. While classroom management programmes might have as their goal, complete compliance with classroom and school rules, no teacher could ever expect that his or her students will always feel both competent and self determining. A more realistic goal might be that all students must experience some level of intrinsic motivation for at least some part of the curriculum. The goal is to help all students recognise that academic pursuits can lead to pleasure and personal satisfaction.

2.8.1 Motivation to learn

Teachers face a lot of frustrations in trying to motivate weak students. Teachers ought to understand that everything they do in the classroom has a motivational influence on students' attitude. This includes the way information is presented, the kind of activities teachers' use, the ways teachers interact with students, the amount of choice and control given to students, and the opportunities for students to work alone or in groups. Students react to who teachers are, what they do and how comfortable they feel in the classroom. This is because motivation is a function of what motivation researchers Deci and Ryan (1991) describe as natural needs for control, competence, and belonging that exist in all of us.

Learners of all ages are naturally quite adept at being self-motivated and at directing and managing their own learning on tasks that they perceive as interesting, fun, personally meaningful, or relevant in some way. The foregoing implies that activities, which are engaging or related to implicit or explicit personal goals such as feeling competent, in control, and / or connected to others, encourage learning. In short, the issue of needing to help students want to learn and self-regulate their learning comes up in those situations in which students are; asked to learn something that does not particularly interest them; have little or no control or choice; lack the personal skills or resources needed to be successful; or lack adequate external supports and resources, including adult help, respect, and encouragement, since for too many students, these conditions describe much of their schooling experiences. There is need to understand how to develop not only the student skills involved in self-regulation, but also the motivation or will to self-regulate their own learning. To enhance motivation to learn, all the preceding personal and contextual variables involved in schooling must be addressed.

To understand how different schooling experiences can influence motivation to learn, it is important to distinguish its qualities in situations or on learning tasks that individuals perceive as interesting, fun, personally meaningful, or relevant versus tasks that are perceived to be boring, tedious, meaningless, or irrelevant from the individual perspective. In the first case motivation to learn is stimulated naturally because the learning tasks are perceived as exciting or personally meaningful. In the second case, motivation to learn must be stimulated from the outside to overcome the lack of intrinsic motivation that is caused by the student perceiving the learning tasks to be boring or not personally meaningful. An important distinction is whether choice is present and the degree of choice allowed.

In many learning situations that are externally imposed, choices are limited to control and management of internal thoughts and feelings; behaviour choices are few. Another important distinction, therefore, is whether motivation is a natural response to the learners' curiosity or whether the learner must exert effort to manage feelings arising from negative thinking about external conditions (for example. teacher, curriculum, instructional practices). Motivation to learn is therefore seen as a function of both a personal assessment of the meaningfulness of particular learning experiences or activities and the process of self-initiating, determining or choosing, and controlling learning goals, processes, and outcomes.

2.8.2 Conditions that foster motivation to learn

When learners perceive learning to be interesting, fun, personally involving, meaningful and relevant and the context supports and encourages personal control, motivation to learn and self-regulation of the learning process occur naturally (McCombs & Whisler, 1989; Ridley, 1991). That is, in situations the learner perceives as interesting or related to personal goals that can be pursued in self-determining ways, the learner is caught up in the activity and directs attention to accomplishing the personal goal. The learner may not even be consciously aware of being self-motivated and self-regulatory. In many ways, the learner is in a state of "flow" or immersion in the enjoyment of the activity. In this state the process of learning is intrinsically motivating and motivation to learn is enhanced. Learners then want to regulate their learning and make the decisions necessary to reach personal learning goals or pursue personal interests.

The problem is that many times students do not understand the role of their thinking in learning and do not see current educational content and practices as intrinsically interesting and engaging or relevant to their desired goals and personal interests. They also do not see the context as one that supports basic personal and social needs, such as to be self-determining, competent, and connected to others (Deci & Ryan, 1991).

Another key to motivation to learn is helping students see ways they can change negative thinking and make learning fun by relating it to personal interests, working with others in meeting learning goals, and being able to make choices or have choices in their own learning process. According to Damico and Roth (1994), students who want to learn and stay in school, characterize their schools as having a facilitative orientation towards students. The teachers treat them in positive ways, communicate high expectations and also communicate joint responsibility for learning. Students in schools with high graduation rates, also report that they had strong support systems, fair and consistent discipline policies, and a strong and active role and voice in school practices. Schools with low graduation rates were described by students as punitive and authoritarian, unfair and inconsistent, and with staff who were demoralized and unsure about what type of learning environment they should be creating.

Intrinsic motivation and self-regulation are, by definition, possible only in contexts that provide for choice and control. If students do not have options to choose among or if they are not allowed to control critical dimensions of their leaning, regulation of thinking and learning processes by itself is not fully possible. Such dimensions include: topics to pursue, how and when to study, and the outcomes they want to achieve. Externally imposed conditions then regulate the content, structure, and process of learning. If students are not allowed choice and control, they are not likely to learn strategies for regulating their own learning and as a result, do not attach value to self-regulation strategy, training or willingly self-initiate and control the use of various strategies.

For a variety of reasons, our educational system operates to determine much of what students learn, when they learn it, how they learn it, and how long it takes them. The critical dimensions of self-regulation are then absent; and students opportunities to develop self-regulated learning strategies are unequally distributed among those learners who come from families that value personal responsibility, learning and education and who are in a socio-economic position to provide their children with opportunities to learn personal responsibility and self-regulation skills outside of school. When these more advantaged students are in school, they are characterised as being goal-directed, able to manage their time and effort while learning and having a strong sense of self-efficacy about their abilities to reach learning goals (Caplan, Chay & Whitemore, 1992). They are usually the ones we see doing well in school as contrasted with children who see themselves as less likely to succeed. The later category are also more impulsive, have lower academic goals, are more anxious and are more influenced by extrinsic factors than their more advantaged peers (Caplan et al., 1992).

A number of researchers have emphasized the importance of teacher beliefs in determining not only classroom practices but also the orientation or perspective one has about learners, learning and motivation. Research by Deci and Ryan (1985) has shown that if teachers have an autonomy orientation rather than a control orientation, their students will demonstrate greater intrinsic motivation and self-regulation. Thus an autonomy orientation supports perceptions of self-determination and promotes willingness to learn. Furthermore, as students are given more responsibility for their own learning, Meece (1991) points out, both students and teachers come to believe that learning is supported by student self-regulation. Teachers then are more likely to let students make significant learning choices such as designing class projects, choosing learning partners or setting classroom rules. Making these choices further supports self-regulated learning; and teachers' roles change from maintaining control to providing appropriate instructional supports. Teachers therefore become co-learners in an apprenticeship model of learning.

The psychological dimensions of self-regulation that are possible in school environments are in the goals and motives for learning (the "why" dimension), the method of academic learning (the "how" dimension), the performance outcomes to achieve (the "what" dimension), and the physical and social environment in which they learn (the "where" dimension). When choices are given in all these dimensions, the evidence is clear that student motivation, learning, and performance are enhanced (Meece, 1991). In addition, when students are allowed to be self-regulatory in these critical dimensions, they are more intrinsically motivated, more active in planning and monitoring their learning, more aware of how well they are doing, more resourceful and efficient in their use of resources and more sensitive to the social and environment contexts in which they are learning. The contextual support needed also relate to the interpersonal and classroom climate set by teachers.

In general, effective interventions for promoting the will to learn, motivation, and self-regulated learning focus on an understanding of basic learner needs, interests, and learning capacities as well as an understanding of the personally and socially constructive nature of the learning process. Psychological research from such areas as human development, learning, cognition and motivation are being integrated in ways that can contribute directly to practices that are responsive to the individual learner. Ornstein (1993) argues that the key in those practices that foster motivation and engagement in learning are good teaching and teachers that emphasize the personal and social development of learners. Ornstein's research findings showed that students perform best when they feel respected and valued, when they can develop their own unique strengths and when they are helped to take control of their learning and their lives. Furthermore, Oldfather (1991) contends that students continuing impulse to learn is propelled and focused by conditions that are learner-centred as defined from the perspectives of students. Oldfather's research indicates that higher levels of intrinsic motivation are evoked in contexts that honour students' self-expression when their voices are heard, taken seriously and acted upon.

2.8.3 The Relationship between Motivation and Achievement

The level of achievement obtained by learners depends largely upon their own needs, expectations and the learning environment (Hanrahan, 1998). The teacher should therefore pay close attention to how learners can be motivated. Hanrahan defines motivation as the level at which the learner is able to find a reason to do academic work in such a way that will guarantee high achievement. This is the internal drive that the learner will use to exercise his/her learning abilities. Motivating learners should therefore aim at developing process and a learning environment that will help to ensure that learners deliver results in accordance with the expectations of the school.

Kithaka (2003) alludes that learners have different needs, and take different actions to achieve those goals. It is therefore wrong to assume that one approach to enhancing motivation is suitable for all learners. Motivation practices are therefore most likely to function effectively if they are based on proper understanding of what is involved and the individual differences of the learner.

2.8.4 Building Student Motivation

Teachers can feel overwhelmed, when faced with students who are de-motivated to learn (Orodho, 1996). The task of teaching thus become less daunting when teachers realize that they can boost student motivation by first, making positive changes to the learning environment such as developing a setting in which learners work to encourage them to give their best efforts.

Secondly, according to Horton (1995) learning is a social activity and the interpersonal relationships are a central motivation for most learners. The teacher can therefore boost student motivation through selection and development of learning activities such as; encouraging active student participation in the learning process, using motivating ‘real-life’ examples for review, quiz or test items, structuring work period so that more difficult activities are in the middle with easier tasks at the start and end, allowing students to set their own pace for completing work, use humour, keeping miscellaneous work supplies on hand for students to borrow, setting a timer (for example 5 minutes) and challenge students to finish routine tasks on transition between activities before timer rings.

Thirdly, the teacher can offer students meaningful choice in setting up their assignments (for example, selection of work materials, type of activity). In addition a teacher can invite interesting guest speakers into the classroom to speak on academic topics. Prepare index cards with review questions and answers based on material covered in class. Let the guest speaker 'quiz' teams and award points to teams based on their mastery of material.

Lastly the teacher should keep instructions and assignments short, have students repeat instructions in order to internalise them, reinforce student achievement, use the student mistakes to make the correction, give potentially slow students an opportunity to review activities by conducting them to the whole class or in small groups, plan to use interesting materials for instruction and select activities that encourage group planning

In conclusion, it is worthy noting that **e**very learner presents a unique profile of strengths and weaknesses (Gordon & Jeanneate, 2001). Therefore student motivation can be unlocked when the teacher acknowledge and address unique learning profiles. The subject teacher can build student motivation by accommodating challenges to learning in a number of ways some of which have been aforementioned. Learning is a motivating activity when the learner can count on short or long term benefit for mastering the material being taught. This in turn improves academic achievement.

2.9 Attitude and Gender Disparities in Science Subjects

From literature review, it is evident that students' ability, attitudes and motivation as well as those of teachers are very important determinants of achievement (Nitcher, 1984). These are regarded as the three elements of the academic success equation. Major findings of a study done by Wasanga (1997) on the attitude towards science between primary and secondary schools in Kenya revealed that students have positive attitudes towards science. However, differences were found in the areas of students' gender, school type and teachers' gender.

Male students were found to have more positive attitudes towards all the aspects of science apart from the perception of science as a male domain. Female students were found to be affect by stereotypes regarding science subjects as a male domain. Some of the factors identified to have an influence on the attitude of female students include: the opinion that science is very difficult; poor teaching approaches where by teachers did not necessarily explain concepts to students (Wasanga, 1997); stereotypical attitudes toward science related careers; and low achievement in examinations. In addition male students normally show more confidence in learning science, which is perceived to be more useful in motivation.

According to Wasanga (1997), female students in single sex schools were found to have positive attitudes on all aspects of science apart from the usefulness of science whereas students from mixed schools had more positive attitudes towards the usefulness of science. Female students were also found to be less active in mixed classes where boys were reported to ask questions more in class, and to be called upon by the teachers to answer questions or to help in experiments. When asked why, it was reported that boys volunteer faster and girls are shy and fear to be laughed at by boys if they get the answer wrong.

Students taught by female teachers had more positive attitudes on all the aspects of science. However, female teachers were less positively described in the area of encouragement and teaching but students taught by them had higher scores than those taught by male teachers. The aspects that students like or dislike in their teachers are personality traits. On teaching, many reported that the teachers who were disliked continually used lecture method with few explanations. Female teachers were thought to be quarrelsome and brought personal issues in class (Wasanga, 1997)

Similar studies were carried out by the SMASSE biology team in Kenya (SMASSE, 2003) to identify and determine the needs in Biology Education at secondary school level. The SMASSE report revealed that the approach and methods used in teaching Biology was largely teacher centred with some topics in the syllabus equally difficult to teach and learn such as classification, evolution, ecology, respiration and stimulus and response among others. Indications of poor planning or lack of it was evident.

Arising from the results of the survey, there is need for further research that could identify teaching and learning strategies, which are learner centred, and which could bridge the gap between the abstract and the concrete components of Biology.

2.10 Quality Education

To most people quality education is defined in terms of output; either the number of students completing a cycle within the education system or the number of students passing an important national examination, or both (Eshiwani, 1987). Thus a school that has high dropout and class-repetition rates or low student achievement scores is said to be of low quality. This type of definition ignores the fact that the non-attendance or poor academic performance of pupils in a school may stem from factors other than the character of their school. Fuller (1985) observes that 'a diagnosis of the school quality problem that focuses on outputs (dropouts and student performance) fails to inform us about the antecedent causes (inputs and practices). Moreover, the child learns more from the school than just academic skills that achievement test and examinations measure. The intervention strategies in the improvement of school quality that are based only upon school achievement are not likely to be useful in defining the quality of education for a country like Kenya. A clearer definition is needed to sharpen how we conceptualise the problem of quality education and to show how we may formulate intervention strategies. The researcher would like to define educational quality as comprising:

a). The pre-school development. Parental and community beliefs regarding education, exercised early in the child's life, may influence later school achievement.

b). The school quality. Once the child enters school, the characteristics of the institution may influence his or her achievement. The quality of instructional process experienced by each student determines the school quality. Factors associated with instructional processes are material inputs such as textbooks, teacher quality, teaching practices and classroom organization, school management and structure. School quality can therefore be best defined by noting its essential characteristics which include: the level of material inputs allocated to schools per student (resource concentration), the level of efficiency with which a fixed amount of material inputs are organized and managed in order to raise student achievement, the socio-economic context of the child, the school outcomes and the post-school outcomes.

The implication of this definition is that only inputs and management practices empirically linked to student performance are valid indicators of school quality. Other elements of school such as classrooms and laboratories may be symbols of a higher quality of education but cannot be used to define the quality of education. School quality is also adversely affected in areas or homes where there is a demand for the child's labour or other detractors. A school whose pupils pass with high achievement scores but who cannot communicate effectively and socialize easily cannot be regarded as a high quality school. A school that emphasize academic excellence but ignore physical, moral and cultural outcomes is a low-quality school. In the final analysis, the quality of the education system will be judged according to how well the school graduates perform in their jobs and the social quality of life they lead (Eshiwani, 1993).

