# EFFECT OF CONSTRUCTIVIST INSTRUCTIONAL METHODS ON LEARNER ACHIEVEMENT IN BIOLOGY IN SECONDARY SCHOOLS IN HOMA BAY COUNTY, KENYA

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## DECLARATION

This thesis is my original work and has not been submitted by me for the award a degree, title or recognition at any other University before.

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## DEDICATION

I dedicate this work in memory of my late parents, Tabitha Rachuonyo Mwanda and Josiah Mwanda.

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## ABSTRACT

The study investigated the effects of constructivist instructional methods on learner achievement in biology in secondary schools in Homabay County, Kenya. Independent variable for the study was effect of constructivist instruction on learning biology in secondary schools while the dependent variable was the learners' achievement in biology and learner attitude towards the constructivist instructional methods. The specific objectives were to compare the effect of constructivist and conventional instruction on learner achievement in biology in Secondary schools in Homabay County, to establish the effectiveness of constructivist instructional methods on learner achievement in biology among students in different class categories in Secondary school in Homabay County, to determine the effectiveness of constructivist instructional methods on learner achievement between boys and girls in Secondary school in Homabay County, to establish the differences in attitude between boys and girls towards the constructivist instruction in Secondary school in Homabay County. The hypotheses formulated for the study compared the effects of constructivist and convention instruction on learner achievement in Biology, learner achievement in biology in different classroom categories and gender difference in leaner achievement in biology. Also compared was difference in attitude towards the constructivist instruction based on gender of the student. The study design was quasi-experimental non-equivalent groups with a pre-test and a post-test. The experimental group was assigned to constructivist methods of instruction while the control group assigned to conventional methods of instruction. Target population for the study was 61,115 students enrolled in 196 secondary schools of Homabay County. The study adopted multistage sampling where 57 Schools which had biology mean score ranging from 4.5 to 6.4 in year 2010 KCSE were purposively selected from the 196 schools in the County(schools met the biology achievement criteria required for the study). The list of 57 schools was stratified to include boys, girls and mixed schools. Four boys' four girls' and four mixed schools were then randomly selected to participate in the study. Finally, only one form three class was randomly selected from the schools which had two or more form three steams to participate in the study. Total sample consisted of 477 students. Participants were then purposively assigned into the two instructional groups. Instruments used in the study were; a constructivist instruction manual, a biology achievement test which served as a pretest and as a posttest and an attitude questionnaire. The instruments were pilot tested to establish their validity and reliability. The reliability coefficient of the biology achievement test established using the split-half procedure was r= 0.926. Reliability of the biology achievement test was also improved by establishing clear guidelines for administration of the tests. The study commenced by participants taking a pre-test, followed by five weeks of instruction. After the instruction, participants took a post-test and also completed an attitude questionnaire. Data collected for the study was analysed descriptively using mean and standard deviation values while t-tests and one way ANOVA-tests were used to test for significance in difference between group means at $\alpha$=0.05 level. Findings of the study were as follows: constructivist instruction is more effective in learning biology compared to conventional instruction. When taught through the constructivist instruction, girls learn and perform better in biology than boys. When learning achievement was compared along classroom category, girls performed better than students in mixed sex classrooms and students in boys' classrooms. The study also revealed that girls have a more positive attitude towards constructivist instruction than boy. The study recommends that biology teachers be encouraged to use constructivist method of instruction in order to improve students' performance. Also a similar study can be done in urban areas to reveal the attitude of students in urban schools towards constructivist learning.

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## ABBREVIATIONS AND ACRONYM

| | |
|---|---|
| EFA | Education for All |
| ICED | International Conference on Education and Development |
| KNEC | Kenya National Examination Council |
| KCSE | Kenya Certificate of Secondary Education |
| MDG | Millennium Development Goals |
| MoE | Ministry of Education |
| MOEST | Ministry of Education Science and Technology |
| NACOSTI | National Commission for Science Technology and Innovation |
| NGO's | Non - Governmental Organizations |
| UNESCO | United Nations Educational Scientific and Cultural Organization |

# CHAPTER ONE: INTRODUCTION

## 1.1 Background to the Study

Science education has in the past four decades attracted great expectations from educators and general public who continuously advocate for increased performance in scientific inventions and ability to apply and communicate scientific understandings Mintzes, J.J., and Wandersee J H. (1998). In America, the desire to improve science education was anchored on the report, *A Nation at risk*, by National Commission of Excellence in Education (Mintzes *et al*., 1998) which detailed falling standards in America's science education due to teachers using ineffective methods of teaching that do not promote high order thinking and creativity in youth. In Australia, poor performance in mathematics and science education led federal Government to establish a centre for science and mathematics education to enhance quality teaching and learning of mathematics and science (Fraser and Walberg, 1995).Similar sentiment has been raised by Talbot-Smith, Abell, Appleton, & Hanuscin, (2013) in the Handbook of research in education. Some of the factors identified as indicators for poor performance in science education include; use of ineffective instructional methods, gender imbalance in science education, negative attitude of students in learning science subjects and enrolling in science related careers and lastly unavailability of facilities for learning sciences in secondary schools (Fraser and Walberg, 1995; Trowbridge *et al., 2004).*

In Kenya, conventional methods of instruction marked by teacher lecturing dominate classroom practices (Amollo, 2005). Conventional methods of teaching though has been popular, has generated a lot of negative and positive thoughts. For instance, Keshta, (2013), warns that conventional teaching often give pseudo impression that proper learning has occurred when students confirm comprehension of rote memorized material but hold many misconceptions about the same materials when tested at application levels of learning. Amollo (2005) also found conventional methods, particularly lecturing strategy to be characterised with; lack of planning, poor time management, unstructured presentation and content overload, less innovative and inconsistency in delivery resulting into students getting bored, and less motivated and so only few concepts are learned in a lesson.

The increasing negative effects of conventional teaching methods on quality of education and learner performance in science based subjects, it is necessary that the constructivist approaches be explored so as to find ways through which learner acquisition of knowledge and skills can be enhanced. In this period of time, Brown (2005), suggest that constructivist instruction methods should be promoted as the most relevant instructional method in classroom learning and be promoted by education policies and practices. Spector *et al*. (2010,) define constructivist theory as; a way of knowledge creation by the learner based on the learner interaction with the environment. The learning theory focuses on strategies that promote interaction between individual and the environment thus making learning a reflective and meaningful process.

Enrolment and achievement of female students in science based subjects in post-secondary institutions is another challenge facing Kenyan education sector. According to the Kenya Education Sector Support Programme (2005 – 2010), relatively low number of females compared to males enrol and pursue further studies in science subjects and science related courses. The report further details that female students perform relatively dismally compared to boys in the science subjects. For example, in year 2008 KCSE examination, analysis of the biology results revealed that boys had a percentage mean score of (M= 32.01) while girls had a mean score of (M= 29.08). Similarly in year 2009, the biology performance nationally in KCSE by gender revealed that boys had a percentage mean score of (M= 28.49) while girls had a mean score of (M=25.15).

This disparity in performance could be explained as a result of poor instructional methods. Some factors which have been identified as responsible for low performance of girls in science education include; culture, religion, attitudes of the girls and the instructional method used in science classrooms (Glover & Law, 2002). Dewey in 1972 had espoused that learning results from cognitive dissonance rather than reinforcement of behaviour as proponents of behaviourist learning suggest.

When students encounter new learning tasks they have not met before, they are forced to adjust their understanding to accommodate the new experiences and are therefore involved in cognitive rather than behavioural response. It is therefore imperative that the instructional methods will determine the quality of instruction offered. When doing a project work, students get time to reflect on learning materials received earlier there by helping them to solve new learning tasks they encounter in the project. The students always involve in both individual and group reflection exercise. Use of interactive methods of instruction eliminates disparities in achievement between boys and girls while use of lecture methods can promote disparity in learning achievement between boys and girls (Miheso-O'Connor, 2002). Students' attitude towards sciences or methods of instruction in science classrooms can be a contributing factor on performance of sciences in secondary schools, for instance Wan-Ju-Lin (1998), found attitude of high school students towards learning biology to be characterised by less motivation when teacher centred methods of teaching were used compared to when interactive methods were used. Constructivist method of instruction, as Brown (2005) suggests, is an example of interactive method of learning.

The policy document, Kenya Education Sector Support Programme (KESSP) of 2005 – 2010, indicates that secondary education is characterized by poor performance in mathematics and sciences in national examinations. In the same document, it is indicated that the poor performance in mathematics and science is due to lack of enough trained teachers, equipment and teaching and learning materials. Similarly, Kenya National Examination Council (KNEC) in KCSE examination reports of year 2006, 2007 2008, 2009, 2010, 2011 and 2012 blame poor methods of instruction that teachers use as responsible for poor performance in sciences.

Due to the challenges facing the students as highlighted above, to improve learner achievement, the students should be enabled to learn and use high order thinking skills in order to be relevant in a fast technologically changing world. To achieve this, teachers should use instructional methods that provide opportunity for learners to involve in knowledge creation. Also, teachers should encourage preparation of instructional objectives and assessment procedures that reflect learning at high order thinking skills. The present study investigated the effect of constructivist instruction on learner achievement in biology on students learning in different classroom categories as boys, girls and mixed sex classrooms.

## 1.2 Statement of the Problem

Teaching and learning of biology in many secondary schools in Kenya has generally taken a pattern where teachers mostly use instructional methods characterized by lectures and few demonstrations (KNEC, 2005 and 2010). The instructional methods expose students to minimal practical activities, group discussions and are hardly taken on educational trips. Consequently, learner achievement in biology has been poor. For instance, The Kenya National Examinations reports from the year 2008-2009 indicated that the mean score for biology in KCSE examinations at the national level has never reached the average score of 50%. This has also been characterised by high standard deviation of up to (S.D= 30.44) implying discrepancies in learner achievements. In Homabay County, learner achievement in Biology has been equally poor. In year 2010, KCSE examinations and only 26 out of 196 schools managed to obtain a mean score of 6.4 and above in biology. Majority of the schools, 113 obtained a mean score less than 4.5 (mean grade D+) in biology. This was not different for the year 2013 where the average mean score for biology in the county was 5.71. According to the KNEC reports for 2007-2013, the poor learner achievement is specifically experienced in the topic of ecology.

The poor performance calls for reconsideration of instructional methods used in secondary schools for teaching biology and specifically the topic of ecology. Such a method with the capacity of enhancing learner achievement should be learner centred. This study therefore considered, the constructivist instruction as learner centred instructional methods. According to Spector et al., (2010), Constructivist instructional approach provides learners with opportunity to construct knowledge rather than being recipients of inert learning and therefore resulting into better learning. Learners own the learning process, acquire knowledge, skills and understanding and also manage the knowledge and skills acquired (Spector *et al.,* 2010). Acknowledging the poor performance of candidates in biology in KCSE examinations, this study sought to determine the effects of constructivist and conventional instructional methods on learner achievement in biology in secondary schools in Homabay County, Kenya.

## 1.3 Purpose of the Study

The purpose of the study was to examine the effect of instructional methods on learner achievement in biology in Secondary schools in Homabay County.

## 1.4 Objectives of the Study

The study sought to fulfil the following objectives:

1. To compare the effect of constructivist and conventional instruction on learner mean score achievement in biology.
2. To establish the effectiveness of constructivist instruction on learner mean score achievement in biology among students in different class categories.
3. To determine the effectiveness of constructivist instruction on learner mean score achievement between boys and girls in Secondary school.
4. To find out the differences in attitude between boys and girls towards the constructivist instruction in Secondary schools

## 1.5 Hypotheses for the Study

The present study was guided by the following four hypotheses:

$H_0$ 1. There is no significant difference in biology mean score achievement between learners instructed through the constructivist and those instructed through the conventional methods.

$H_0$ 2. There is no significant difference in biology mean score achievement of students in different class categories instructed through the constructivist methods.

$H_0$ 3. There is no significant difference in biology mean score achievement between boys and girls instructed through constructivist instruction methods.

$H_0$ 4. There is no significant difference in attitude between boys and girls towards constructivist instruction methods in learning biology.

## 1.6 Significance of the Study

The study extended the horizons of constructivist theory of learning by outlining the effect of constructivist theory on learning biology amongst students in` different classroom categories as; boys, girls and mixed classrooms. Biology teachers may use the revealed differences in learning achievement and attitude of girls and boys in relation to constructivist instruction to organise effective and appropriate learning methods. Since constructivist instruction was found to be more effective than conventional instruction, Kenya Institute of Curriculum Development (KICD) may recommend for its use in teaching and learning biology in secondary schools. Textbook Publishers and media developers may take advantage of the findings to incorporate constructivist language and activities in the content of biology materials to facilitate teachers' and students' use of constructivist learning methods. Application of constructivist instruction might improve performance in Biology by eliminating large performance gaps that exist in Biology results in KCSE examination.

## 1.7 Limitations of the Study

The study used quasi experimental design and was not able to control the age of the participants. Also, the researcher was not able to control the exact time of the day when biology achievement tests were given. Time of day might affect performance of candidates in an examination. The instruments for the study were pilot tested and amended. However, since the instruments had not been used before in other studies, a better comparison of their performance could not be ascertained. Brooks and Brooks (2001) suggest a variety of assessment methods to be considered in effective implementation of a constructivist method of instruction. It is possible that participants in different classes did not have similar test taking experience.

## 1.8 Delimitation of the Study

The present study was delimited to secondary schools in Homabay County. Only schools with biology mean score falling in between 4.5 - 6.4 in year 2010 KCSE were considered to participate in the study because the schools were considered to be comparable in terms of academic performance. The schools were also considered to be low achieves in biology performance. The study was also confined to students registered in form three and taking biology as one of the subjects offered at KCSE examination. Form three was chosen for the study because the topic ecology which KNEC has singled out as poorly performed in KCSE examinations (KNEC report, 2010) is covered in this form at the secondary school level. The study took a period of five weeks.

## 1.9 Assumptions of the Study

The study assumed that teachers fully understood training on the use of constructivist instruction manual provided earlier. The study also assumed that students participating in the experimental group accepted a change from the regular instruction methods used in biology lessons and adopted a new methods of instruction and used the new methods of instruction up to end of the study. Study also assumed that students' performance in the post-test was directly influenced by the method of instruction the students were exposed to during the five weeks of instruction. Another assumption was that, the two methods of instruction presented different learning experiences to the participants.

## 1.10 Definition of Key Terms

For proper conceptualization of the key terms used in the study, operational definitions of the terms are given below:

**Achievement Test:** Test used to diagnose the knowledge that learners or individuals have on a topic. The specific knowledge measured is based on the instructional objectives. In this study, the pre-test and the post-test were considered achievement tests.

**Attitude refers:** To opinion, feelings and values that students have about objects, events, people and activities they are exposed to, for example an instructional method is an activity students can be exposed to.

**Classroom category:** Refers to the sex composition of the students in a formal set up for learning as; boys, girls or both boys and girls.

**Constructivist MethodS of Instruction:** Is characterized by active participation of learners in creation of knowledge, skills and understanding by interacting with the environment collaboratively with others in carrying out investigations and discussions.

**Constructivist Learning Theory:** Is the belief that knowledge is actively created by learners as a result of physical, social and cultural interaction with the environment. The theory also stress on importance of prior learning experiences held by the learner.

**Conventional Methods of Instruction:** Methods of instruction characterized by lectures, minimal demonstrations carried out mostly by teachers and few questions allowed from students. The teacher passes information to be learned directly to students who are mostly passive in the learning process.