In conclusion, research carried out reveal that, teacher quality, instructional materials especially text books, length of instructional programme, school library activities and school administration are elements that have been consistently related to student achievement (Fuller, 1985). These elements are considered important in the student achievement in Biology. Fuller (1985) acknowledged other quality factors that could affect achievement, which included frequency of homework, teacher's correction of student's exercise books, instruction radio and in-service teacher training. Quality elements that are not consistently related to achievement comprised class size, laboratories and individual teachers' salary levels (Fuller, 1985).

2.11 Raising the Quality of Science Education in Kenya

The quality of Education is the issue that significantly features in most debates concerning education in Kenya (Eshiwani, 1985). This is because the government has experienced an unprecedented investment in educational provision during the last twenty-five years. It is important to point out that the emphasis on educational expansion that took place during the post-independence era was complemented by an increasing priority accorded to programmes of quality improvement (Lewis, 1984). The rationale of this improvement was to enhance the role of education in national development. During the first two decades of independence, curriculum reform played a central part in strategies to improve quality of education. Major innovations were introduced in the curriculum. They include: the 'new mathematics, agricultural education, industrial education, the Science Education project for Africa (SEPA), the School Science Project (SSP) and Nuffield-based science programmes among others (Eshiwani, 1993). It is unknown if these curriculum efforts brought about the desired quality in Kenyan education system. The new curricula seem to have failed to respond to the problems of low-quality curriculum materials, irrelevant content and inappropriate instructional approaches (Eshiwani, 1987). These therefore, are some of the key issues that must be considered in discussing the future quality of education in Kenya.

Perhaps the main question that will face those charged with administration of education in Kenya in future is the maintenance and enhancement of quality education. The most urgent need in the improvement of quality education is upgrading of teaching/instructional skills of those whose responsibility is to teach students. The immediate target group in this category are the subject teachers. Lewis (1985) observed that teacher morale and professional support, and awareness of educational possibilities through adequate pre-and in-service training are critical determinants of curriculum quality over and above that level of physical support. Accordingly, quality of education can only improve through changes in teacher behaviour. Initiatives are needed in those areas, which support teachers and boost their morale through providing access to information and advice. Other areas that require attention are those that assist the development of professional associations and recognition of performance. Initiative in such areas have more potential for wide spread impact and the possibility of extensive multiplier effects. Therefore, as Kenya prepares herself to face the challenges of the 21st century, it is obvious that she will have to pay greater attention to teacher education.

2.12 Concept Mapping

Concept mapping is a classroom activity, which involves making of a diagrammatic representation of the relationship between the major concept (topic) and the subordinate (minor) concepts in a hierarchical order. Concept mapping was at first the investigator's construction of the concepts and propositions expressed by the learner, either in an interview or in a work sample (Novak and Gowin, 1983). As their work progressed, they began to construct concept maps to represent the set of prepositional meanings in a lecture or other unit of instructional material. The early maps usually did not include "labels on the lines", since they assumed the meaning of the linkage was obvious. However, they began to recognize that even expert persons would see significantly different "linkage meanings" between the same two concepts on a map. They therefore took a significant step forward when they begun to insist that the linkage lines be labelled for explicit propositions to be expressed involving two concepts. Strategies were finally developed to help students construct their own concept maps (Novak and Gowin, 1983).

Concept maps can be constructed in several ways. According to Novak and Gowin (1984), a simple method is to supply students with a list of related concepts and have them construct a map, placing the most inclusive, most general concept at the top and then showing successively less inclusive concepts at lower positions in a hierarchy. Students must decide how best to represent the concepts hierarchically and the words to use to link concepts together. Another method is to have students identify key concept words in text of some kind and then use these concepts to form a hierarchical map. The third method, which may require the greatest creativity, is to construct a concept map without any supplied words or text, but drawing on an individual's fund of knowledge on some specific topic.

Concept mapping strategy was developed at Cornell University and came to the attention of education specialists shortly after the publication of a book by Novak & Gowin (1984) titled 'Learning How to learn'. In the years that followed, the education specialists became interested in the possible role of concept mapping as a learning strategy in various fields. For example, Pinto, Angelo, Zeitz and Harward (1997) did research on concept mapping as a strategy for promoting meaningful learning in medical education. This study was carried out on medical students in the United States of America (USA). Similar studies on concept mapping in Biology were done by Kinchin and Ian (2000) in England and Wales. The purpose of these studies was to examine the use of Concept mapping as an educational tool that encourages meaningful learning. The findings of these studies revealed that Concept mapping is one strategy that leads to meaningful learning (Novak, 1998; Okebukola, 1992). Researchers suggest that it enhances meaningful and self-directed learning in several ways.

It is an active, creative, visual and spatial learning activity in which concepts are organized according to their hierarchical relationships. It helps students to understand, relate and integrate the various concepts. It helps students to gain a more unified understanding of a topic, reduce subject-based anxiety and overcome differential gender-related performance with respect to learning and achievement in science (Kinchin & Ian, 2000). It improves long-term retention of non-meaningful information. It improves transfer of knowledge in future problem-solving activities. Concept mapping skills can be quickly and easily acquired (in a 2-3 hour workshop).

Once students acquire Concept-Mapping skills, they can use it to (i) organize and integrate information; (ii) assess existing knowledge; and (iii) gain insights into new and existing knowledge. It is an activity that provides the students with an opportunity to organize, summarize, analyse and evaluate many different ideas. It thus, promotes critical thinking skills. The process externalises the concepts in the student's existing knowledge structure, hence, making it possible to identify misconceptions, incongruities and weaknesses in that structure. Correction of these errors leads to greater and deeper understanding of the material under study. Concept mapping is an important strategy for meaningful learning because it helps students to organize new knowledge, to review and if necessary to adjust existing knowledge, and to relate new information in a usable, integrated network (pinto, Angelo, Howard and Zeitz, 1997).

The researches that were earlier described also indicate that Concept Maps can benefit the teaching profession by being used as a teaching aid in the classroom. As an example, a teacher can organize a lecture by making a concept map to use as a teaching guide. This will give a conceptual flow to the lecture and help the teacher to pinpoint important aspects for students to understand. Such maps may be shared with students (as in collaborative learning) to help them organize and integrate important concepts and also to expand on the maps. They can also be used to obtain feedback, by having students make concept map of what they were taught in a lecture (Pinto et al, 1997).

Following from this, the researchers have considered Concept Mapping to be a viable agent for curriculum change. Biology teaching in Kenya could benefit from adopting this similar strategy. Biology is considered difficult to learn because it consists of a myriad of unfamiliar concepts involving complex relations (Njuguna, 1998). The schools' favoured approach to teaching unfamiliar material is rote learning, which fails due to multilevel, complex interaction of concepts in Biology. Concept mapping leads to meaningful learning, and appears to be suited to address the Biology subject content (Schmid & Telaro, 1990 in Kinchin, 2000).

2.13 Vee Mapping

Vee mapping is another learning activity (strategy), which involves making of a V-shaped representation with two sides, that is, the theoretical (thinking) side and methodology (doing) side. The Vee mapping strategy was designed by Gowin (1970) from the Vee heuristic derived from his interest in the structure of knowledge and work dealing with problems of laboratory instruction. The formal definition of heuristic is a method of solving problems by finding practical ways of dealing with them or learning from past experience (Hornby, 2002). For purposes of this research, heuristic teaching/education is one, which encourages students to learn by discovering things for themselves. Gowin's epistemological concerns are part of a more general effort in theory development for any act of teaching (Novak & Gowin, 1983). He came up with ten key elements as illustrated in Figure 1, showing the general form of the Vee.

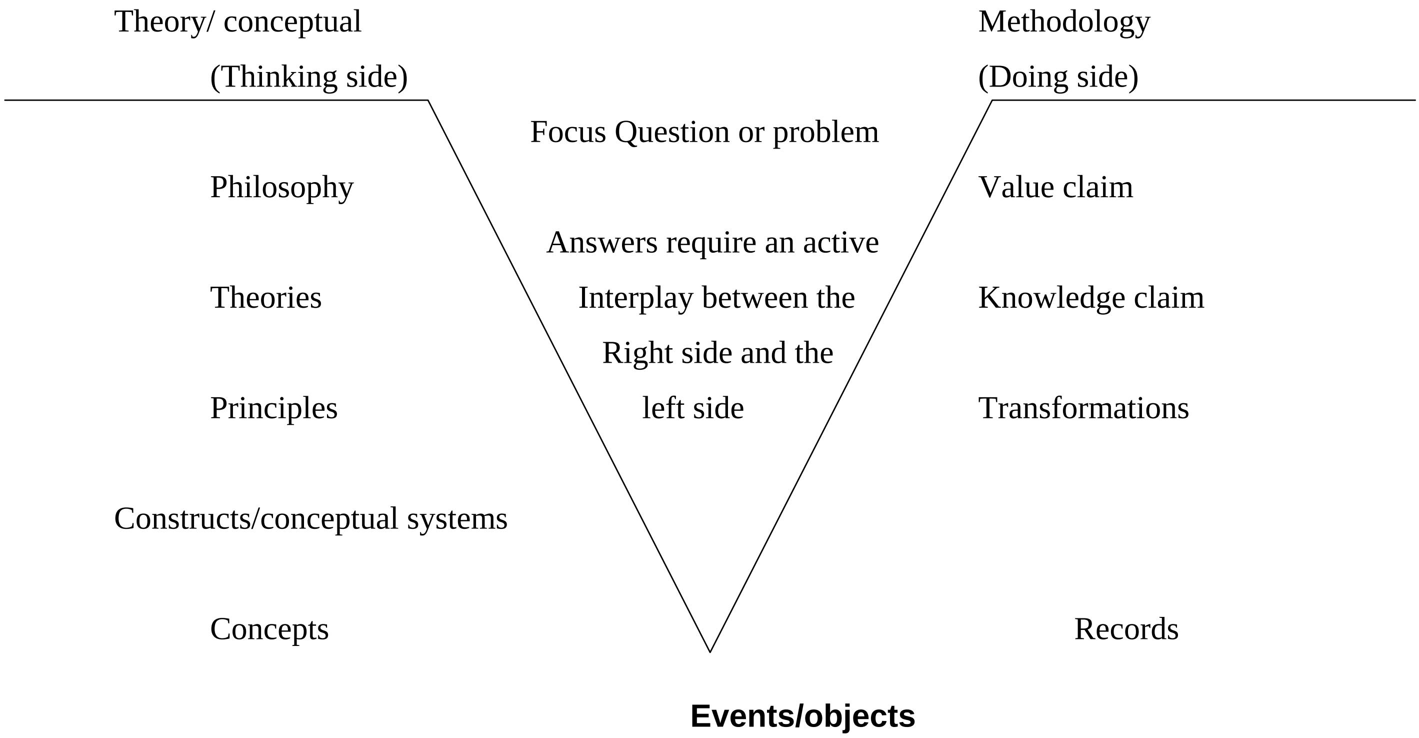

Figure 1: Gowin's Vee heuristics showing the ten elements included in this representation for the structure of knowledge. See appendix F for an illustration of how laboratory activity was "mapped" onto the Vee in class discussion after the activity.

There is, of course, no basic reason why the "V" shape should be used to represent these ideas but this form does tend to emphasize the "point" upon which we must focus in knowledge creation, that is, the objects or events we choose to observe. According to Novak and Gowin (1984), our concepts, principles and theories guide us in selecting or constructing objects or events to be observed, so the "left side" of the Vee is inextricably tied to the "point" of the Vee. The record making and record transforming technology or ideas play a crucial role with respect to the knowledge or value claims that the learner eventually constructs. Therefore, the central idea of Vee mapping is that, every element shown on Gowin's Vee is interdependent with every other element on the Vee. The fundamental assumption is that knowledge is not absolute, but rather is dependent upon the concepts, theories and methodologies by which learners view the world (Novak & Gowin, 1983).

Gowin outlines the following procedure for constructing a Vee map:

1. Identify the "focus" question or questions and the events or objects observed to answer the questions. These first steps can be difficult thus leading to much useful class discussion.
2. Identify the eight other elements on the Vee. This step can also be very challenging.
3. Map out the identified elements in their respective positions on the Vee.
4. The end product is a Vee map, which shows hierarchical organization of the key elements of knowledge.

The benefits of Vee mapping include the ability to make students understand the general worldview and philosophy guiding the inquiry and the beliefs about the nature of knowledge being sought. It also enables learners to become aware of relevant concepts and theories, the data recording and transforming procedures as well as the knowledge and value claims that derive from the inquiry (Novak & Gowin, 1984). It therefore allows students to understand the interplay between conceptual and methodological elements involved in practical work and facilitates integration of each element into the learner's cognitive meaning frameworks. This departs widely from the usual practice in school learning where rote memorization of knowledge is emphasized. Vee maps can therefore be constructed for laboratory exercise/practicals, a textbook description of an experiment or a research study.

When students perform a laboratory investigation and "place it on the Vee" they are often surprised to learn that different principles or theories considered on the "left side" will lead to an expectation of different knowledge claims. Novak and Gowin (1984), further notes that science students may be surprised to learn that every knowledge claim can also be the basis for a value claim. In conclusion, Vee mapping produces on paper the structure of the unit of knowledge being studied. It is therefore a valuable instructional tool since it enhances understanding and use of knowledge. Novak and Gowin (1983) carried out research studies on use of Concept mapping and Vee mapping strategies with high school students in Ithaca, New York. The results of the study showed that most students were successful in using the Concept mapping and Vee mapping strategies and that the performance also improved. The best explanation to this is that CVMS produce meaningful learning, which leads students to organize knowledge hierarchically with consequent improvement in their ability to use this knowledge (Novak, 1980).

Studies in secondary schools in Kenya revealed that the way Biology instruction is done leaves a lot to be desired in terms of students' understanding of science phenomena (SMASSE, 2003). There is therefore need to strengthen the teaching of this subject since teaching effectiveness is the most significant determinant of students achievement (Higgins & Taylor, 1996; Mondoh, 1994). Teaching effectiveness may also depend on the teaching method that the instructor utilizes. Teaching is an experimental process in which all techniques should be examined routinely and revised if necessary (Vaidya, 2001) hence the need for this particular study. In this study, CVMS were used to teach the topic respiration. Concept mapping was used to present the overall framework of the concept respiration while Vee mapping was used to teach practical work covered under that topic. Vee maps were suitable for practical work since it involves observing objects or events and selecting or constructing the objects and events based on concepts, principles and theories learned.