**Effect:** The extent to which instructional process facilitates or influences acquisition of concepts in the learning process. Effect is reflected on the learners' performance in achievement tests and other performance behaviours.

**High Order Cognitive Skills:** Knowledge acquisition at the levels of analysis, evaluate, and create as per Bloom et al. (1956), taxonomy of cognitive domain objectives.

**Instruction:** The process of guiding the learner to create knowledge, skills and understandings, by the instructor as a result of interactions with learners.

**Learner achievement:** The total scores that a learner attain in an examination

**Learning:** Learning refers to active and social construction of knowledge, skills and understandings, by the learner as a result of interactions with the environment.

**Low Order Cognitive Skills:** Low order cognitive skills refer to learning attained as remember, comprehension and application levels of cognitive domains.

**Mixed Classes:** These are classrooms whose student population consists of boys and girls.

**Secondary School:** In Kenya, secondary school refer to a learning institution that give instructions to students in form one to form four.

# CHAPTER TWO:

# REVIEW OF RELATED LITERATURE

## 2.1 Introduction

This chapter presents review of literature related to the study and contain sections concerned with the constructivism theory, constructivist instructional methods as well as the conventional instructional methods .The chapter also contains literature on evaluation of learning process, earlier studies comparing learner achievements between the constructive instructed learners and the conventionally instructed learners. This comparison is further discussed in the section according to gender differences as well as class categories. The chapter then discusses the attitude of students towards constructivist learning environment and the differences that occur in attitude for boys and girls. The last section of this chapter contains a brief discussion of the theoretical and conceptual frameworks upon which the study is built.

## 2.2 Constructivism Theory

Constructivism is an instructional theory based on belief that learning should be based on knowledge creation by the learner (Kirschner, Sweller & Clark, 2006). According to the theory, individual construct their understanding and knowledge of the environment, through experiencing with objects and reflecting on the experiences they have received (Van Manen, 2015). Therefore implication here is that when learners come into contact with new information, they compare it with previous ideas and experiences and there after accept or not accept the new information and in that way they acquire new knowledge. Based on the theory, human beings are considered active in knowledge creators. In order to be knowledge creators, learners should be able to ask questions, involve in exploring their environment, and they should also carry out assessment of their own learning activities (Boud, 2013).

Also important in the application of the theory of constructivism in learning is that learners must be encouraged to use active methods of learning like carrying out experiments, involving in discussion and problem solving. These methods of learning enable learners to reflect on what they are doing and thus result to more knowledge creation. The instructor has the role of making sure they understand the students' pre instructional ideas, align the class activities on the same and build on the students' ideas as way of promoting learning (Kolb, 2014). Constructivist teacher should encourage learners to involve in self-assessment of their own activities to promote better understanding. It is expected that learners who interrogate their ideas, strategies they use and products of their work end up as ‘’expert learners’’ who are motivated to carry on with learning activities. The classroom become a good environment for learning if well-planned with varied activities for learners to do but if not well planned, it impedes learning process (Nelson, 2013).

Constructivism has multiple roots in psychology and philosophy (Mertens, 2014)**.** Several scholars have been credited for the development of constructivism theory. Among them include, Piaget, Vygotsky and Bruner. Others include Gibson, Goodman, Dewey, Fouccult and Thomas Kuhun (O'Connor, 1998). Piaget focused on the development of mathematical and logical concepts. Piaget developed his theory of reasoning on concept of cognitive structures which people form when involve in reasoning. According to Piaget, people use Cognitive structures for reasoning. Piaget explains that cognitive structures are forms of physical or mental reasoning that are associated with specific acts or intelligence and correspond to stages of child development (Beard, 2013). As a result of his studies, Piaget came up with four main principles in learning or development; that Children usually give different explanation of what is real to them at different stages of cognitive development; that Cognitive development in learners can be promoted by making the learning environment challenging with many activities for the learners to engage in and which require adaptation (assimilation and accommodation) of new information received by the learner; that learning materials should be organized in a way that it commensurate with the level of motor and mental operations for a child of a given age; that students should not given assignments beyond their cognitive capabilities and lastly learning should make use of instructional methods presenting challenges to learners ideas and making them active (Derry, 1996).

Vygotsky on the other hand focused on Context of language learning in children (Lantolf, Thorne & Poehner, 2015). Vygotsky built his themes on how Social interaction provide an important role in the development of cognition and came up with the following principle of learning; that the level of cognitive development in children is restricted to limited range at any given age but full cognitive development can be attained if children are provided with room for social interactions (Butterworth, 2014). According to Vygotsky (1980), learning and development means the same thing and the two cannot be separated in children and further explained that the process of socialization and education help in promoting learning and development in children. Vygotsky noted that culture provide important cognitive tools that transform the perception, attention and memory ability of children. The cognitive tools provided in culture include history, social context, traditions, language, and religion. According to his suppositions learning occur when children make full use of social environment by interacting with others and are therefore able internalize the experiences. It is the earlier notions of a child and new experiences resulting from interacting with others in the environment which leads to the construction of new ideas. Vygotsky gave a classical example of pointing a finger

(1978, p. 56), explaining that when a person is pointing a finger he/she is explaining how behavior which begins as a simple motion becomes a clearly defined movement as others response to the gestures. As a result of his inclusion and propagation of the idea that culture and the social context play a role in the cognitive process, Vygotsky’s contribution to constructivism came to be referred to as social constructivism (Kim, 2001). Bruner researched on Child development in 1966 (as cited by Takaya, 2013). Bruner’s contributions to constructivism was based on the premise that learners construct new ideas or concepts based upon existing knowledge. Bruner theorized that learning is an active process that involves not only what the instructors present to the learners but also what the learners make out of the learning process. Further Bruner also suggested that the various dimensions of the process of learning include selection and transformation of information, making new decisions based on the information gathered, generating new hypotheses from the information gathered, and making meaning from information received and experiences encountered.

Bruner's theories emphasize the significance of categorization in learning (Bruner, 1966). He posited that for one to perceive, one must be able to categorize. He therefore made a conclusion that to make decisions is to categorize (Bruner & Austin, 1986). Another key concepts of Bruner’s hypotheses is that information and experiences are interpreted based on similarities and differences of learners’ prior experiences (Jonassen & Hernandez-Serrano, 2002). Bruner centered his studies on the concept that Learning is considered an active process where learners construct new concepts and ways of reasoning by putting into consideration current and past knowledge (Duffy & Jonassen, 1992). It is the responsibility of the learner to select and transform new information and make desition based on his/her cognitive structures. By doing so, Bruner developed three major learning principles: that instruction should take care of the learners' prior knowledge and the learning environment to make the learner be able and willing to learn (readiness of the learner). Instruction should be presented in a structured way which students can easily grasp (spiral organization of the curriculum). Lastly instruction should be designed to enable the learner fill in the learning gaps by providing room for extrapolation (Sivan, 1986).

## 2.3 Constructivist Instructional Theory

Constructivist theory is basically an active and interactive view of learning where people create their own meaning and understanding of things, events and objects by combining what they already know with new experiences they encounter (Fosnot, 2005). Constructivist theory place more emphasis on how learning occurs than what is learned. The theory also considers knowledge as a construct that is temporary, developmental, and social in nature in addition to being non-objective (Brooks and Brooks, 2001). The temporary and developmental nature of knowledge implies that as a person grows up he/she encounters new experiences in the environment, discards the old viewpoints about an object or event and acquires new viewpoints about the same object or event. In this way a person's knowledge about an object or event is changed. Further constructivist theory does not consider knowledge as being discovered but as constructed by individuals themselves as they encounter new experiences (Straits and Wilke, 2007).