2.14 The Concept and Vee Mapping (CVMS)

The initial studies on the use of concept mapping and Vee mapping with high school science students had its origin in initial work on problem solving (Novak, 1988) wherein teaching strategies were conceived to facilitate students' ability to solve problems in science. Novak, Gowin and Johansen (1983) of Cornell University, NewYork carried out studies focusing on Ausubel's (1968) assimilation theory of cognitive learning on the central role that prior concepts play in the acquisition and use of knowledge and the contrast between rote and meaningful learning. From this theory, they developed the technique of concept mapping. Later, the Vee mapping technique was developed from the philosophical and epistemological origins of the project derived from the writings of Kuhn (1962) and Toulmin (1972), but most specifically from the work of Gowin (1970, 1981). From the epistemological perspective, they developed the Gowins's Vee mapping technique, which has also become a curriculum and instructional tool. The Concept mapping and Vee mapping are two distinct techniques identified as recent advances/ innovations in science education that have been shown to enhance motivation and achievement of the learners in some other countries. The two learning techniques, though distinct, have many commonalities. Both techniques involve concepts and their relationship. The relationships in concepts create a graphical outlook.

2.15 CVMS and Mastery learning

A fundamental change in thinking about the nature of teaching was initiated in 1963 when Carroll (1963) argued for the idea of mastery learning. Mastery learning suggests that the focus of instruction (teaching) should be the time required for different students to learn the same material. This contrasts with the classical model (based upon theories of intelligence) in which all students are given the same amount of time to learn and the focus is on differences in ability to learn. This classical model is consistent with the Kenya education system whereby students are subjected to a national and final examination after a period of time. For example the Kenya Certificate of Secondary Education (KCSE) examination, which is done after four years of learning. The achievement scores that learners obtain is primarily a measure of differences in ability to learn and to some extent a measure of the time required to learn. This offers a good explanation of why some learners are able to improve on achievement score when they repeat a class occasioned by poor performance.

Therefore the idea of mastery learning amounts to a radical shift in responsibility for teachers. Consequently, the blame for a student's failure rests with instructions (teaching method and strategy) not a lack of ability on the part of the student. In a mastery learning environment, the challenge of the teacher is to provide enough time and use teaching strategies so that all students can achieve the same level of learning (Levine, 1985; Bloom, 1981).

The key elements in mastery learning are:

- Clearly specifying what is to be learned and how it will be evaluated,
- Allowing students to learn at their own pace,
- Assessing student progress and providing appropriate feedback or remediation, and
- Testing that final learning criterion has been achieved.

Mastery learning has been widely applied in schools and training settings, and research shows that it can improve teaching effectiveness (Slavin, 1987). On the other hand there are some theoretical and practical weaknesses including the fact that students do differ in ability and tend to reach different levels of achievement (Cox & Dunn, 1979). Furthermore, mastery learning programs tend to require considerable amounts of time and effort to implement which most teachers and schools are not prepared to expend. Mastery learning is closely aligned with teaching objectives and the systematic design of teaching programmes. The concept mapping and vee mapping strategies are an attempt to implement the mastery learning model. In addition, the theoretical framework of constructivism with its emphasis on knowledge construction by the learners is also relevant to mastery learning. The CVMS have been used to reveal the details of the learners' prior knowledge and misconceptions, which are the main predictors of learners' achievement in science (Semra, Caren & Omer, 2001).

2.16 CVMS and the Learners' Misconceptions

Learners begin to develop theories to explain the world around them before they even begin their formal education. Some of their theories may be consistent with the traditional scientific view while others may not. Those that are not in agreement with the accepted view are usually referred to us misconceptions or alternative frameworks (Kararo, 2002; Kinchin, 1998). Learners' misconceptions are often difficult to eliminate even with instruction specially designed to address them. Since new knowledge is linked to the existing conceptions (Prior knowledge), misconceptions therefore interfere with further learning. (Semra, Caren & Omer, 2001).

Concept mapping and Vee mapping have become very useful tools in revealing these misconceptions. These learning/teaching tools are able to reveal the details of individual misconceptions so that the subject teachers can address each one in an appropriate manner (Kinchin, 2000). Therefore, teachers should be aware of students' prior knowledge and misconceptions because they are determinants of achievement in science. CVMS would help to externalise the learners' misconceptions and, therefore, give teachers the opportunity to organize appropriate learning experiences to address them.

2.17 CVMS & Constructivism

The use of CVMS is often linked to constructivist theory of teaching. This theory holds that from birth to death, people construct and reconstruct the meanings of events and objects they observe (Keraro, 2002). Constructivism emphasizes science as a creative human endeavour, which is historically and culturally conditioned, and that its knowledge claims are not absolute. Therefore, for constructivists, knowledge is created rather than discovered.

In science education, the development of constructed knowledge can be represented graphically using Concept mapping and Vee mapping. Therefore, teaching that helps this construction process will lead to meaningful learning. Consequently, understanding what the learner knows and guiding the student to build upon them is the essence of the constructivist view of learning. This goal can be achieved by use of Concept mapping and Vee mapping.

The Concept maps show how the learner's knowledge is interlinked in his/her schema. The Vee maps show the structure of knowledge and thus help learners to understand the general worldview and philosophy guiding scientific inquiry and beliefs. Vee maps are very useful in work dealing with problems of laboratory instruction.

2.18 Theoretical framework

The target of the study is premised on student centred teaching. Therefore, theories that have to do with the characteristics of this entity as they affect learning would be applicable. The constructivist theory would therefore provide theoretical basis for the study. The constructivist epistemology asserts that knowledge resides in individuals and is constructed from within (Driver & Oldham, 1986). This means that prior knowledge is crucial in the learning process because it makes understanding of knew knowledge easier. The implication of this is that teachers have a role of helping students to learn how to learn. In the light of this, when the teaching method (in this study, concept mapping and vee mapping strategy) is used, effective and meaningful learning is likely to take place.

Constructivist theory offers opportunities for the Biology teacher to diagnose students' misconceptions and help them to learn more effectively, thus permitting more adequate individualization and personalization of Biology instructions. It is on this premise that constructivist anchors their belief that previous knowledge and experience have a major role in determining the learners' performance. It is within this framework that the present study looked into the effects of using concept and vee mapping strategy (CVMS) on students' achievement and motivation in secondary school.

2.19 Conceptual Framework

Learning is influenced by various factors, ranging from teacher factors, learner characteristics and teaching approaches used as shown in Figure 2.

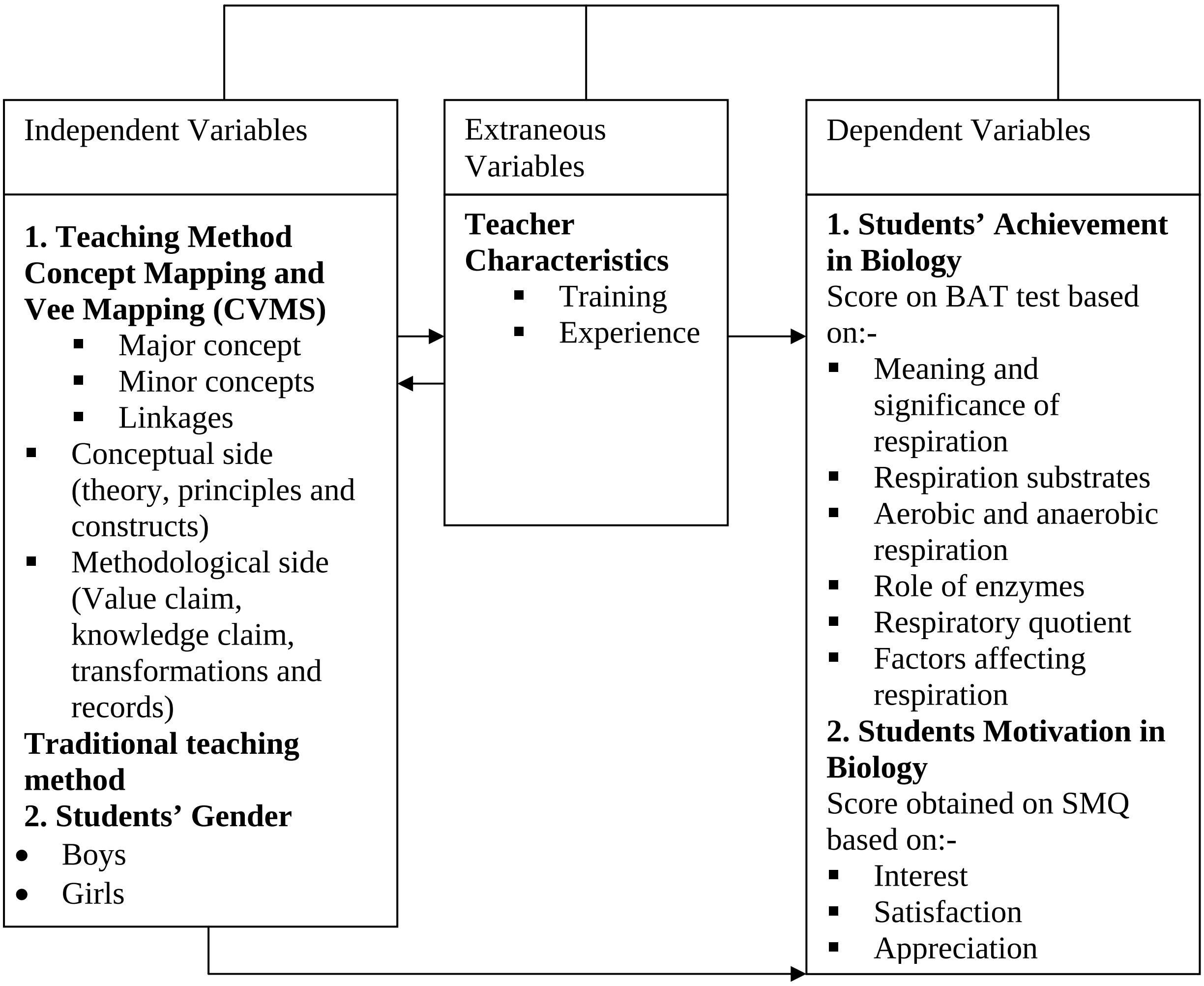

Figure 2:
Conceptual framework showing variables that interact to influence students' achievement and motivation in Biology

Teacher training and experience determine the teaching approaches a teacher would use. It also determines how effective a teacher would use the approaches. The study used qualified Biology teachers with a minimum of two years teaching experience to control for the mentioned extraneous variables. The influence of the teaching approach on the students' achievement and level of motivation in Biology was studied. Student's gender may influence their attitudes and motivation to learn Biology. It is one of the extraneous variables that could not be controlled. Since it's effects cannot be assumed, the study addressed the issue of gender by investigating it in a co-educational schooling environment. Student classroom behaviour may influence teacher classroom behaviour in an interactive pattern that eventually results in student achievement as measured by instruments such as the Biology Achievement Test (BAT). Student achievement then becomes a student characteristic as learning progresses.

CHAPTER THREE:

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the procedures and methodology used in carrying out the study. It covers the research design, target population and accessible population, sampling procedures, instrumentation and development and use of instructional materials. Data collection procedures and statistical methods that were used for data analysis conclude this chapter.

3.2 Research Design

In this study, a quasi-experimental research design was used. This is because there was non-random assignment of subjects to the groups since the school authorities do not normally allow the classes to be reorganized so that they can randomly be re-constituted for the purpose of research (Borg and Gall, 1996). The design that was adopted in this study is Solomon's Four Non-equivalent Group Design.

The Solomon Four Non-equivalent Group Design is as follows:-

Group I	O_1	x	O_2
Group II	O_3	–	O_4
Group III	___	x	O_5
Group IV		—	O_6

Where: O_1 and O_3 are pre-tests: O_2, O_4, O_5 and O_6 are post – tests. X is the treatment where students were taught using Concept mapping and Vee-mapping strategies.

__ means no treatment. It refers to the control group.

Group 1 is the experimental group, which received the pre-test, the treatment (X) and the post-test.

Group II is the control group, which received a pre-test followed by the control condition and lastly a post-test.

Group III received the treatment X and a post-test but did not receive the pre-test.

Group IV received the post-test only.

Group II and IV were taught using traditional teaching methods.

The Solomon Four Non-equivalent Group Design was used because as Gall, Borg and Gall (1996), and Wiersma and Jurs (2005) argue, it is considered suitable in achieving the following purposes:-

- Assess the effect of the experimental treatment relative to the control treatment.
- To assess the effect of a pre-test relative to no pre-test, hence using 2 control groups.
- To assess interaction between pre-test and treatment conditions.
- Determine the extent to which the groups are uniform before giving the treatment.

The Solomon Four Non-equivalent Group design controls for all major threats to internal validity except those associated with interactions of selection and history, selection and maturation and selection and instrumentation (Cook and Campbell, 1979). To control for interaction between selection and maturation, the schools were assigned randomly to the control and treatment groups. No major event was observed in any of the sample schools that would have introduced interaction between selection and history. The conditions under which the instruments were administered were kept as similar as possible in all the sample schools to control for interaction between selection and instrumentation.

3.3 Target Population and Accessible Population

In this study, the target population was secondary school students in Uasin Gishu District, Rift Valley Province of the Republic of Kenya. The accessible population was form two Biology students in provincial secondary schools in Uasin Gishu District from which a study sample was drawn. The researcher chose Uasin Gishu District because it has a good number of mixed secondary schools. In addition, these types of schools enrol majority of the students in the district. The district is also one of the regions where majority of the students perform poorly in K.C.S.E examinations. Since the study also considered the aspect of gender in performance and motivation, mixed provincial schools were used.

3.4 Sample Size and Sampling Procedures

The sampling unit was the secondary schools and not individual students since students operate as intact groups. The study used provincial secondary schools to ensure that students involved in the study had academic abilities that were comparable. A list of Provincial secondary schools in Uasin Gishu District was used as a sampling frame. Purposive sampling technique was used to select four schools that formed the study sample. This sampling technique was preferred because the District has only five mixed provincial schools. The sampled schools are far apart and this minimized experimental treatment diffusion. In schools that had more than one form two stream, the stream with the highest mean score in the previous end term exam was selected for the study. The schools were randomly assigned to the four groups. The schools in each group were as follows:-

Group I (Experimental group), N = 32

Group II (Control group), N = 30

Group III (Experimental group), N = 44

Group IV (Control group), N = 38

A total of 144 form two students participated in the study.

3.5 Instrumentation

Three instruments were used in this study. These are the Biology Achievement Test (BAT), The Students Motivation Questionnaires (SMQ 1 and SMQ 2). A detailed description of these instruments is given in sections 3.5.1, 3.5.2 and 3.5.3 respectively.