Neo (2007) explains that constructivist learning theory put much emphasis on the learner, but the entire learning activity is affected by the learning context, beliefs and attitudes. So learners find their own solutions to problems by building on prior knowledge and create new knowledge by gaining a deeper understanding of events as they interact with the environment. Three variants of constructivist theory of learning are much recognized (Yilmaz, 2008).The three variants are: Individual, social and radical constructivist learning theories. Individual constructivist learning theory emanated from the works of Dewey (1972) and Piaget (1967), while social and radical constructivist learning theory is found in the works of Vygotsky (1978) and Glaserfeld (1993) respectively.

Piaget, (1991), expanded on the idea of active learning that Dewey proposed in the project work. In his work, Piaget asserts that people learn actively by constructing own knowledge understanding by use of mental representation or schema. Piaget uses the term schema to mean knowledge structures that a person forms about an event or idea and uses for new learning experiences to edge on. If in a learning process a person encounters new learning experience that fits into his/her knowledge structure then assimilation is said to have taken place and if the new learning experience cannot fit into the existing knowledge structure of a person, then the person is forced to revise the existing knowledge structure to accommodate the new information. Learning therefore is an active process that involves incorporation of new learning tasks into existing knowledge structure (assimilation) and also modifying understanding to create room for new learning to occur (accommodation).

Since constructivist learning is an active process that demands for constant reflection and comparison of old and new ideas, experience and environmental context greatly affect the learning process. Piaget's contribution to constructivist theory of learning rest on his stance that a person's understanding of reality or truth is constantly revised and reconstructed through time as one get exposed to new experiences. Piaget's theory of development tends to focus mostly on development of an individual and from his work emerged the individual constructivist theory of learning.

Dewey (1972) espoused that learning results from cognitive dissonance rather than reinforcement of behaviour as proponents of behaviourist learning suggest. When students encounter new learning tasks they have not met before, they are forced to adjust their understanding to accommodate the new experiences and are therefore involved in cognitive rather than behavioural response. He also suggested that teachers should give students assignments which involve practical work like projects to be done in groups. When doing a project work, students get opportunity for reflecting on what they had learned before there by helping them to solve new learning tasks they encounter in the project. The students always involve in both individual and group reflection exercise.

The work of Vygotsky (1978) has formed what is now known as social constructivist theory in education settings (Andrew, 2007). Vygotsky (1978) emphasises the role of greater community and the significance of others in promoting leaning in an individual. He argued that learning is a collaborative process where an individual collaborates with family members and peers in day to day interaction resulting into knowledge construction. Vygotsky also suggested that collaboration in knowledge construction is effective with the help of language which is an effective tool in learning (Santrock, 2004). Further, Vygotsky also brought into learning the idea of zone of proximal development in children's ability to learn concepts. Vygotsky explain that children are able to learn concepts which are within their zone of proximal development, but that is only after getting assistance from a more competent peer or adult. This implies that for a person to achieve good learning there must be a continuous inter-play between the person and other people in the environment. When a person gets assistance from other people, the learning process is said to be others regulated. However, Vygotsky also recognised that individuals get involved in self-regulated learning leading to intellectual growth. Application of social constructivist learning principles do occur in schools when teachers involve pupils in cooperative and collaborative instructional strategies (Slavin, 2009; Trowbridge *et al*., 2004). This study is based on the principles of social constructivist learning.

Radical constructivism is attributed to views of Glaserfeld (1993) concerning knowledge construction by individuals. Glaserfeld (1993) espoused that knowledge is achieved when the inner mind accurately represents the external world. This implies, individuals construct knowledge by logical reasoning from environmental factors and inner factors. Proponents of radical constructivism theory therefore view knowledge as a result of both individual and social construction (Neo, 2007).

## 2.4 Constructivist Instructional Methods

The constructivist method of instruction is a method of instruction which allows learners to interact with their learning environment and participate in the construction of knowledge. According to Fosnot (2005), the pedagogical framework of constructivist theory challenges teachers to create innovative learning environment for students to think, explore and reflect on their ideas without fear. Students are active in selection of learning tasks and objectives for the lessons. The classroom teacher guides selection of learning activities to ensure it is challenging but intrinsically motivating to the students. Throughout the lesson, teacher collaborates with the pupils and he or she is readily available to provide material and information support to students. Learning materials focus on bigger ideas rather than facts and students are encouraged to follow their own interests to reach unique conclusions

(Brooks and Brooks, 2001). In the constructivist instructional methods, assessment of learning outcome occurs as a continuous process. In this endeavour, both the teacher and the students are involved in the assessment of the learning outcome using students' portfolios, short quiz, and concept mapping. Assessment occurs within the learning context and feedback offered to the students is non-judgemental (Brooks and Brooks, 2001; Fosnot, 2005).

The constructivist instructional methods require strategies that allow the learners to be part of the knowledge creation. Appleton and Asoko (cited in Trowbridge *et al.*, 2004) outlined characteristics of constructivist instruction as involving goal setting and clear strategies of achieving the set goals. A constructivist teacher should have clear conceptual goals for the learners to attain from the instruction process and how the goals can be attained. The goals should also reflect high order thinking skills. The teaching and learning strategies employed by a constructivist teacher should identify and make use of the learners' pre-instructional knowledge. The instructional methods should modify or change the learners' prior knowledge to reflect accepted ideas. This can be done by asking learners thought provoking questions that change their conceptual framework (Meyer, & Land, 2013). A constructivist teacher should provide opportunities to the learners to utilize and construct new ideas learned to new contexts. Lastly a constructivist teacher should provide learners with opportunities to perform learning tasks within the learners' relevant and realistic environment. All this implies that, during class activities and group discussions, learners can be allowed to make reference on textbooks and other learning resources. All the characteristics of constructivist instruction cited by Appleton and Asoko are similar to what Brooks and Brooks (2001) call the five pillars on which a constructivist classroom is built. The five pillars enumerated by Brooks and Brooks are herein mentioned and discussed briefly: The first pillar is posing emerging problems relevant to the learners. If learning tasks given to learners are relevant to them, the learners find transfer of learning easy and a change in the earlier held ideas is also readily accepted. Relevance in this case refers to the value the learners attach to the learning material. Second, structuring learning around primary concepts.

Teachers adopting the constructivist method of instruction should have an overview of the learning process so as to be able to present the learning materials in whole but not in parts. According to Schank and Abelson (2013), learners can then make sense by breaking the whole into parts so that they understand how the parts relate to the whole. When learners break a whole into parts, learning is at analysis skill level which is a higher cognitive domain level. The teacher at this time should also be able to seek and value students' points of view. All learners have some pre-instructional knowledge they hold about the information to be learned and therefore the constructivist teacher needs to identify the learners' pre-instructional knowledge and elaborate on it to enable the learner formulate a new understanding and reconstruct new knowledge which is scientifically accepted (Brophy, 2013). Constructivist teachers can achieve this by acting as 'a guide on the side and not a sage on the stage' and he/she should be a good listener so as to get the learners' point of view.

The constructivist learning curriculum is based on methods that address suppositions in learning. Suppositions are ideas and belief that students hold as true but still need to be authenticated as true knowledge (Ewing, 2012). These suppositions can be considered as misconceptions that learners hold about the learning material presented. Constructivist teachers can address learners' suppositions by engaging in instructional methods that engage in the first three pillars mentioned earlier. The teachers' present questions of emerging relevance to the learner, structure learning materials around primary concepts, seek and value students' points of view (Earl, 2012). The constructivist learning approach also involves assessment of learning in the context of teaching (Savery, 2015). Assessment in the context of teaching implies assessment procedures carried out in the process of instruction. Such kind of assessment should involve observation of learners' work and all forms of interactions in the classroom environment.