3.5.1 Biology Achievement Test (BAT)

The Biology Achievement Test was developed by the researcher and used as a pre-test. The items were re-organized for it to be used as a post-test. The test had 30 items, which carried different scores ranging from 2 – 10. All items added to a total of 100 marks. The test items were open-ended. The items tested knowledge, comprehension, application, analysis and evaluation of what students had learned (See appendix I). The test was based on the Form Two Biology topic; “Respiration.” The test was given to five experts in Science Education and five secondary school Biology teachers for validation. The researcher had more interest in content validity, which was assessed by determining the degree to which BAT represented the teaching objectives of the topic respiration. According to Lewis (1976), achievement tests are usually content validated. The validation was done by comparing the content of the BAT to the syllabus outline of the subject content that was covered in the topic of respiration. As Lewis further argues, this is criterion related validity and receives the greatest attention in educational measurement. The criterion in this case is the judgement of the subject-matter experts. The pre-test sought to test students’ mastery or understanding of the topic respiration, which was the focus of this study. A comparison was made on the pre-test BAT scores for boys and girls for group 1 and group 2 schools which had been subjected to the pre-test. In this test the two groups were combined and their means established based on gender. The gender based pre-test means scores were then compared using an independent sample t-test to establish whether there were any differences in the performance.

The test was pilot-tested using two secondary schools with the similar characteristics as the sample schools from North Nandi District. This was used to validate and estimate the reliability. Since the items were not scored dichotomously, the reliability coefficient of the test was estimated using Cronbach's coefficient alpha (Thorndike & Thorndike, 1994)

$$a = \frac{K}{K-1}\left[1 - \Sigma\frac{S^2 i}{S^2 x}\right]$$

Where K = Number of items on the test.

S^2x = Variance of test x

S^2i = Variance of item i

This is the most appropriate reliability tool used to assess homogeneity of items and can be determined using only one administration of the instrument (Kathuri & Pals, 1993). A reliability coefficient for the BAT was found to be 0.90. This is far above the minimum acceptable reliability coefficient of 0.70 (Kathuri & Pals, 1993; Nsubuga, 2000). An alpha value of above 0.70 is considered suitable to make possible group inferences that are accurate enough. Therefore the BAT instrument was appropriate for this purpose. The instrument was then used to collect data that is analysed and discussed in Chapter Four.

3.5.2 Students Motivation Questionnaire 1 (SMQ 1)

The SMQ 1 was used to measure the students' motivation and interest towards Biology when they were taught using the Concept and Vee mapping strategy (treatment group). 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 researcher adapted and modified the SMQ developed and used by Kiboss (1997) and Wachanga (2002) to suit the study. The adopted SMQ was re-written to find out students' opinion and perception on Biology and the strategies used for instruction. The adapted SMQ 1 had 37 five-point Likert type items.

A higher number on the scale represented agreement with the item on the scale and a more favourable 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. In this study, a perception was taken to be a measure along continuum ranging from strongly negative effect to strongly positive effect. In analysing the data, an item such as "learning biology using Concept and Vee maps prepared by students made me feel as if I was wasting my time" had the scores reversed since "strongly disagree" would reflect a high positive effect toward Biology. Two representative items of 2 scales and their relative interpretations are presented in Table 5.

Like the BAT, the SMQ 1 was pilot-tested in the same school in order to determine its reliability coefficient. Like the case with BAT, the formula developed by Thorndike & Thorndike (1994) was used to calculate the Cronbach's coefficient alpha, which was found to be 0.82. It was thus accepted as a reliable measuring tool.

3.5.3 The Student's Motivation Questionnaire 2 (SMQ 2)

The SMQ 2 was used to measure the students' motivation and interest towards Biology when taught using the traditional teaching methods (control group). It was adapted from Wachanga (2002) in the same way as the SMQ 1 and similarly, it was used to evaluate students' opinions and perceptions on Biology and the traditional teaching methods used. The SMQ 2 was a 30-item fixed-response format questionnaire comprising two scales with 15 items per scale. The students responded to a five point system on the Likert scale as the one described for SMQ 1. Its interpretation framework was also similar to that of SMQ 1. As an indicator of effort and devotion to study biology, students from both groups were asked a set of questions to establish their level of motivation after being taught through CVMS for the experimental group and traditional teaching approaches for the control group. SMQ1 was used on students in the experimental group while SMQ2 was used on students in the control groups. However, the contents of the two questionnaires were similar hence in both will be referred to as SMQ in the results. The questionnaire with 37 items sought the opinion and perceptions of students on the respective teaching methods used and were measured on a five-point Likert scale (scored 0 to 4) whose sum constituted the motivation index. The maximum possible score on the index was 148 while the minimum possible score was 0.

To determine reliability of SMQ 2, the instrument was pilot-tested in a different mixed provincial secondary school from the experimental and control groups to avoid influencing the treatment. The school was also located in Nandi district. The choice of school was based on the same reasons given for the other pilot school. Like the case with BAT, the formula developed by Thorndike & Thorndike (1994) was used to calculate the Cronbach's coefficient alpha, which was found to be 0.80 and the instrument, was thus accepted for use in the study.

3.6 The Development of Instructional Materials

The subject content used in the study was based on the Kenya National Examinations Council (KNEC, 2002) and the Kenya Institute of Education approved Biology syllabus (KIE, 2002). The Concept & Vee mapping strategy required the teacher to have a manual (booklet) throughout the teaching period. The manual (appendix G) was prepared by the researcher and contained the content outline, teaching and learning activities. The following subtopics were covered:

- Definition & significance of respiration
- Respiratory substrates
- Aerobic respiration
- Anaerobic respiration
- Comparison between Aerobic and Anaerobic respiration
- The role of enzymes in respiration
- Respiratory Quotient
- Factors affecting respiration

The researcher inducted teachers for the experimental groups for one week. Prior to the commencement of the treatment, a pre-test was administered to the learners in group I and II. The treatment was then administered for a period of 1 month (4 weeks) to the experimental groups. Each week had four lessons, one double lesson of 80 minutes and two single lessons of 40 minutes each. During the lessons, teachers taught using the Concept mapping & Vee mapping strategies in about equal proportions. The control groups were taught using the traditional approach. After the treatment, the researcher with the help of regular teachers administered the post-test.

3.7 Data Collection

The researcher began by pilot-testing the research instruments. The first step was to induct two teachers for the experimental groups (I and III) on the use of Concept and Vee mapping strategy in teaching. After the induction, BAT was administered as a pre-test to groups I and II. The two teachers for experimental groups used the CVMS to teach their students (group I and III) while those of control groups II and IV used traditional teaching methods. For treatment groups, teachers begun by first introducing the concept mapping to students. The final instructional sequence used with experimental groups I and III was (1) "Learning how to learn" activities; (2) Concept mapping, introduce examples and explain principles behind concept mapping with subsequent practice in conjunction with regular Biological Science activities; and (3) Introduction to Vee mapping, usually after class work, with an experiment that lent itself to Vee mapping (teachers illustrated Vee mapping with subsequent practice by students). The use of Concept mapping and Vee mapping continued from the beginning to the end of the topic. Students in all the four groups were then subjected to BAT as a post-test. Students of group 1 and 3 were taught the topic respiration using the CVMS developed by the researcher hence constitute the experimental groups. On the other hand, students of group 2 and 4 schools were taught using the traditional teaching approaches and thus constituted the control groups. The intervention took 4 weeks after which a post-test BAT was administered. The BAT was scored and the final score expressed as a percentage. Finally, SMQ 1 was administered to experimental groups (I and III) while SMQ 2 was administered to control groups (II and IV). The three instruments were then scored appropriately.

3.8 Data Analysis

This study generated quantitative data, which was analysed with the help of the Statistical Package for Social Sciences (SPSS) version 11.5. T-test was used to test for different groups and between gender of the students. Analysis of Variance (ANOVA) was used to test for differences in post-test between the four groups under study. In conducting both the ANOVA and t-tests the predetermined 0.05 significance (probability) level was used in order to reject or accept the null hypotheses, which postulated equality or non-significant differences between groups. After establishing that there was a statistically significant difference between the means, $F(3, 140) = 21.37$, $P < 0.05$, it was necessary to carry out further tests to find out where the differences existed. There are several post-hoc tests that could be used depending on the comparison of interest. The Least Significant Difference (LSD), Post hoc test was used for the mean separations with each separate comparison tested at 0.05 (Moore & MC Cabe, 1989).

In order to determine the differences in motivation and achievement in Biology between girls and boys and between experimental and control groups, t-test was used. On the other hand in order to test the significance of the differences in motivation and achievement between the four groups involved in the study a One-way Analysis of Variance, ANOVA was used. The statistical analyses that were used to test the four hypotheses are summarized in Table 4.

Table 4:

Summary of Methods used to Test Hypotheses

Hypothesis	Independent variables	Extraneous Variables	Dependent variables	Method of analysis and statistical test
H_O1 There is no statistically significant difference in achievement in Biology between learners who are taught using the Concept and Vee mapping strategies and those taught using the traditional method.	Concept and Vee mapping strategy		Achievement (Test scores)	t-test and One-way Analysis of Variance (ANOVA)
H_O2 There is no statistically significant difference in the level of motivation in Biology between learners taught using the Concept and Vee mapping strategy and those taught using traditional methods.	Concept and Vee mapping strategy		Motivation (scores)	t-test and One-way Analysis of Variance, ANOVA
H_O3 There is no statistically significant difference in achievement in Biology between boys and girls taught using the Concept and Vee mapping strategy.	Concept and Vee mapping strategy	Gender	Achievement scores	t-test
H_O4 There is no statistically significant difference in motivation to learn Biology between boys and girls taught using the Concept and Vee mapping strategy.	Concept and Vee mapping strategy	Gender	Motivation	t-test

CHAPTER FOUR:

RESULTS, INTERPRETATION AND DISCUSSION

4.1 Introduction

In this chapter, results obtained, their interpretation and discussion are presented. The results are presented in form of tables. This chapter is organized into the following sections:-

(a) Results of the pre-test.

(b) Effects of CVMS on students' achievement in Biology.

(c) Effects of CVMS on students' motivation to learn Biology.

(d) Achievement of boys and girls who were exposed to CVMS teaching approach.

(e) Motivation of boys and girls who were exposed to CVMS teaching approach.

(f) Discussion of the results.

4.2 Results of the Pre-test

The Solomon Four Non-equivalent Group Design used in this study enabled the researcher to have two groups sit for the pre-test. Group 1 and 2 sat for the pre-test BAT. As recommended by Gall, Borg and Gall (1996) this was necessary because it enabled the researcher to:-

(i) Assess the effects of pre-test relative to no pre-test.

(ii) Assess if there was an interaction between the pre-test and the treatment conditions.

(iii) Assess the similarity of the groups before administration of the treatment

4.2.1 Performance In BAT Pre-Test Between Experimental And Control Groups

To assess the similarity of experimental and control groups, a BAT pre-test was administered to Form Two students in groups 1&2 prior to the experiment. Group 1 and group 2 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 statistical differences in their performance. Table 5 shows the results of the t-test.

Table 5:

Independent Samples T-Test of the Pre-Test Mean Scores on BAT

Group	Mean score	Std. Dev.	T-value	P-value
1	6.94	5.04	-0.937	0.352(ns)
2	8.40	7.13		

Group 1, N = 32; Group 2, N = 30

ns= not significant at P< 0.05 level; Std. Dev = Standard deviation

An examination of the results in Table 5 shows that the mean scores for groups 1 and 2 on pre-test BAT are not statistically different. The T-value of 0.937 has a significant level (p–value) of 0.362, which is much greater than the threshold 0.05 level. The implication is that group 1 and group 2 are homogenous in their learning ability.

4.2.2 Performance in pre-test BAT between Boys and Girls

Table 6 shows the results of the pre-test BAT scores for boys and girls in group 1 and 2

Table 6:

Independent samples t-test of the pre-test scores on BAT based on student's gender

Gender	Mean	Std. Dev.	T-value	P-value
Male	7.72	6.38	0.121	0.904(ns)
Female	7.52	5.82		

Male, N = 39; Female, N = 23

ns = not significant at P< 0.05 level; Std. Dev. = Standard deviation

An examination of the results in Table 6 shows that the difference in the pre-test mean scores between male and female students in groups 1 and 2 was not statistically significant. This, therefore, means that the male and female students used in the study were similar and were suitable for the study.

4.3 Effects of CVMS on Students' Achievement in Biology

The BAT mean scores achieved by students in the four respective groups are presented in Table 7.

Table 7:

BAT post-test mean score obtained by the students in the four groups

Group	N	Mean score	Std. Dev.
1	32	38.44	11.61
2	30	31.03	9.73
3	44	49.66	20.83
4	38	24.89	11.58
Total	144	36.66	18.91

Results in Table 7 shows that group 3 had the highest post-test mean score at 49.66 followed by group 1 with a mean score of 38.44. Groups 2 and 4, which were control, groups had lower mean scores at 31.03 and 24.89 respectively. The scores achieved by students in the four groups were then analysed, using One-way Analysis of Variance (ANOVA), to determine the relative effects of CVMS teaching approach on students' achievement. This was to test hypothesis H_o1 of the study, which sought to find out whether there was any statistically significant difference in achievement between students exposed to CVMS teaching approach and those exposed to traditional methods.

The results of the One-way Analysis of Variance (ANOVA), based on those means are shown in Table 8.

Table 8:

Analysis of Variance (ANOVA) of the Post-test Scores

	Sum of squares	df	Mean square	F	p-value
Between groups	13744.69	3	4,581.56	21.37	0.000
Within Groups	30010.31	140	214.36		
Total	43755.00	143			

Results in Table 8 reveal that there exists a statistically significant difference in the mean scores across the four groups since the p-value of 0.00 is less than the acceptable value of

0.05. In other words, some groups achieved significantly higher scores in post-test BAT than other groups.

Table 9 shows the results of the LSD post-hoc comparisons of the post test mean scores of the 4 groups

Table 9:

LSD Post Hoc Comparisons of the Post-test of BAT means of the Four Groups

	1	2	3	4
1	-	7.40*	-11.22*	13.54*
2	-7.40*	-	-18.63*	6.14
3	11.22*	18.63*	-	24.76*
4	-13.54*	-6.14	-24.76*	-

* The mean difference is significant at $p<0.05$

Results in Table 9 show that the mean difference between group 1 and groups 2, 3 and 4 was statistically significant. Group 1 achieved a higher mean score compared to groups 2 and 4. However, it achieved a lower mean score compared to group 3. Group 1 and 3 showed statistically significant difference in their means regardless of being experimental groups. This could be attributed by other factors besides the treatment that ought to be investigated.

The mean score for group 2 students was also found to be statistically different from groups 1 and 3. Group 2 students achieved a lower mean score compared to groups 1 and 3. However, group 2 achieved a higher but non-significant mean score compared to group 4. The mean difference between group 3 and groups 1, 2 and 4 was statistically significant at an alpha level of 0.05 whereby group 3 achieved a higher mean score than the three groups.

The mean difference between group 4 and groups 1, 2, and 3 was –13.54, -6.14 and –24.76 respectively. Group 4 achieved the lowest mean score compared to the three groups. Results also show that the mean difference between group 4 and groups 1 and 3 was statistically significant. However, the mean difference between group 4 and 2 was not statistically significant.

To compare the performance in post-test BAT between experimental groups and control groups, an independent sample t-test was employed. This was done by categorizing the 4 groups into 2 groups of experimental (group 1 and 3) and control (group 2 and 4) then running the t-test whose results are shown in Table 10.

Table 10:

Independent Sample t-test on post-test BAT between Experimental and Control Groups

Group	N	Mean	Std. Deviation	T	df	p-value
Experimental	76	44.93	18.24	6.81	142	0.00
Control	68	27.60	19.80			

Results in Table 10 show significant difference in the mean scores of the experimental and control groups where the experimental group achieved significantly higher scores as compared to the control groups. The results therefore imply that the treatment, CVMS teaching strategy was effective and led to better achievement by students than the traditional teaching approaches.

A comparison of the students' scores in the pre-test and post-test BAT was carried out to establish the mean gain in scores after the treatment. Table 11 shows the mean gain in scores over the pre-test.

Table 11:

Comparison of the Mean Scores and Mean Gain Obtained by Students in the BAT

	Group 1 (N = 32)	Group 2 (N = 30)	Overall (N = 62)
Pre-test mean	6.94	8.40	7.65
Post-test mean	38.44	31.03	36.75
Mean gain	+31.50	+22.67	+29.10

The pre-test and post-test mean scores reveal that both groups gained significantly from the teaching. However, group 1 whose students were taught using the CVMS had by far, a higher mean gain than group 2 whose students were taught using the traditional approach. This strengthens the position that the CVMS resulted in higher achievement than the control condition.

A Summary of the Results for Hypothesis:

(i) The pre-test BAT did not affect the students in the learning of the content. If this was the case, the students who did not do pre-test would not have different results from others who did the pre-test. This therefore made the pre-test suitable for the study.

(ii) The BAT pre-test did not interact significantly with the treatment conditions If this was the case, the students who did not do pre-test would not have different results from others who did the pre-test. (Borg and Gall, 1996).

(iii) The use of CVMS resulted in higher students' achievements than the traditional teaching methods since experimental groups obtained significantly higher scores compared to control groups, as was shown by the independent sample t-test statistics.

(iv) Hypothesis Hol, which stated that there is no statistically significant difference in achievement in Biology between learners who are taught using the Concept & Vee Mapping Strategies and those, taught using the traditional methods is thus rejected.

4.4 Effect of CVMS on Students' Motivation

The results of the post test SMQ mean scores for the respective groups are shown in Table 12.

Table 12:

SMQ post-test mean scores obtained by Students in the Four Groups

Group	N	Mean score	Std. Deviation
1	32	85.53	7.73
2	30	84.20	10.67
3	44	88.60	9.69
4	38	70.24	15.37
Total	144	82.16	13.39

As shown in Table 12, students in group 3 showed the highest level of motivation followed by group 1 and 2 respectively. Students of group 4 showed the lowest level of motivation. The motivation level was tested with reference to the teaching methods used namely CVMS for groups 1 and 3 and the traditional teaching method for groups 2 and 4.

To test hypothesis two, Analysis of Variance (ANOVA), was carried out on SMQ scores. Table 13 presents ANOVA results of the Post Test SMQ scores.

Table 13:

ANOVA Results of SMQ

	Sum of squares	df	Mean score	F	P-value
Between groups	7718.10	3	2572.70	20.08	0.00
Within groups	17933.52	140	128.10		
Total	25651.61	143			

An Analysis of Variance for the Post-test SMQ scores, as shown in Table 13 indicates that there is a statistically significant difference in motivation between the groups. This is because the P-value of 0.00 is less than the threshold alpha of 0.05. The implication is that there exist differences in motivation levels across the four groups of students. After establishing that there was a significant difference between the means for the various groups, it was necessary to carry out further tests on the various combinations of means using LSD, to find out where the difference really occurred. Table 14 gives the LSD post hoc comparisons.

Table 14:

Post Hoc Comparisons of the Post-test SMQ means of the Four Groups

	1	2	3	4
1	-	1.33	-3.07	15.29*
2	-1.33	-	-4.40	13.96*
3	3.07	4.40	-	18.38*
4	-15.29*	-13.96*	-18.38*	-

*The mean difference is significant at the 0.05 level

LSD post hoc comparisons indicate significant differences ($p<0.05$) between groups 1, 2 and 3 on one hand and group 4. The difference between the mean scores of group 1 and 2, 1 and 3 and 2 and 3 was not significant at alpha of 0.05. The expectation was that the motivation level of groups 1 and 3 (experimental) be similar as well as groups 2 and 4 (control). The other expectation was for groups 1 and 3 to be different from groups 2 and 4. However, while group 1 and 3 gave expected results (were similar), group 2 and 4 did not.

Group 2 had unexpectedly high mean scores, which was not statistically different from groups 1 and 3. The implication would be that the students in group 2 drew their motivation for the subject from other factors other than the teaching method.

To compare the performance in post-test SMQ between experimental groups and control groups, an independent sample t-test was employed. This was done by categorizing the four groups into two groups of experimental (group 1 and 3) and control (group 2 and 4) then running the t-test whose results are shown in Table 15.

Table 15:

T-test on mean difference in SMQ scores between experimental and control groups

Group	N	Mean	Std. Deviation	T	df	p-value
Experimental	76	87.31	9.00	5.33	142	0.00
Control	68	76.40	15.12			

Results in Table 15 show that the difference in motivation between experimental groups and control groups was statistically significant at $P<0.05$. Experimental groups scored higher on the motivation index compared to students in the control groups. CVMS strategy therefore has a positive effect on the motivation of students to learn biology.

Hypothesis Ho2, which stated that there is no statistically significant difference in the level of motivation between learners taught using Concept and Vee Mapping teaching strategy and those taught using traditional methods, is thus rejected.

4.5 Effects of CVMS on the Achievement of Boys and Girls

Hypothesis three (Ho3) stated that there is no statistically significant gender difference in achievement when learners are taught using Concept and Vee mapping teaching strategy. To test this hypothesis, post test BAT scores of experimental groups 1 and 3 were used in the analysis. The experimental groups had a total of 41 male students and 35 female students. The post-test BAT scores for the boys and girls involved are presented in Figure 3.

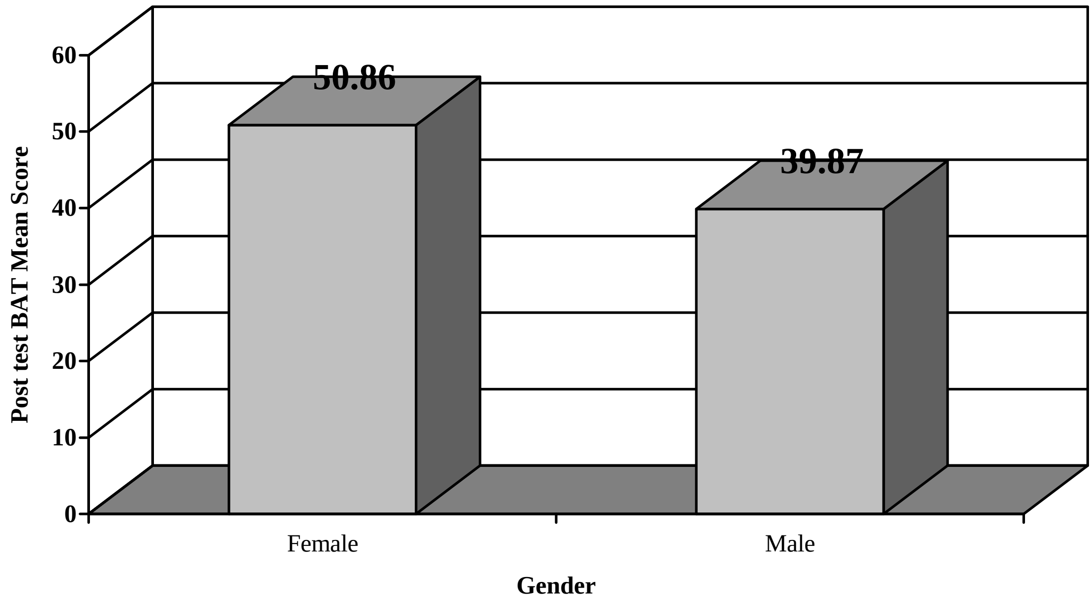

Figure 3: Post-test BAT Mean Scores of Boys and Girls

The results in Figure 3 show that female students scored higher than male students. The mean scores were 50.86 for female students and 39.87 for the male students. The difference in the means is approximately 11 percentage parts.

In order to test Hypothesis Ho3 that sought to establish whether there is a statistically significant difference between the achievement of boys and girls who were taught using the CVMS, an independent sample t-test was carried out. The t-test results are shown in Table 16.

Table 16:

Independent sample t-test results of the post-test BAT Scores of Boys and Girls Exposed to CVMS

Gender	N	Mean	Std. Deviation	T	df	p-value
Male	41	39.87	16.68	-2.71	74	0.01
Female	35	50.86	18.59			

As shown in Table 16, the P-value is 0.01, which is less than the acceptable alpha of level 0.05. This means the difference in the BAT post-test mean scores of boys and girls taught using CVMS was statistically significant. The implication is that CVMS leads to higher achievement in biology among girls than boys. Hypothesis Ho3, which stated that there is no statistically significant gender difference in achievement in biology when taught using Concept and Vee Mapping teaching strategy was thus rejected.

4.5 Effects of CVMS on the Motivation of Boys and Girls

The research also sought to establish the effect of CVMS on the motivation to learn biology among boys and girls. There were in total 41 boys and 35 girls in the experimental group whose mean scores on the motivation index for the SMQ is shown in Figure 4.

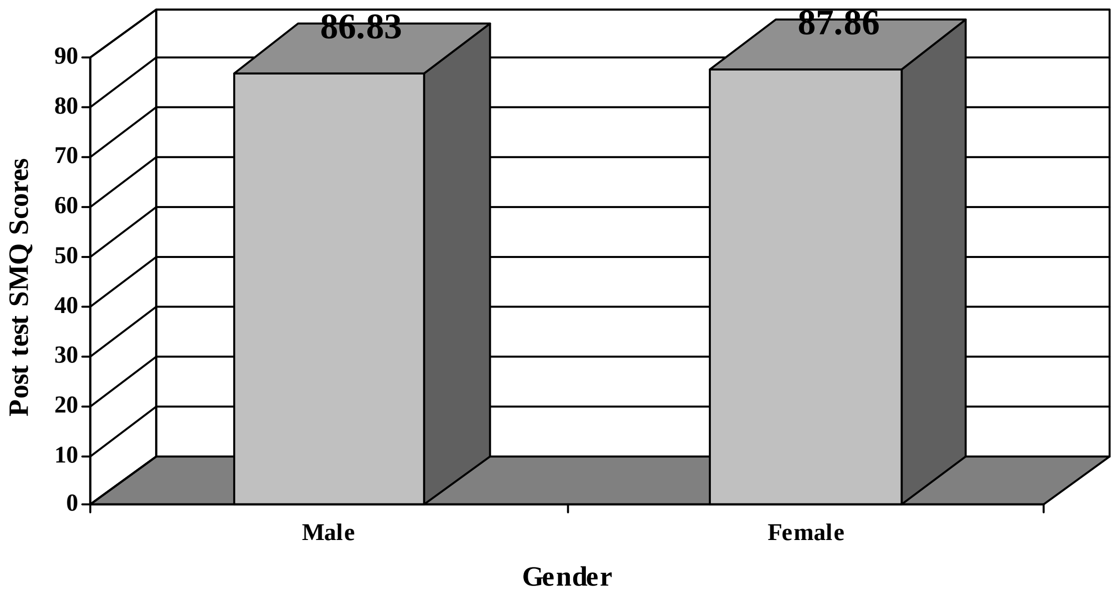

Figure 4: SMQ Mean scores based on gender

Results in Figure 4 show that girls' students scored slightly higher than boys on the SMQ with a mean score of 87.86 and 86.83 respectively.

To test H_04, which sought to establish if there was a statistically significant difference in motivation between boys and girls taught using CVMS strategy, an independent t-test was used. The results are presented in Table 17.

Table 17:

Independent sample t-test on motivation scores of boys and girls

Gender	N	Mean	t-value	df	P-value
Male	41	86.83	-0.492	74	0.62
Female	35	87.86			

Results in Table 17 show that the t-test had a p-value of 0.62, which is far greater than the acceptable alpha of 0.05. There is, therefore no statistically significant gender difference in the motivation scores. This implies the motivation level of boys and girls who were taught using the CVMS strategy was similar.

Hypothesis H_o4, which stated that there is no statistically significant gender difference in motivation to learn Biology when learners are taught using Concept and Vee Mapping teaching strategy is thus accepted.

Discussion of the Results

The results have shown that students who were taught using CVMS achieved significantly higher scores in the BAT than those who were taught by traditional teaching approaches. The experimental group also achieved a higher mean gain in the post-test over the pre-test. The positive effect of CVMS teaching strategy is attributed to the fact that the overall framework of the concepts being learned is made explicit and this ensures careful sequencing of the material in order to promote meaningful learning. The students can also attribute higher achievement to its effectiveness in revealing patterns of understanding and misunderstanding. CVMS also make students to understand the general worldview and philosophy guiding the inquiry and the beliefs about the nature of knowledge being sought. It gives students the awareness of relevant concepts and theories, data recording and transforming procedures as well as knowledge and value claims that derive from the inquiry (as in laboratory experiment exercises).

Similar work by Kinchin and Ian (200), though focussing only on use of concept mapping in Biology teaching, found similar results and concluded that concept mapping leads to meaningful learning. Consequently, Novak and Gowin (1990) and Okebukola (1992) concluded that the positive effect of concept mapping was attributed to its being interactive, creative and visual. Similar results were also found by Orora, Wachanga and Keraro (2007) who investigated the effect of Cooperative Concept Mapping approach on students' achievement in Biology.

The results of this study indicate that students in the experimental were highly motivated compared to the students in the control groups. This shows that CVMS resulted in higher students' motivation than the traditional teaching methods. This can be explained by the nature of the concept and vee mapping strategy's interactive nature. Students are actively involved in the construction of the concepts and vee maps. This draws their interest in the subject under discussion.

The traditional teaching methods, which are commonly used in Kenya's secondary schools, are teacher-centred and thus students control and participation is minimal (Brown & Atkins, 1988). In contrast to the traditional teaching methods, the Concept and Vee–mapping strategy is learner–centred, hence maximizing student control and participation. Concept maps and vee maps are powerful graphic techniques, which work in harmony with how the mind function (Gordon & Jeannette, 2001). The maps are more visual than the traditional notes because they show the relationship between the different concepts being learned. The task of making the maps in itself requires clear thinking and understanding and this in turn improves learning (John, 2003).

According to Cheryl (1992), there are three motivational orientations i.e. intrinsic, extrinsic and amotivation. While Concept and Vee Mapping improves intrinsic and extrinsic motivation among students, other factors could also have extrinsic motivation effects on students. This could explain why students in group 2, who were taught using the traditional method, also exhibited an equally high level of motivation. Such factors ought to be investigated and reported.