### 2.4.1 Historical background of constructivist instructional methods

Constructivist instructional methods have developed over a period of time. The concept of constructivist instructional methods itself is said to be rooted to the classical antiquity (Hawkins, 2012). Many scholars agree that it can be traced back to the Socrates's dialogues with his followers (Boghosian, 2006: Chrenka, 2001). Socrates way of teaching was by asking his students directed questions which led the students to discover their own weakness in thinking. Constructivist educators still today use the Socratic dialogue as an important tool in assessing their students' learning and plan new learning experiences. The Socratic dialogue formed the basis of what was later on called theories of childhood development and education propagated by the likes of Jean Piaget and John Dewey what we now call Progressive Education that led to the evolution of constructivist instructional methods (Trawick-Smith, 2013).

The development of solid ideas towards the constructivist instruction methods all begun in the 1960s and 70s. According to Ryu and Parsons (2009), it was at this time that education psychologists distinguished individual constructivism from social constructivism This period was also associated with the birth of constructivist instructional theory and active research on constructivist instructional methods in the education sector. According to Mintzes, Wandersee, and Novak, (Eds.) (2005), many studies were conducted by scholars all over the world in pursuit of the most appropriate instructional method. These studies converged with the concept of Stimulus-response psychology. Consistent with stimulus-response psychology, it was believed that instructional methods directed what instruction did to the learner and this best accounted for learning. In support for this, Bakan (1972) in the book Psychology Today argued that stimulus response psychology as an epistemology of instruction best explained the process of learning. The stimulus-response psychology is the belief that knowledge consists of habits which mediate designative symbols (Berlyne, 1954)

Based on the development of the concept of stimulus-response psychology, in the 1980s there was a shift to cognitive learning theory and related instructional theories. Some of the scholars who researched on the cognitive learning theory include Markus and Zajonc (1985) and Bandura (1986). Bandura systematically applied the cognitive theory to personal and social change and strongly believed that personal and social change was the real indicator of learning. Most scholars at this time believed that what goes on in people's heads was an important mediator in learning. Mayer (1988), for instance believed that learning process is what goes on in the learner's head during learning. The constructivist instructional methods, a result of this belief were therefore designed to change how people processed and structured information. With the focus being directed towards the processing and structuring information, it was believed that educational strides would be achieved effectively. At this time, scholars also made related advances including expert systems, intelligent tutors, expert-novice research, mental models, cognitive task analysis, and cognitive load theory (Trawick-Smith, 2013).

By 1990s, there was yet another shift to constructivism and situated learning. Situated learning was viewed as a theory on how individuals acquire professional skills, extending research on apprenticeship into how legitimate into how peripheral participation leads to membership in a community of practice (Lave & Wenger, 1991). It was at this time that the qualitative side of cognition rose in prominence, complementing the prior work on information\processing and memory structures. The role of the environment in learning was considered and postulated as important in determining the learning outcome (Vincente, Mumaw, & Roth, 2004). During this time, constructivist instruction methods more about authentic practice and community participation and less about acquisition of declarative and procedural knowledge (Barab & Duffy, 2000). This period also saw many researchers becoming more aware of different theories of knowledge (epistemology) and postmodern critiques of theory and practice (Ertmer & Newby, 1993). In the 2000s, much attention in the constructivist movement was paid to practice, engagement, and experience. Situated practice rose in prominence, for learners but also for instructors and designers. Guided by the growth of educational games, media, and the Web, old models of motivation gave way to models of interest, engagement, participation, and the learning experience (Wilson, 2012).

### 2.4.2 Epistemological groundings of constructivist instructional methods

The constructivist instructional methods is based on the belief that learning occurs when learners are led through a process whereby they are in a discourse that involves them with the content. According to Kroll and LaBoskey, (1996), the constructivist instructional methods is grounded on the belief that knowledge is acquired when the learner is actively interacting with learning material instead of mayor imitation and repetition. Based on this grounding, the constructivists believe that there is no absolute knowledge, but it varies depending on one interpretation of information received therefore for knowledge to be acquired by a person that person must first consider the new information based on his or her past experiences, personal views and cultural background it is only after sieving the information is when a person can construct an interpretation of the information presented (Ting-Toomey, 2012). When Students add new ideas and experiences to their existing knowledge they are able to construct new rules or adopt the new rules to come up with a clear understanding of their environment and in such learning environment, the teacher cannot be in charge of students' learning as everyone's view of reality is different. Teaching methods geared to promote knowledge creation must make a deliberate effort to discard the objectivist models of teaching which are full of memory transmission to amore student centred approach (Cannella & Reiff, 1994). The main theorists behind the constructivist instructional methods include Dewy, Piaget, Bruner and Vygotsky.

Dewey (1998) is considered as the father of constructivist theory of learning. Bruner (1990) and Piaget (1972) are considered as scholars who promoted the idea of cognitive constructivist learning while Vygotsky (1978) promoted social constructivist learning. Dewey rejected the idea of schools focusing of school and rote memorisation but instead proposed a method that would engage students in real world situations like practical or project work in which students are able to demonstrate knowledge they have through creativity and collaborative learning activities. According to Faini and Stack (2013), Dewey envisaged a system of education where students are given opportunities to think for themselves and to articulate their thoughts.

Piaget on the other hand rejected the belief that learning was perceive assimilation of transmitted knowledge and instead proposed that learning comprises of activities which are ever changing and adopting to different situations as learners construct knowledge. Although Dewey's ideas on learning are not contemporary, it has inspired many important educational principles such discovery learning, recognition of learners' readiness level and individual differences in learning (Engeström, 2014).

Bruner was greatly influenced by Vygotsky (Bruner & Bruner, 2009). On his part, Bruner emphasized the role of the teacher, language and instruction in the process of learning and reasoned that different processes were used by learners in problem solving. The processes he said, vary from person to person and that social interaction lay at the root of good learning. Bruner's work builds on the Socratic tradition of learning through dialogue, encouraging learners' to enlighten themselves through reflection. According to Bruner, Careful curriculum design is essential and should be done a way that latter learning builds upon earlier learning. Learning also should be a process of discovery where learners build their own knowledge as they engage in active dialogue with teachers and others in their environment. Bruner initiated curriculum change based on the notion that learning is an active, social process in which students construct new ideas or concepts based on their current knowledge. He provides the following principles of constructivist learning: Instruction must be concerned with the experiences and contexts that make the student willing and able to learn (readiness), instruction must be structured so that it can be easily grasped by the student (spiral organization) and that instruction should be designed to facilitate extrapolation and or fill in the gaps (Bruner, 1982)

Vygotsky on the other hand is credited for social constructivism. He rejected the assumption made by Piaget that it was possible to separate learning from its social context. According to Vygotsky, every function in the child's cultural development appears twice: First, on the social level and, later on the individual level or first, between people (inter psychological) and then inside the child (intra psychological). This applies equally to voluntary attention, to logical memory, and to the formation of concepts. All the higher functions originate as actual relationships between individuals. (Hodson & Hodson, 1998)

### 2.4.3 5 Es of the constructivist instructional model

The 5 E's model of instruction was proposed by Roger Bybee for the teaching of sciences in schools. The model was developed under the Biological Science Curriculum Study (BSCS) project. Origin can be traced back to the mid-1980s, when BSCS received a grant from IBM to conduct a design study that would produce specifications for a new science and health curriculum for elementary schools (Bybee, Taylor, Gardner, Van Scotter, Powell, Westbrook, & Landes, N. (2006). The 5 ‘Es’ instructional model is based on the five stages of learning namely; Engage, Explore, Explain, Elaborate and Evaluate. The model was designed to provide an Inquiry Based Learning and originates from constructivism theory. It is based on the fact that learners need to build their own understanding of new ideas based on their prior experience and knowledge. They do this via explorations, testing out new ideas, asking questions, exploring options and rejecting incorrect assumptions, eventually constructing new knowledge and a new mental map that fits together and builds on their existing knowledge (Yoon & Onchwari, 2006).