Therefore, the higher motivation acquired by students who were taught using CVMS strengthens the case for implementation of this method in secondary Biology teaching. If this is implemented, the teachers' task will be easier because they will be dealing with motivated learners.

In their study on the effects of using the cooperative concept mapping (CCM) teaching approach on secondary school students' motivation in biology, Keraro et al. (2007) also found out results similar to this study. CCM teaching approach led to increased motivation among students to learn biology.

The findings of this study have shown that there was a statistically significant difference in post-test BAT means scores between boys and girls who were taught using CVMS. Girls taught using the strategy achieved significantly higher scores than the boys. According to Collins (1985), girls utilize their right side of the brain more, which emphasizes Rhyme, Rhythm, pictures and imagination. This is contrasted to boys who mostly use their left hemispheres, which emphasize words, Logic, Mathematics, numbers and sequence. The CVMS would have probably enhanced learning for girls more than boys because of their pictorial or graphic nature. Therefore the disparity between girls' and boys' achievement at KCSE Biology examination can be addressed by using the Concept Mapping and Vee Mapping Strategies.

The results indicate that girls and boys taught using CVMS had similar scores on post-test SMQ implying similar motivation levels. From the findings of this study, CVMS is shown to have eliminated the gender disparity in motivation to learn Biology. These results are in agreement with work done by Keraro, Wachanga and Orora (2007) who investigated the effects of using the cooperative concept mapping (CCM) teaching approach on secondary school students' motivation in biology. According their study, there was no statistically significantly gender difference in motivation towards the learning of biology among secondary school students exposed to CCM. According to a research done by the Forum for African Women Educationists (FAWE, 1999), aimed at improving the participation and performance of girls in science and mathematics in primary and secondary schools, it was reported that the achievement of girls in science in Kenya was far lower than that of boys. This was partly attributed to the poor attitude girls have towards science subjects. The Female Education in Mathematics and Science in Africa (FEMSA, 1997) argued that poor attitudes of girls are due to the traditional teaching methods, which provide a conducive environment for teachers to consciously or unconsciously discourage girls' participation in learning. The FAWE (1999) also reported 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. This erodes their confidence thus leading to low achievement.

CHAPTER FIVE:

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of the contributions of this study to the body of knowledge in the area, conclusions, recommendations and suggestion for further research.

5.2 Summary

A summary of the main findings of this study based on the results in chapter four are presented. First: the use of CVMS teaching strategy led to better achievement in biology compared to the use of traditional teaching approaches. Second: the results of this study indicate that the CVMS resulted in higher students' motivation to learn biology as compared to the traditional teaching methods. This was attributed to the active role that students play in the learning process. Third: Female students taught using CVMS teaching strategy had higher mean scores in Biology Achievement Test (BAT) compare to boys. And Fourth: the results showed that the motivation to learn biology was similar for boys and girls who were taught using the Concept and Vee Mapping teaching strategy hence eradicating the gender disparity.

5.3 Conclusion

Results revealed that the use of CVMS in teaching Biology in mixed secondary schools leads to higher student achievement compared to the traditional teaching approaches. This is because the CVMS teaching strategy is more interactive than the traditional approaches.

Consequently, the use of CVMS in teaching Biology leads to higher motivation of students to learn the subject compared to the traditional teaching approaches. Its interactive nature makes students desire to learn more about the subject at hand. A discussion with the students revealed that they were surprised on discovering the interplay between conceptual and methodological elements involved in practical work when taught using CVMS teaching strategy. This increased their motivation to learn the topic more.

While the CVMS strategy leads to better achievement in Biology for both male and female students, its impact on achievement is felt more among female students compared to the male students. Since the performance of girls has consistently been lower generally than that of boys, this strategy could just be the best to uplift the performance of girls in Biology.

Results also led to the conclusion that the use of CVMS teaching strategy increases the motivation to learn Biology equally among male and female students. The method can therefore be useful in addressing the existing gender based differences in motivation to learn Biology that is currently expressed with use of traditional teaching methods.

CVMS could therefore be used to address the problem of poor performance in Biology if adopted as one of the teaching approaches. The incorporation of these approaches in teaching would be beneficial to learners. In view of this, the following recommendations are made.

5.4 Recommendations

i. The adoption of CVMS teaching strategy is necessary to address the current poor performance of students in Biology.

ii. The adoption of CVMS teaching strategy would enhance the interest and motivation of secondary students in learning Biology as a science subject.

iii. Since the achievement of female students in Biology has, over the years, been lower than that of their male counterparts, this teaching approach is recommended to boost the girl’s performance to the level of boys and eradicate the gender disparity.

iv. Kenya Institute of Education (K.I.E) should consider adopting CVMS teaching strategy as a viable teaching approach for Biology in Kenyan secondary schools. This is because KIE is responsible for preparing teaching and learning materials that are used in all schools in Kenya. The materials prepared by KIE have classroom teaching and learning instruction in addition to the content.

5.5 Areas of further Research

The following areas require further investigation:-

(i) A study on the application of CVMS in sciences as an evaluation tool for student achievement.

(ii) A study to give further insight into the finding that girls tend to perform better than boys when taught using the CVMS.

(iii) A study on the effects of CVMS in teaching on the acquisition of the science process skills at secondary school level.

(iv) A study on the effects of CVMS teaching approach on secondary school learners creativity in Biology.

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APPENDIX A: Students' Motivation Questionnaire (SMQ1)

School……………………………………………

Student No……………………………….……

Class……………………………………………….

Gender…………………………………………..

The purpose of this questionnaire is to find out what you think about the biology subject. Please indicate what your view is about each item.

INSTRUCTIONS

1. Read each item carefully and ensure that you have understood before choosing what truly agrees with what you think.
2. Circle around the letter that corresponds with how you really feel towards the biology subject. Circle only one of the choices.
3. The choices are: SA = Strongly agree, A = Agree, D= Disagree, SD = Strongly disagree, U = Undecided.
4. If you change your mind about an answer, you may cross it neatly and circle another one.

Example: A student who agrees with the following statement would answer as follows:-

Solving problems in practical work in biology using vee mapping was stimulating.

SD D U A SA

ITEMS

Learning biology with the teacher using Concept and Vee mapping was:

1.	Fun	SD	D	U	A	SA
2.	Satisfying	SD	D	U	A	SA
3.	Informative	SD	D	U	A	SA
4.	Useful	SD	D	U	A	SA
5.	Boring	SD	D	U	A	SA
6.	Frustrating	SD	D	U	A	SA
7.	Hard	SD	D	U	A	SA
8.	Challenging	SD	D	U	A	SA

Learning biology subject by using Concept and Vee mapping ourselves was:

1.	A pleasure	SD	D	U	A	SA
2.	A source of anxiety	SD	D	U	A	SA
3.	Fearful	SD	D	U	A	SA
4.	Too stressful	SD	D	U	A	SA
5.	Too demanding	SD	D	U	A	SA
6.	Exciting	SD	D	U	A	SA

Learning biology using Concept and Vee maps prepared by students made me:

1.	Feel confident about the biology subject	SD	D	U	A	SA
2.	Feel eager to learn the biology subject	SD	D	U	A	SA
3.	Doubt my ability to learn biology	SD	D	U	A	SA
4.	Want to apply my knowledge to solve practical problems	SD	D	U	A	SA

5.	Happy	SD	D	U	A	SA
6.	Excited	SD	D	U	A	SA
7.	Feel as if I was wasting my time	SD	D	U	A	SA
8.	Frustrated	SD	D	U	A	SA
9.	Unhappy	SD	D	U	A	SA

The learning strategies of Concept and Vee mapping made me:

1.	Appreciate biology	SD	D	U	A	SA
2.	Dislike biology	SD	D	U	A	SA
3.	Interested in biology	SD	D	U	A	SA
4.	Scared of biology	SD	D	U	A	SA
5.	Like biology	SD	D	U	A	SA

Learning biology using Concept and Vee maps prepared by the teacher made me:

1.	Feel confident about the biology subject	SD	D	U	A	SA
2.	Feel eager to learn the biology subject	SD	D	U	A	SA
3.	Doubt my ability to learn biology	SD	D	U	A	SA
4.	Want to apply my knowledge to solve practical problems	SD	D	U	A	SA
5.	Happy	SD	D	U	A	SA
6.	Excited	SD	D	U	A	SA
7.	Feel as if I was wasting my time	SD	D	U	A	SA
8.	Frustrated	SD	D	U	A	SA
9.	Unhappy	SD	D	U	A	SA

APPENDIX B: Students' Motivation Questionnaire (SMQ2)

School………………………………………………

Student No……………………………………..……

Class……………………………………………….

Gender……………………………………………..

The purpose of this questionnaire is to find out what you think about the biology subject. Please indicate what your view is about each item.

INSTRUCTIONS

1. Read each item carefully and ensure that you have understood before choosing what truly agrees with what you think.
2. Circle around the letter that corresponds with how you really feel towards the biology subject. Circle only one of the choices.
3. The choices are: SA = Strongly agree, A = Agree, D= Disagree, SD = Strongly disagree, U = Undecided.
4. If you change your mind about an answer, you may cross it neatly and circle another one.

Example: A student who agrees with the following statement would answer as follows:-

Solving problems in practical work in biology with the teacher demonstrating was stimulating.

SD D U A SA

ITEMS

Learning of the topic respiration was:

1.	Fun	SD	D	U	A	SA
2.	Satisfying	SD	D	U	A	SA
3.	Informative	SD	D	U	A	SA
4.	Useful	SD	D	U	A	SA
5.	Boring	SD	D	U	A	SA
6.	Frustrating	SD	D	U	A	SA
7.	Hard	SD	D	U	A	SA
8.	Challenging	SD	D	U	A	SA
9.	A pleasure	SD	D	U	A	SA
10	A source of anxiety	SD	D	U	A	SA
11.	Fearful	SD	D	U	A	SA
12.	Too stressful	SD	D	U	A	SA
13	Too demanding	SD	D	U	A	SA
14.	Exciting	SD	D	U	A	SA
15.	Interesting	SD	D	U	A	SA

Learning of this topic respiration made me

1.	Feel confident about the biology subject	SD	D	U	A	SA
2.	Feel eager to learn the biology subject	SD	D	U	A	SA
3.	Doubt my ability to learn biology	SD	D	U	A	SA
4.	Want to apply my knowledge to solve practical problems	SD	D	U	A	SA
5.	Happy	SD	D	U	A	SA
6.	Excited	SD	D	U	A	SA
7.	Feel as if I was wasting my time	SD	D	U	A	SA
8.	Frustrated	SD	D	U	A	SA
9.	Unhappy	SD	D	U	A	SA
10.	Appreciate biology	SD	D	U	A	SA
11.	Dislike biology	SD	D	U	A	SA
12.	Interested in biology	SD	D	U	A	SA
13.	Scared of biology	SD	D	U	A	SA
14.	Like biology	SD	D	U	A	SA
15.	Want to learn biology to higher levels	SD	D	U	A	SA

APPENDIX C:BIOLOGY ACHIEVEMENT TEST (BAT) : PRE-TEST

School……………………………………………. ADM. NO………………………….
Class:…………………………………………….. Gender……………………………...

INSTRUCTIONS

- ☐ Answer all questions in the spaces provided.
- ☐ Read the questions carefully to ensure that you understand it before writing your answer.

1. What do you understand by the term respiration?
………………………………………………………………………………
……………………………………………………………………………….

2. What is the importance of respiration in an organism?…………………………
………………………………………………………………………………

3. Where does respiration occur in the cell?………………………………………….

4. Name three raw materials which are used in the process of respiration.
………………………………………………………………………………

5. Name three products of aerobic respiration in plants……………………………..
………………………………………………………………………………

6. List five differences between aerobic respiration and anaerobic respiration.

Aerobic respiration	Anaerobic respiration

7. Are the two forms of respiration in Q6 above mutually exclusive? Explain………
………………………………………………………………………………
………………………………………………………………………………

8. Name three conditions, which are necessary for aerobic respiration to take place.
………………………………………………………………………………………………
………………………………………………………………………………………………
…………………………………………………………………

9. An organism in the course of respiration uses 250cm^3 of oxygen. It gives out 250cm^3 of CO_2 during the same period. Calculate the respiratory Quotient (RQ).

10. Use an equation to summarize chemical changes, which take place in germinating

bean seeds in anaerobic conditions…………………………………………………

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

11. The metabolism of a particular food substance is represented by the following equation $2C_2 H_{98} O_6 + 145 O_2 \rightarrow 102 CO_2 + 98 H_2O + E$
Calculate the respiratory quotient (RQ).

12. What is the significance of respiratory quotient (RQ) in metabolism? ……………………………………………………………………………………
……………………………………………………………………………………

13. State four (4) factors, which affect the respiratory Quotient (RQ) in animals
………………………………………………………………………………………………
……………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………

14. Complete the table below by filling in the general role played by each of the following groups of enzymes in respiration.

Group of enzymes	Role in respiration
(i) Phosphorylases	
(ii) Hydrogenases	
(iii) Decarboxylases	
(iv) Isomerases	

15. State two (2) uses of energy released from breakdown of ademosine triphosphate (ATP) in the cell.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

16. Differentiate between obligate anaerobes and facultative anaerobes.

……………………………………………………………………………………………

……………………………………………………………………………

17. Briefly describe the process of aerobic respiration in a living cell.

……………………………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………

18. Define the following terms, giving an example in each case

Definition	**Example**
Metabolism	
Anabolism	
Catabolism	

19. Name the condition under which aerobic and anaerobic occur in muscle cells and compare the amount of energy produced in each case…………………………..

20. In man, aerobic breakdown of glucose yields 2880 kj of energy whereas anaerobic breakdown yields 150 kj. Give an explanation to account for this difference………………………………………………………………………………
………………………………………………………………………………………
…………………………………………………………………

21. Under what conditions do animals use the following foods for respiration?

(a) Carbohydrates ……………………………………………………………...

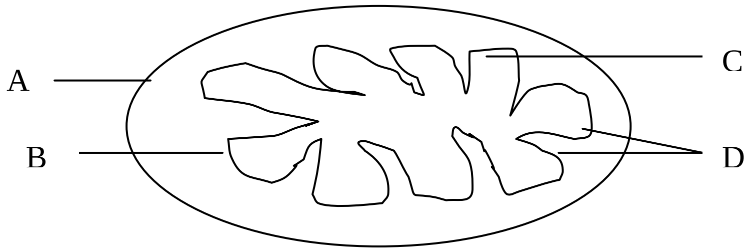
(b) Fats ……………………………………………………………………………

(c) Proteins …………………………………………………………………….

22. Explain what you understand by the term basal metabolic rate (BMR)

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

Below s a diagram of an organelle that is involved in aerobic respiration. Use it to answer questions 23-26



23. Name the organelle drawn above ……………………………………………

24. Name the parts labeled A …………………………………………………

B ……………………………………………

C ……………………………………………

25. What is the purpose of the foldings labeled D ……………………………
………………………………………………………………………………

26. Give the full name of the chemical compound which is formed in this organelle and forms the immediate source of energy for biological activities.

………………………………………………………………………………

27. Name two industrial uses of anaerobic respiration ……………………………

……………………………………………………………………………

28. Name the products of anaerobic respiration in yeast cells ……………

………………………………………………………………………………

29. Briefly explain how the body uses proteins as a source of energy

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………

30. Write an equation to summarize aerobic respiration in muscle cells.

………………………………………………………………………………………

………………………………………………………………………

APPENDIX D:BIOLOGY ACHIEVEMENT TEST (BAT) : POST-TEST

School……………………………………………. ADM. NO………………………….
Class:…………………………………………….. Gender……………………………...

INSTRUCTIONS

- Answer all questions in the spaces provided.
- Read the questions carefully to ensure that you understand it before writing your answer.

1. Name the condition under which aerobic and anaerobic occur in muscle cells ………………………………………

2. Briefly describe the process of aerobic respiration in a living cell.

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

   ………………………………………………………………………………

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

3. What is the importance of respiration in an organism?…………………………
   ………………………………………………………………………………………

4. An organism in the course of respiration uses $250cm^3$ of oxygen. It gives out $250cm^3$ of CO_2 during the same period. Calculate the respiratory Quotient (RQ).

5. Name three products of aerobic respiration in plants……………………………..
   ……………………………………………………………………………………

6. Differentiate between obligate anaerobes and facultative anaerobes.

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

7. The metabolism of a particular food substance is represented by the following equation $2C_2H_{98}O_6 + 145\ O_2 \rightarrow 102\ CO_2 + 98\ H_2O + E$
   Calculate the respiratory quotient (RQ).

8. In man, aerobic breakdown of glucose yields 2880 kj of energy whereas anaerobic breakdown yields 150 kj. Give an explanation to account for this difference……………………………………………………………………………………
………………………………………………………………………………………
……………………………………………………………………

9. Name the products of anaerobic respiration in yeast cells …………………..

…………………………………………………………………………

10.Write an equation to summarize aerobic respiration in muscle cells.

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

11. Where does respiration occur in the cell?……………………………………….

(i) Phosphorylases	
(ii) Hydrogenases	
(iii) Decarboxylases	
(iv) Isomerases	

12. State two (2) uses of energy released from breakdown of ademosine triphosphate (ATP) in the cell.

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

1. Briefly explain how the body uses proteins as a source of energy

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

14. Complete the table below by filling in the general role played by each of the following groups of enzymes in respiration.

Group of enzymes	Role in respiration
(i) Phosphorylases	
(ii) Hydrogenases	
(iii) Decarboxylases	
(iv) Isomerases	

15. Give the full name of the chemical compound which is formed in this organelle and forms the immediate source of energy for biological activities.

…………………………………………………………………………………….

16. State four (4) factors, which affect the respiratory Quotient (RQ) in animals
……………………………………………………………………………………………
…………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………

17. Under what conditions do animals use the following foods for respiration?

(a) Carbohydrates ……………………………………………………………...

(b) Fats ……………………………………………………………………………

(c) Proteins ……………………………………………………………………….

18. Name two industrial uses of anaerobic respiration ……………………………

……………………………………………………………………………………..

19. What do you understand by the term respiration?
……………………………………………………………………………………

……………………………………………………………………………

20. What is the significance of respiratory quotient (RQ) in metabolism?

21. Define the following terms, giving an example in each case

Definition	**Example**
Metabolism	
Anabolism	

22. List five differences between aerobic respiration and anaerobic respiration.

Aerobic respiration	Anaerobic respiration

23. Are the two forms of respiration in Q6 above mutually exclusive? Explain………
………………………………………………………………………………………
………………………………………………………………………………………

Below s a diagram of an organelle that is involved in aerobic respiration. Use it to answer questions 24-26

24. Name the organelle drawn above……………………………………………………………

25. Name the parts labeled A……………………………………………………………..

B………………………………………………………………

C………………………………………………………………

26. What is the purpose of the foldings labeled

D…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………

27. Explain what you understand by the term basal metabolic rate (BMR)

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

28. Name three raw materials, which are used in the process of respiration.

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

29. Name three conditions, which are necessary for aerobic respiration to take place.

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

30. Use an equation to summarize chemical changes, which take place in germinating bean seeds in anaerobic conditions.

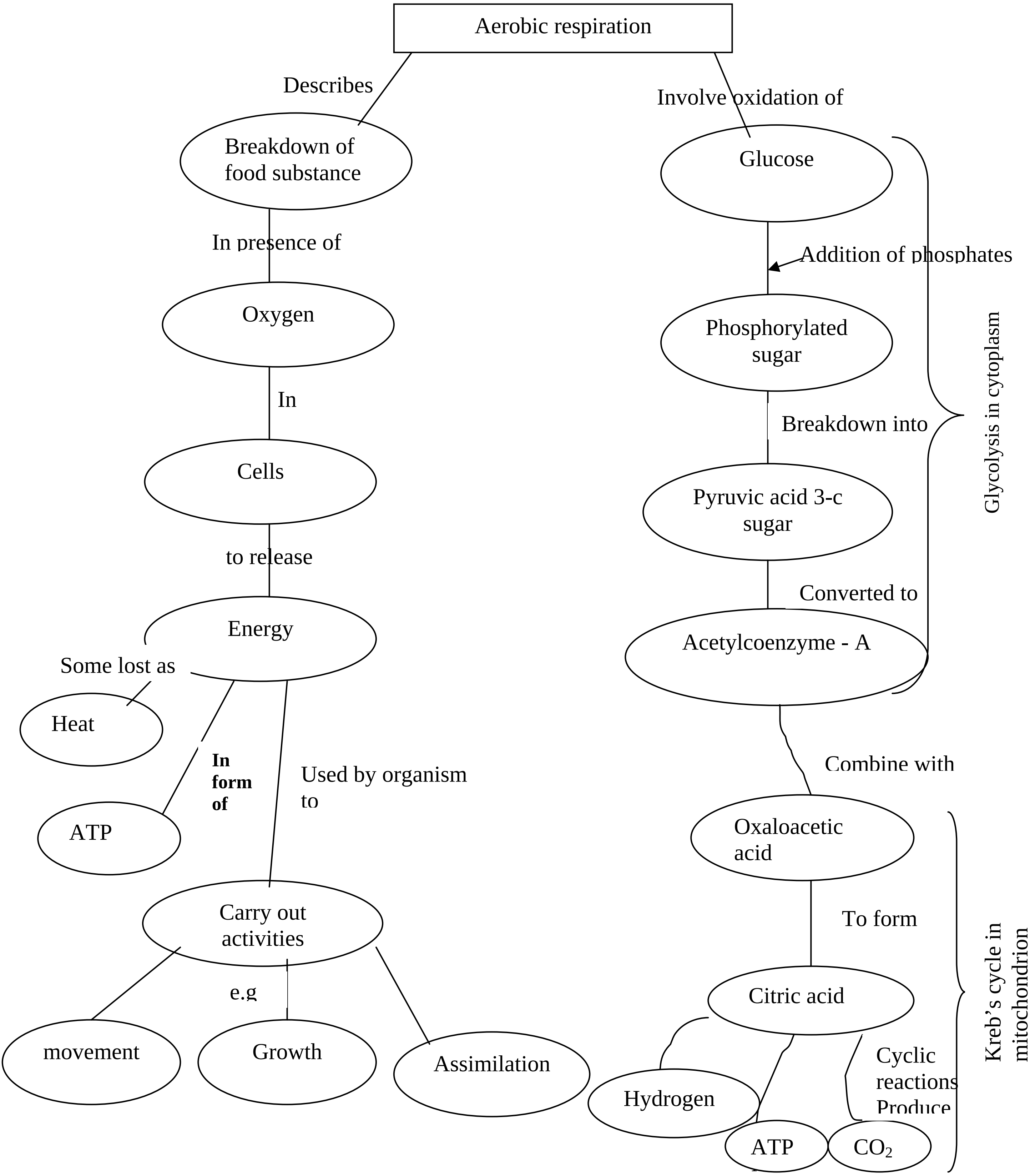
………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

APPENDIX E: Concept Map



APPENDIX F (Vee Map)

THINKING SIDE (Conceptual)

Theory

- Some of the energy produced in respiration is lost as heat

Principles

- Heat energy is one of the products of respiration
- Heat produced can be measured

Constructs

- Breakdown of glucose release energy
- Breakdown of ATP release energy

FOCUS QUESTION

Is heat produced during anaerobic respiration?

DOING SIDE (Methodological)

Value Claim

- Heat released during respiration helps to maintain suitable temp. of cells for enzyme activity

Knowledge Claims

- Enzymes, present in living cells work best at certain temperature range.
- Heat produced enhance enzyme activity

Transformations

Thermometer readings.

Thermos flask	Treatment	Reading (O C after
A	100ml 10% glocuse soln +oil + unboiled 10% yeast suspension + thermometer	1st hr 2nd 3rd 4th 5th 6th 7th
B	100ml 10% glucose soln + oil + 10% boiled yeast suspension + thermometer	1st hr 2nd 3rd 4th 5th 6th 7th

Note: glucose is first boiled in order to expel O_2

Records

- Temp. Readings after every 1 hour up to 7 hours
- Gradual increase in temp.flask A while B remain more or less constant

EVENTS

- Anaerobic respiration occurs in flask A, releasing energy, some of which is produced in form of heat
- In flask B, respiration does not occur since the respiratory enzymes in the yeast suspension were denatured by boiling

APPENDIX G: TRAINING MANUAL FOR TEACHERS & STUDENTS

INTRODUCTION TO CONCEPT MAPPING

1. Make a list of nouns of familiar objects on the chalkboard, for example tractor, cow, table, plant and computer. Make another list of verbs of familiar events such as moving, flowering, typing, milking and eating. Assist learners to understand that the first list represents names of objects or things and the second one is of events or happenings.
2. Ask the learners to describe what they "see mentally" or think when they hear the words on the first list (tractor, cow, table, plant, and computer). Consequently, help them to understand and realize that even though we use the same words to communicate, each of us may think of something a bit different. We may have different mental images for each word. These mental images we have for words are our concepts. Therefore at this point, introduce the word concept to the learners.
3. Make a list of other words such as with, of, and, for, where, is, are. Ask learners if these words are also concepts. Help them under that these are not concept words but instead they are linking words. They are used in conjunction with concept words to construct sentences that have meaning.
4. Assist learners to recognize that proper nouns are not concept words but rather names of specific places, objects, events or people.
5. Use two concept words and linking words from the lists to construct a few short sentences on the chalkboard. This will help to illustrate how concept words and linking words are used by human beings (people) to convey meanings or information. Example would be: the tractor is moving or computer is used for typing.
6. Choose a topic from the biology pupils' textbook. Refer to a section of the text that conveys a specific message. Ask the learners to individually and collectively read the passage or paragraph and identify key concepts. Also ask them to take note of some concept words and linking words that are less important in the text.
7. Place the most inclusive (main) concept at the top 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. For example, using taxonomic units in classification of living organisms, the kingdom is placed at the top (as the main concept) followed by phylum/Division, then class, order, family, genus and lastly species as the most specific concept. Students usually don't agree on the ordering but normally only a

few major differences in the ranking of concepts will arise. This observation suggests that readers may see the meaning of the texts in more than one way.

8. Start constructing a concept map, using the rank-ordered list as a guide in building the concept hierarchy. Ask learners to choose good linking words to form the prepositions indicated by lines on the map.
9. Check/look for cross-links between concepts in one section of the map and concepts in another part of the concept 'tree'. Ask students to assist in choosing the linking words for the cross-links.
10. Most maps constructed for the first time have poor symmetry or have some concept clusters poorly located relative to other more closely related concepts or clusters of concepts. Therefore, it may be necessary to reconstruct the map. Point out to learners that at least one and sometimes two or three trials of reconstruction of a map are needed to show a good representation of prepositional meanings, as they understand them.
11. Learner – constructed maps can be presented to the class on the chalkboard. 'Reading' the map should enable other learners in the class to clearly understand what the text was all about, as interpreted by the mapmaker.

INTRODUCTION TO VEE-MAPPING

1. Assist learners to understand that practical work involves observing of objects or events which we choose to observe as well as selecting or constructing objects (events) to be observed, being guided by our concepts, principles and theories.
2. Tell learners that a practical lesson has a question to be answered, for example; is carbon dioxide present in exhaled air? Or is heat evolved during the process of respiration?
3. Learners also need to understand that the question leads to the aim of the experiment and to be able to answer the question, there is need to carry out an investigation. The investigation involves thinking and doing exercises.
4. Thinking requires use of theoretical knowledge, which is categorized into three elements, namely:
   i. **Theory**, which means the general principles guiding the investigation for example respiration involves oxidation.
   ii. **Principles**, which are statements of relationship between concepts that explain how events or objects are expected to appear or behave. For example; food substance (object) **burns** in air, turns black and produce heat and smoke.

iii. **Constructs**, which are ideas showing specific relationships between concepts. For example: Aerobic respiration produce energy, carbon dioxide, and water. Assist learners to understand that the type of respiration is specific and also the products. That is why the term carbon dioxide is used instead of gas.

iv. Concepts, which are labelled ideas or regular events and objects. For example respiration, fermentation, Glycolysis, respiratory quotient, Adenosine Triphosphate among others.

5. Doing component involve performing the experiment or investigation in a particular way. It refers to the method or procedure. Assist learners to understand that in respect to doing, they must consider the following;

i. **Value claims**, that is, a statement to show that what is being investigated is of value. For example respiration produce energy for use by the organism or fermentation is used in bread making.

ii. **Knowledge claims**, which are statements based on reasonable interpretation of data or records that, answers the focus question. For example; some energy produced in respiration is lost in form of heat or carbon dioxide is given off during respiration.

iii. **Transformations,** which refer to tables, graphs, concept maps and statistics among others.

iv. **Records**, which are observations made or recorded from the events or objects.

6. Arrange the elements of thinking component on the left hand side and those of doing on the right hand side. Place the focus question at the top middle position (that is; between the thinking side and the doing side). Put the events, at the bottom middle position.
7. Construct the vee-map by drawing a vee-shape, and then fill in the details under each element on both sides of the vee-map. First you have to fill the left hand side in order to do the right because the left hand side tells you what you have to know. And the right hand side tells you how to do it and how to end it. Therefore the left hand side stuff is what you already know and you use that stuff on the left hand side to figure out the information on the right hand side.
8. Ask learners to provide the details and give them some task of constructing a vee-map, using a given focus question and events.

APPENDIX H: TEACHERS GUIDE ON RESPIRATION

OBJECTIVES:

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

a) Explain the significance of respiration in living organisms.
b) Distinguish between aerobic and anaerobic respiration.
c) Describe the economic importance of anaerobic respiration in industry and at home.
d) Describe experiments to show that respiration takes place in plants and animals.