### 2.4.4 Engagement, learner achievement in biology

Constructivist instructional methods based on the 5Es model usually begins with the engagement phase. The engagement stage is one of the activity stage which is meant to help the learner to make connections between past and present learning experiences. Engagement in the constructivist instruction methods has been defined as the involvement of the students in the pedagogically active process in the classroom or outside with an aim of getting computable results (Kuh, 2007). Similarly, Krause and Coates, (2008) refer to engagement as the level of student's involvement in various activities that is linked with learning outcomes. The engagement process therefore should help focus the students to become thoughtfully involved in the concept, process, or skill to be learned. The student to relate to the problem being posed and be involved in finding a solution. The phase forms an integral part of the constructivist instruction bearing on the definition of constructivist instructional methods as an active process of learning in which learners construct new ideas or concepts based upon their current and past knowledge (Driver & Oldham 1986).The learner is therefore involved in encountering and processing information, formulation of hypotheses, and making decisions while relying on their cognitive structure. Pratkanis, Breckler and Greenwald, (2014) defines Cognitive structures as the basic mental processes people use to make sense of information. It is these Cognitive structures (i.e., schema or mental models) that Bruner (1960), postulated to be involved in the provision of meaning and organization to experiences which allows the individual to move past supplied information as envisaged in constructivist instruction which is credited as a successful pedagogical method by stimulating the enthusiasm in students and helping them deepen their understanding through experience (Danielson, 2011).It is an individual's experience that ultimately provides the meaning of learning opportunities (Brown, Collins & Duguid, 1989).

In constructivist instruction, the engagement activities shapes student's gain in content understanding in a unique way (Wolf-Wendel, Ward & Kinzie, 2009).This process allows the learners to see themselves in the teachings of the teacher, to become connected to his message and to begin anticipating the processes as it unfolds. According to Dewey (1902), constructivist instructional methods centres on the idea that students learn by doing and that learning is the responsibility of the learner. That line of reasoning allows the students to use their experiences in addressing misconceptions and in developing proper conceptual connections (Rutherford & Algren, 1990). The constructivist curriculum should therefore be aligned with the learner and the learner's experiences, to realize an evolving and ever changing content. Dewey (1902), further added that the method requires the development of experience and adding into experience. Constructivist instruction builds on prior knowledge and gives students and instructors' opportunity to make sense of the world by engaging learners in exploratory investigations. The engagement phase should activate the critical thinking processes by integrating authentic activities that involve real world topics (Duffy & Jonassen, 1992). During this stage students should be asking questions such as "Why did this happen? How can I find out?"

### 2.4.5 Engagement, prior knowledge and learner achievement in biology

Prior knowledge refers to all the general information a student has concerning a given topic. (Schank, & Abelson, 2013). Students gain knowledge on various phenomenon based on their Experience, culture and environment (Kolb, 2014). Piaget referred to the prior knowledge as schema. Schema is the organized knowledge that is accessed during the learning process (van Kesteren, Ruiter, Fernández & Henson, 2012). Learner's prior knowledge can confound instructor's best efforts to deliver ideas accurately. Studies indicate that learning proceeds primarily from prior knowledge, and only secondarily from the presented materials during the instructional process (Boud, Keogh & Walker, 2013). In support of this, Bruner (1986) proposed the concept of Spiral Curriculum where training topics are presented in consistence with learners forms of thought at an early age and then reintroducing those topics again later in a different form.

In a constructivist class therefore, the teacher motivates the students, creates interest, taps into what students know or think about the topic, raise questions and at the same time encourages responses from the students. While this is happening, the students are expected to be attentive in listening, ask questions, demonstrate interest in the lesson and respond to questions demonstrating their own entry point of understanding. In secondary biology curriculum prior knowledge based on the student's environment, past experiences based on the earlier learning stages can be diagnosed at the engagement stage to enable the instructors reconcile the facts presented and to build on the existing facts. When learning occurs in such manner then the students will experience enhanced learning.

Ausubel (1958) concluded from his studies that the degree (content and degree of organization) of prior knowledge of a student must be familiar or measurable for the achievement of optimal learning and that a learning situation is optimal to the degree to which it is in accord with the level of prior knowledge. The study conducted by Hailikari, Katajavuori, and Lindblom-Ylanne (2008), on the relevance of prior knowledge in learning among nursing students concluded that prior knowledge from previous courses significantly influenced student learning achievement. Similar studies have also been conducted in the learning of biology. For example, Asikainen, Virtanen, Parpala, and Lindblom-Ylänne, (2013) in their study on the variation in bioscience students' conceptions of learning in the 21st century found out that students in a biology class who were trained based on their prior knowledge on biological concepts gave significantly higher achievement scores than those whose prior knowledge were not put into consideration during the instructional process. When prior knowledge is at odds with the presented material, the learners may distort the information presented in the material. When prior knowledge is not addressed, the learners may learn something opposed to the instructor's intentions no matter how well those intentions are executed in an exhibit, book, or lecture.

#### 2.4.6 Engagement, generation of interest and learner achievement in biology

Student's interest (situational or personal) or lack of it can have a confounding effect on the learning process. Situational interest is referred to as the spontaneous, transitory, and environmentally activated interest, while personal or individual interest, is less spontaneous, of enduring personal value, and activated internally. Situational interest normally precedes and facilitates the development of personal interest (Durik & Harackewicz, 2007). Students who are interested in a given topic or activity are more likely to engage and persist, which in turn leads to the acquisition of new skills and knowledge. For instance, Renninger (2000) in his study concluded that when low achiever learners were motivated and their interest aroused, learning process was enhanced and this was indicated by their achievement in examinations. Engagement enables learners to develop conceptual knowledge and essential procedural skills within a domain which in turn provides motivation necessary to promote persistence within a domain that needed to develop true expertise. Persistence produces greater competence, which increases confidence and self-efficacy, and makes learning easier and more enjoyable.

Ainley, Hidi, and Berndorff (2002) investigated the relationship between learning outcome and interest that students developed in topics of study. They found a relationship between the topics of interest and outcome of learning. In their study they concluded that students learnt better the topics they had interest in. Similarly, Köller, Baumert, and Schnabel, (2001) studied the relationship between academic interest and achievement in mathematics and concluded that interest affected achievement and that high achiever students had higher interest in the subjects studied. Yapici and Akbayin (2012) studied the effect of blended learning model on high school students' biology achievement and on their attitudes towards the internet and concluded that the blended learning model improved the interest of learners in biology which ultimately improved their achievements in a post-test exam. Generation of learner interest during the engagement stage is therefore fundamental in improving learner achievement and especially in biology as a science based discipline. In Kenya, studies have indicated that female students perform dismally in sciences because they do not have interest in the science based subjects (Migosi, Muola, & Musau 2013). The interest of learner in the learning process is generally generated by relating prior knowledge with the topic of study in an interactive manner.

### 2.4.7 Engagement, Connecting to past knowledge and learner achievement in biology

Connecting to prior knowledge involves making associations. During the instructional process, learners actively construct meaning through the process of interacting with what they are learning and connecting this knowledge with what they already know (Siemens, 2014). These connections, or associations, help to elucidate meaning and deepen comprehension. Sousa (2001) notes that learner's past experiences always influence new learning and that what one know acts as a filter and thus helping them to attend to those things that have meaning and by so doing discard those that they don't. It is thus expected that when students learn new things, they are much more likely to understand it if they can be able to see connections in what they had already experienced relevant to it. When these connections are murky or unseen, the instructional process gets cloudy. According to Riggs and Gil-Garcia, (2001), there are three types of past knowledge which are important for students as they study: knowledge about the topic, knowledge about the structure and organization of the text, and knowledge about terms and concepts. If during the instructional process, the learners are able to connect learnt concepts with their past knowledge, then the learning process becomes enjoyable and yields better outcomes.

One way of provoking learners to use their prior knowledge is through brainstorming. Brainstorming allows students to share their knowledge and experiences related to a topic, creating interest in the learning process.