The Concept maps and Vee maps should be used throughout the teaching learning process. Teacher should show the learner how to draw the maps. Learners must draw the maps both individually and in groups.

WEEK ONE

Lesson 1&2:

Lesson Topic: Respiration

Method: Class discussion (30 minutes)
Group concept mapping (20 minutes)
Presentation and discussion of the concept maps (30 minutes).

Class discussion (30 minutes)

The following points are stressed in the discussion:

(a) Definition of respiration.
(b) Importance and types of respiration.
(c) Respiratory sites in a living organism & cell.
(d) Types of respiratory substrates.
(e) Products of respiration.

Group concept mapping (20 minutes)

Learners to form groups to construct Concept maps based on the content already covered. Learners in their groups to identify important concepts in the content. They then arrange the concepts hierarchically starting with the most inclusive and general to less inclusive and specific concepts. Teacher to move around, ensuring that all learners participate actively and to help them identify and arrange concepts when stuck. Learners to use linking words to link the concepts together.

Presentation and discussion of the concept maps (30 minutes)

One member from each group to present the concept map drawn by the group to the whole class. The class to discuss about the map guided by the teacher. Teacher to make concluding remarks about the various concept maps presented.

Assignment

Learners to draw concept maps on their own based on the content covered.

WEEK ONE

Lesson 4 :	(40 minutes)
Lesson topic:	Anaerobic respiration
Method:	Class discussion (15 minutes)
	Concept mapping (10 minutes)
	Presentation and discussion (15 minutes)

Class discussion (15 minutes)

The following points are stressed during the discussion:-

a) Definition of aerobic respiration
b) Necessary conditions for aerobic respiration
c) The stages

WEEK ONE

Lesson 4	(40 minutes)
Lesson Topic:	Aerobic respiration
Method:	Class discussion (15 minutes)
	Concept mapping (10 minutes)
	Presentation and discussion (15 minutes)

Class discussion (15 minutes)

The following points are stressed during the discussion:-

a) Definition of anaerobic respiration

b) The conditions under which anaerobic respiration takes place

c) The stages involved in anaerobic respiration

d) Where it takes place in a cell and the products

e) Meaning of the terms, fermentation, oxygen debt, obligate anaerobes, facultative anaerobes.

Concept mapping (10 minutes)

Learners to individually construct maps on anaerobic respiration. Teacher to move around in class to ensure that each one is doing the work.

Presentation and discussion of concept maps. (15 minutes)

Teacher to ask a few learners to present their concept maps so that the class can discuss them with the assistance of the teacher.

Assignment

Learners to design an experiment to show that germinating seeds carry out respiration

WEEK TWO

Lesson 5&6

Lesson topic: Aerobic & Anaerobic organisms

Method: Class discussion (30 minutes)

Concept mapping (20 minutes)

Presentation and discussion of concept maps (30 minutes).

Class discussion (30 minutes)

The following points are stressed in the discussion;

a) Industrial uses of anaerobic respiration

b) Obligate anaerobes vs facultative anaerobes.

c) Differences between aerobic respiration and anaerobic respiration.

d) Role of enzymes in respiration

Concept mapping (20 minutes)

Learners to identify important concepts in the content then arrange them hierarchically as before. Teacher to ensure that students are doing the work.

Presentation and discussion of the concept maps (30 minutes)

Several learners to present the concept maps they had each drawn to the whole class for discussion with the help of the teacher. The teacher to make concluding remarks about the concept maps presented.

Assignment

Learners to make a graphic representation of how ATPs are formed and used in a cell.

WEEK TWO

Lesson 7

Lesson topic: Respiratory Quotient (RQ)

Method: Class discussion (15 minutes)

Concept mapping (10 minutes)

Presentation and discussion of concept maps.

Class discussion (15 minutes)

The following points are stressed during the discussion:-

(a) Meaning of respiratory Quotient (RQ)

(b) Calculation of respiratory Quotient (RQ), using either the number of molecules or volume of oxygen used and carbon dioxide produced.

(c) Significance of respiratory Quotient (RQ).

(d) Definition of the terms, catabolism, anabolism and metabolism.

Concept mapping (10 minutes)

Teacher to ensure that learners draw concept maps based on the content discussed.

Presentation and discussion of concept maps (15 minutes).

Several learners to present their concept maps to the class for discussion. Teacher to make concluding remarks.

Assignment

Questions involving calculation of respiratory quotient (RQ).

WEEK TWO

Lesson 8

Lesson topic: Factors affecting respiratory Quotient (RQ).

Method: Class discussion (15 minutes)

Concept mapping (10 minutes)

Presentation and discussion of concept maps. (15 minutes)

Class discussion (15 minutes)

The following points are stressed during the discussion:

a) Oxygen concentration

b) Age

c) Activity

d) Hormones

e) Health

f) Surface area to volume ratio

g) Substrate concentration

h) Temperature

Concept mapping (10 minutes)

Learners to make concept maps based on the content discussed. Teachers to ensure that each learner is involved in doing the work.

Presentation and discussion of concept maps (15 minutes).

A few learners to present their concept maps for class discussion. Teacher to give concluding remarks.

Assignment

(i) Write chemical equations summarizing aerobic and anaerobic respiration in plants and animals.

(ii) Make a concept map for the entire topic of respiration.

(iii) State the aspects of respiration, which can be demonstrated in the laboratory.

WEEK THREE

Lesson 9 & 10

Lesson topic: To demonstrate that carbon dioxide is produced during aerobic respiration and is present in exhaled air.

Method: Class discussion/practical (30 minutes)
Vee – mapping (20 minutes)
Presentation and discussion of Vee-maps (30 minutes).

Class discussion (30 minutes)

Focus question: Is carbondioxide present in exhaled air?

Identify the following elements regarding the investigation to carry out:

(i) **Theory** - Respiration produce carbondioxide.

(ii) **Principles** - Carbondioxide is produced in respiration as a by-product.
- Carbondioxide can accumulate to toxic levels in the body.
- Carbondioxide should be constantly removed from the body.

(iii) **Constructs** - oxidation of glucose converts it's carbon to carbondioxide.
- Carbondioxide is produced in mitochondria when citric acid undergoes cyclic series of reactions.

(iv) **Concepts** - oxidation, glucose, glycolysis, kreb's cycle, expiration, excretion, tissue respiration, mitochondria, and cytoplasm.

(v) **Knowledge claims** - Constant removal of end products is a necessary condition for aerobic respiration.
- Removal of carbondioxide is necessary to avoid poisoning.

(iv) **Value claims** - the removal of carbondioxide in exhaled air is an excretory process.

(vii) **Transformations** - None.

(vii) **Records** - Limewater turns milky, which confirms the presence of C02 in exhaled air.

(ix) **Events** - Breathing air in a beaker containing limewater.

Vee - mapping (20 minutes)

Learner to form groups to construct the vee-maps based on the elements identified. They proceed by drawing a vee, then labelling the left side as thinking side and the right as doing side. On the thinking side are outlined the theory, principles, constructs and relevant concepts. The doing side to contain knowledge claims, value claims, transforms and records. The focus Question is placed at the top centre position and the events written at the bottom centre.

Presentation and discussion of vee - maps (30 minutes)

One member from each group to present the vee – map drawn by the group to the whole class. The class to discuss the vee-map, guided by the teacher. Teachers to make conclusion remarks about the various vee-maps presented.

Assignment

Learners to draw vee - maps to answer the focus question: Is oxygen used in aerobic respiration?

WEEK THREE

Lesson II

Lesson topic: To demonstrate that heat is produced during anaerobic respiration.

Method: Class discussion practical (15 minutes)

Vee - mapping (10 minutes)

Presentation and discussion of vee-maps.

Class discussion/Practical (15 minutes)

Focus Question: Is heat produce during anaerobic respiration?

Teacher to lead learners in identifying the following elements regarding the investigation.

(i) **Theory** - Respiration produce carbon dioxide

- Perspiration produces heat.

(ii) **Principles** - carbon dioxide is produced in respiration as a by-product.

- Carbon dioxide can accumulate to toxic levels in the body.

(iii) **Constructs** - oxidation of glucose converts its carbon-to-carbon dioxide.

- Carbon dioxide is produced in mitochondria when citric acid undergoes cyclic series of reactions.

(iv) **Concepts** - oxidation, glucose, glycolysis, kneb's cycle, expiration, excretion, tissue respiration, mitochondria, and cytoplasm.

(v) **Knowledge claims** - constant removal of end products is a necessary condition for aerobic respiration.

- Removal of carbondioxide is necessary to avoid poisoning.

(iv) **Value claims** - The removal of carbondioxide in exhaled air is an excretory process.

(vii) **Transformations** - None.

(viii) **Records** - Lime water turns milky, which confirms the presence of co_2 exhaled air.

(ix) **Events** - Breathing air in a beaker containing lime water.

Vee mapping (20 minutes)

Leaner to form groups to construct the vee-maps based on the elements identified. They proceed by drawing a vee, then labeling the left side as thinking side and the right as doing side. On the thinking side are outlined the theory, principles, constructs and relevant concepts. The doing side to contain knowledge claims, value claims, transforms and records. The focus question is place at the top centre position and the events written at the bottom centre.

Presentation and discussion of vee - maps (30 minutes)

One member from each group to present the vee - map drawn by the group to the whole class. The class to discuss the vee - map, guided by the teacher. Teacher to make concluding remarks about the various vee-maps presented.

Assignment

Learners to draw vee-maps to answer the focus questions. Is oxygen used in aerobic respiration?

WEEK THREE

Lesson 11

Lesson topic: To demonstrate that heat is produced during anaerobic respiration.

Method: Class discussion practical (15 minutes)

Vee mapping (10 minutes)

Presentation and discussion of vee-maps.

Class discussion/practical (15 minutes)

Focus question: Is heat produced during anaerobic respiration?

Teacher to lead learners in identifying the following elements regarding the investigation.

Theory - Some of the energy produced in respiration lost as heat.

Principles - Heat energy is one of the products of respiration.

- The amount of heat produced can be measured.

Constructs - Breakdown of glucose release energy.

- Breakdown of ademosine triphosphate (ATP)
- Breakdown of release energy.
- Energy released from breakdown of ATP can be converted to mechanical energy or chemical energy.

Relevant concepts - Glucose, ATP, heat energy, mechanical energy, chemical energy, oxidation.

Value claims - Heat released during respiration helps to maintain suitable temperature of cells per enzyme activity.

Knowledge claims - Enzymes present in living cells work best at certain temperature range.

- Heat produced enhance enzyme activity.

Transformations - **Thermometer readings**.

Thermos flask	**Treatment**	**Reading (0c) after**
A	100ml 10% glucose solution toil + unboiled yeast suspension + Thermometer	1st 2nd 3rd 4th 5th 6th 7th 8th
B	100ml 10% glucose Solution + Oil + 10% boiled yeast suspension + thermometer	1st 2nd 3rd 4th 5th 6th 7th 8th

Records - Temperature readings after every one hour up to 8 hours.

- Gradual increase in temperature in flask A
- Temperature readings in flask B remain constant

Events - Anaerobic respiration occurs in flask A, releasing energy, some of which is produced in form of heat.

- in flask B, respiration does not occur since the respiratory enzymes in the yeast suspension were denatured by boiling.

Vee – mapping (10 minutes)

Learners to draw vee-maps following the procedure in the previous lesson. Teacher to ensure that each one does the work.

Presentation & discussion of vee maps (15 minutes)

Teacher to pick on a few learners to present their maps to the whole class for discussion being guided by the teacher. Teacher to make concluding remarks on the vee-maps presented.

Assignment

Learner to draw vee-maps to answer the focus question ‘Is heat produced by germinating seeds?

WEEK THREE

Lesson 12: **(40 minutes)**

Lesson topic: To demonstrate that oxygen is used in aerobic respiration.

Class discussion/practical (15 minutes)

Vee mapping (10 minutes)

Presentation & discussion of vee-maps (15 minutes)

Class discussion (15 minutes)

Teacher to assist learners use the guidelines of the previous lessons in order to identify elements to use in answering the focus questions. “Is oxygen used during aerobic respiration.

Vee-mapping (10 minutes)

Learners to make vee-maps based on their experience of the previous lesson teacher to walk around to see what the learners are doing.

Presentation and discussion (15 minutes)

A few learners to make presentation of their vee – maps and the teacher to make concluding remarks.

Assignment

Learners to draw vee-maps to demonstrate the following:

(a) Water is produced during aerobic respiration

(b) Alcohol is produced in anaerobic respiration.

(c) Determination of respiratory quotient (RQ).

WEEK FOUR

Lesson 13 & 14 (80 minutes)

Method: Learners take BAT (10 minutes)

Researcher/teachers collect the test papers (10 minutes)

Note: Biology Achievement test (BAT) to be administered to the students by the researcher with the help of biology teachers.

- Supervision of BAT be sufficient enough to ensure that learners write their own answers to the question.
- BAT to take one hour and ten minutes.

Lesson 15 (40 minutes)

Method: Learners fill the students motivation questionnaire (SMQ) (30 minutes) researcher/biology teachers to collect the questionnaires (10 minutes).

- Learner centredness – the teachers role should be that of a facilitator, guider, counsellor, motivator, innovator and researcher.
- Appropriate teaching methods – the teacher should use appropriate teaching methods, which address the needs of the learners.
- Activities – teachers should come up with well-designed activities that will eventually bring out the scientific concepts to be learned.
- Group work – learners should be given opportunities to work/discuss in groups followed by group reports in class since they can generate useful ideas.
- Use of materials – teachers should use materials that are immediate to the learners environment so that science is not a detached subject.
- Use of analogies – this improves the understanding of concepts by learners.

- Problem solving – teachers should stress on the qualitative analysis of a problem prior to the use of formulas because more exposure of learners to laboratory work does not automatically produce understanding of the concepts.
- Scientific language – teachers should make use of activities such as concept mapping and key word sentences to improve learners understanding of the scientific language.
- Teacher reflection – at every stage of lesson development, a teacher should reflect on the lesson so that he can see where to improve.
- Practical work – practical work should be used to bring out scientific concepts and theory so that the learners spirit of enquiry, enthusiasm and individually created understanding is not lost.

APPENDIX I: TABLE OF SPECIFICATIONS FOR BAT

Behavioral objective	**Content (Subtopic)**							
	Definition and significance of respiration	Respiratory substrates	Aerobic respiration	Anaerobic respiration	Comparison between aerobic and anaerobic respiration	Role of enzymes in respiration	Respiratory quotient	Factors affecting respiration
Knowledge of technology and specific facts	1,1,1 (3 items)	1 (1 item)	1,1,1,1 (4 items)	1,1 (2 items)	1 (1 item)	1 (1 item)	1,1 (2 items)	
comprehensiveness	1 (1item)	1,1 (2 items)	1,1,1,1 (4 items)	1 (1 item)	1,1,1 (3 items)			1 (1 item)
Application				1 (1 item)			1,1 (2 items)	
Analysis				1 (1 item)				
Synthesis								
Evaluation					1 (1 item)			