### 2.4.8 Engagement, Setting parameters of the focus and learner achievement in biology

In setting the parameters of the focus, the instructor introduces factors which clarifies the centre of interest or activity in the lesson: distinct issues to be learnt during the lesson or the boundaries of the topic. The teacher can achieve this by setting the lesson aims and objectives. Setting objectives is the process of establishing a direction to guide learning (Pintrich & Schunk, 2002). When teachers communicate objectives for student learning, students can see more easily the connections between what they are doing in class and what they are supposed to learn. They can gauge their starting point in relation to the learning objectives and determine what they need to pay attention to and where they might need help from the teacher or others. This clarity helps decrease anxiety about their ability to succeed. In addition, students build intrinsic motivation when they set personal learning objectives.

Studies related to setting objectives emphasize the importance of supporting students as they self-select learning targets, self-monitor their progress, and self-assess their development (Glaser & Brunstein, 2007; Mooney, Ryan, Uhing, Reid, & Epstein, 2005). For example, in the Glaser and Brunstein study (2007), 4th grade students who received instruction in writing strategies and self-regulation strategies (e.g., goal setting, self-assessment, and strategy monitoring) were better able to use their knowledge when planning and revising a story, and they wrote stories that were more complete and of higher quality than the stories of control students and students who received only strategy instruction. In addition, they retained the level of performance they reached at the post-test over time, and when asked to recall parts of an orally presented story, the strategy plus self-regulation students scored higher on the written recall measure than did students in the other two groups.

### 2.4.9 Engagement, framing ideas and learner achievement in biology

At this stage, the instructor collaborates with the learners in framing the ideas from the learners for better understanding. Important in the process is the understanding and utilization of the concept of anchoring ideas. Anchoring ideas are said to be those specific, relevant ideas in the learner's cognitive structure that aids the entry for new information to be connected (Mead, Gray, Hamer, James, Sorva, Clair, & Thomas, 2006). Helping learners to anchor ideas allows them to construct meaning from new information and experiences (Nelson, 2013). Studies show that, leaners gain better understanding of concepts by connecting new information and concepts to what they already know and believes in (Meyer, & Land, 2013). Since concepts are essential units of human thought that do not have multiple links with how a person thinks about the world and therefore are not likely to be remembered all the time. But if remembered, may not be able to affect thoughts about any other aspect of the world. Concepts are learned best when they are encountered in a variety of contexts and expressed in a variety of ways, for that ensures that there are more opportunities for them to become imbedded in a student's knowledge system (Vygotsky, Hanfmann & Vakar, 2012).

Effective learning often requires more than just making multiple connections of new ideas to old ones, but also requires that learners restructure their thinking radically (Kolb, 2014). By so doing, learners will be able to incorporate some new idea, change the connections among the things they already know, or even discard some long-held beliefs about the world. The necessary restructuring might require restructuring the new information to fit their old ideas or to reject the new information entirely. Students come to school with their own ideas, some correct and some not, in almost every topic they will encounter (Hattie, 2013). However, if their original intuition and misconceptions are ignored or dismissed out of hand, the original beliefs are likely to win out in the long run, and interfere with learning as required by teachers. Mere contradiction is not sufficient, students must be encouraged to develop new views by seeing how such views help them make better sense of the world (Tomlinson, 2014).

## 2.5 Exploration and Learner Achievement in Biology

At the exploration phase, the learners are expected to have a common base of experiences. The instructor adopts an open ended approach which allows the learners to identify and develop concepts, processes, and skills (Hanke, 2009). Exploration enable active search of the environment and manipulation of material by the learners in the learning process. By relying on the above approach, learners are able to form connections, manipulate materials during hands on activities and get the necessary experience required for growth and learning. In facilitating these interactions, a teacher should often give out learning tasks on the learning material for the learners to explore and come up with clear understanding of truth in the learning material (Hirst-Loucks & Loucks, 2013).

To facilitate the exploration phase, the constructivist instructional curriculum should be designed to give a reflection of real life conditions (Bentley, 1995). Towards this end Hofstein & Yager (1982) proposed that social issues should be used as an organizer for the curriculum so as to contextualize the content of instruction in different discipline of study. Instructors in their distinct disciplines are expected to go beyond their disciplines and avoid sticking to the issues that are unique to their discipline. They are expected to integrate language, knowledge and process application so as to be able to lead students in creating real life situations in the process of acquiring knowledge. The instructors are also supposed to encourage research based activities at this phase of the instructional process. Research based programs give students the ability to retain facts through critical thinking by working through problems logically and making connections to the real world. In support of this, Bruner (1960) advised that students should be allowed to know what it feels to be completely absorbed in a problem and that this experience is normally not experienced in schools where the conventional lecture methods are applied as a method of instruction (Bruner, 1960).

In order to effectively guide learners in solving problems at this stage, the learners should be encouraged to seek answers to their own questions (Boud, Keogh & Walker, 2013). During the exploration phase, learners should have opportunities to work with material resources in different ways including manipulation of the materials to enable them develop real experience of the world. Learning by manipulation of objects has an important role in constructivist instructional methods as it is a process that allows learners to come into contact with real world. When hands-on learning is facilitated by use of variety of tools and equipment's, learners experience more interest in the topic of study and thereby enhance learning. Technology is more affordable these days and should be effectively used during the exploration stage. Fink (2013) posits that, in order to understand concepts better, instructors are advised to plan for learning conditions that enable students to effectively integrate their own experiences with familiar material resources for example, students who enjoy learning about animals life can be provided with opportunity to explore concepts in population estimation methods and especially capturing organisms for the purposes of estimating their populations. They may also use perforated sacks as sweep nets to capture insects. This approach allows the learners to study important science topics in the context of their learning interests (Hirst-Loucks & Loucks, 2013). Exploration gives learners opportunities to form a broad understanding in learning because they are able to see and do what others are doing and compare similarities and differences in their understanding in the context of others work.

Also important at this stage is the fact that learners can have self identification of the misconceptions they are holding about content materials. The phase allows for the sharing within cooperative groups and this is one of the fundamental concept in constructivist instructional methods since it allow the teacher to perform his/her role as a facilitator in the learning process by allowing learners to interact with resources and gain personal experiences which the learners can then connect with the learning concepts. Hirst-Loucks and Loucks, (2013) states that learners can be helped to develop problem solving techniques and good conceptual understanding if they are involved in collaborative hands-on exploration of concepts. This in turn will help the learners to build an understanding of processes and concepts (Barkley, Cross & Major, 2014). Lee and Anderson (2013), advises that during the exploration phase, three students should be given opportunities to work together without direct instruction from the teacher and that the teacher should only act as a facilitator in helping the students to frame questions by asking questions and making observations. Based on Piaget's theory, this is the time for disequilibria. The learning environment should be able to make students be puzzled. It is also the opportunity for students to form hypotheses and test predictions, try alternatives ways of solving problems, record observations and discuss with peers to come up with new ideas or suspend judgment (Hirst-Loucks & Loucks, 2013).

#### 2.5.1. Exploration, use of open ended approach and learner achievement in biology

According to Boud (2012) an open ended learning method refers to learning conditions in which the learners' intents and purposes are identified early enough and pursued. In this way the learning goals and the means by which the learning goals are pursued must take open ended approach. The underlying assumptions in open ended approach are that learners gain more through concrete and direct experiences they meet. Direct experience help to shape and refocus the earlier hypothesis formed by the learners. Learners judgement on what, when and how learning occurs results in cultivating a cognitive process which is more critical than generating learning products. Higher order cognitive skills like manipulating variables, identification, data interpretation, forming hypothesis and designing experimental procedures are activities which are promoted by use of open ended learning approach. Bhaskar (2013) states that the quality the quality of learning depends on the quality of the learning methods used. Open ended learning conditions met in the exploration stage, provide learners with opportunity for manipulation of objects and ideas at first hand level, instead of students being told about their environment thereby leading to increased quality of learning.

Mahlobo (2009), conducted a study on the effects of use of open ended approaches on learner achievement in mathematics and found out that open ended method in teaching and learning of mathematics promotes understanding of mathematics by the learners. This study reviewed that this method of instruction yields better results in learning biology also.

### 2.5.2 Exploration, use of real life situations and learner achievement in biology

In constructivist learning methods, problems, incidents, events and stories are all environmental factors considered to be realistic and authentic to a learner. That is, they reflect real life situations. These factors provide learners with a base on to which they can situate or anchor learning experiences received. Anchoring learning experiences in the real life situations promotes one of the key requirements for constructivist instruction of closely tying assessment of learning outcome to the learning context (Dalbagh & Dass, 2013). Even though Jiront & Zimmerna, 2015) states that problem based learning is common in many classrooms, using real life situations in learning biology provides students with many opportunities to think of various ways in which they can solve the problems they encounter outside the classroom. When real life situations are employed in learning, learners are required to look at the world in totality by looking at what is in it and how forces in it works. From that perspective, learners form generalizations and make rules to explain the generalizations (Entruistle, 2013).

### 2.5.3 Exploration, Probing, inquiring, and questioning experiences and learner achievement in biology

Probing and questioning experience in the constructivist instruction methods refer to different ways that teachers use to ask for learners' brief responses on lesson content in order to find out the level of the learners' understanding of the lesson content (Bhattacharyya, 2013). Inquiry and questioning during the exploration stage will require the teacher to ask learners short oral questions or give directions for learners to demonstrate pre-instructional knowledge they have. Once the teacher gets the learners pre-instructional knowledge he/she can then adjust the instructional methods to take care of the learners ideas. McTighe and Wiggins (2013), states that inquiry, probing and questioning of learners experiences results into learner achievement benefits.

Brophy (2013), identify ways teachers can use in presenting probing questions as follows: questions should be of moderate level of difficulty so that most students in class can be able to give successful responses, that is, most students are able to successfully answer the questions. During class discussion, teachers must take note of the students who often respond to questions and to ensure that none volunteer learners are also called upon to answer questions, and or elaborate on other students responses. Constructivist teachers can make use of learners' level of understanding to increase the pace of instruction.

Biggs, (2011), states that when probing and inquiry questioning technique done in a proper way as required, most teachers will be able to access the understanding of the learners as the lesson progress and make adjustments as needed. Proper use of probing and inquiry questioning experiences increases content coverage in constructivist instruction method. This is more so, if the teachers monitor the learners responses to the questions to get proper feedback on where the learners are and hence adjust the instructional process or material to be covered. Harris and Sass (2011) recognises a positive relationship between content covered in class and student achievement in examinations.

## 2.6 Explanation, Learner Achievement in Biology

In the constructivist instruction methods, explanation phase come after the exploration phase. Explanation phase gives students opportunity to discuss and reflect on the work and or concepts they have been exploring. Since it involve group discussion, students get opportunity to verbally present their understanding of what they encountered during the exploration and engagement stages and also to demonstrate new skills they have learned in the exploration stage (Loughran, Barry & Mulhall, 2012). Constructivist teachers use the explanation phase to present to learners primary content material in form of questions for discussions, reference to primary sources of information and definition of terminologies. Explanation phase enable learners to identify skills to experience and discover more about the concepts they are learning (Ergin, 2012). After the engagement and exploration phases the learner now have good repertoire of knowledge about the concepts of the learning material but they still find the explanation phase necessary to enable them anchor their experience and fasten it to specific content knowledge.

In constructivist instruction methods, learning activities put a lot of focus on use of primary sources of knowledge in addition to use of secondary sources. Learning materials used during the explanation phase include textbooks, the internet, publications, film, mentors and lecture materials. Constructivist teachers as facilitators of learning must encourage students to utilize their time well and interact fully with the learning materials so as to analyse and synthesize the knowledge information in the material. Good interaction with the learning materials promotes growth of higher order thinking and teachers' role is to promote respect of the learners' point of view or ways of thinking. Each learner bring into learning a difference in understanding of content and concepts being taught as a result of their pre-instructional experience

(Knowles,Halton III & Swanson, 2014). So teachers' as facilitators of learning provides the students with the opportunity to evaluate their pre-instructional knowledge, remove any misconception they may hold and form correct concepts of the learning material.

According to Rutherford and Alhgren (1990), learners' come to school when they already have a lot of ideas on almost everything they come to learn but it is the responsibility of the teacher as the facilitator of learning to provide classroom environment that apart from enabling learners to connect new materials to old ways of thinking also turn students thoughts to reflect new ways of thinking and understanding.

Boud (2012), recognize that learning process should give students ability or experience to enable them construct better sense of their world. Therefore it is important that the skills and the behaviour patterns students acquire or gain during the explanation phase should allow them not only to be successful but also to take responsibility of their learning while the teacher provides a critical role of being a guide in the learning process, by providing relevant content materials and classroom experience required.

Bentley (2012) underscores the role of communication in learning and stress that communication from and between multiple people and perspectives is not only important but very vital in learning. If a person successfully explains concepts to other persons then that person will have good mastery of the knowledge of the material he or she presented. For a student to describe and explain ideas and concepts to other students in group discussion, he/she will first synthesis and fully understand the concept on a higher order thinking ability (Redfern, 2015).

Brookfield (2015), similarly recognize the role of the teacher in promoting students explanation of concepts and states that teachers should encourage students to explain concepts in their own words. Students should also get feedback of their explanation and also critically listen to other people's explanations including that of the teacher. Brookfield further adds that students are allowed to explain from the observations and records they made during the engagement and exploration phases. At this phase, definitions and hints from the teacher should be incorporated with students' previous experiences as basis for discussion.

### 2.6.1 Explanation, sharing of ideas and learner achievement in biology

Sharing of ideas between learners during the instructional process is what Piaget described as social interaction. During social interaction, learners conclude their understanding by comparing own ideas with ideas from others (Kolb, 2014). When students explain their ideas to the others, they gain deeper understanding of the concepts they are presenting. On the same vein, sharing ideas enable learners to develop better skills of presentation during instructional process, then serve as role models and further demystifying misconceptions on the topic under study. When learners discuss controversial topics, they become absorbed in the topic and therefore promote more sophisticated thinking. As students participate in group discussions and share their ideas, they are motivated and in the process, motivate one another (Fosnot, 2013).

In a study conducted by D'Ambrosio, Johnson, and Hobbs, (2005) learners who shared their ideas during group discussion performed better than their counterparts who did not share during the discussions. Similarly, Gaudet, Ramer, Nakonechny, Cragg, and Ramer (2010) conducted a study to compare how students who were organized into groups performed in their exams as compared to their counterparts who did not participate in group discussions in biology lessons. The study found out that study groups will allow for sharing of ideas and enhanced the process of learning and discovery which is part of conceptual evaluation required in scientific thinking. The study concluded that group learning has unique ability of engaging students and in the process promote meaningful learning as required in science. The study groups did not only improve the learners' achievement but also produced longer-term benefits of shifting attitude of students positively which was indicated to have important ramifications for scientific research. The authors noted that academically the development of scientific ideas of discoveries should rely more and more on the efforts of the groups.

### 2.6.2 Explanation, use of primary sources and learner achievement in biology

In learning Biology, primary sources of information include textbooks, experimentation, internet information and other publications. Michaelsen and Sweet (2011) found that primary sources of information enable learners to relate in a personal way to events of the past and thereby promote deeper and clearer understanding of the learning topic or concept. Research work provides students with additional evidence of the information they receive from other primary and secondary sources. First hand encounter with events create reality aspect thereby fostering active reading and practice of research. In Kenya, the Government encourage teachers to use primary sources that require students to read and examine documents and objects so as to develop critical and analytical ability.

Levstik and Barton (2015) warn that some primary sources of information may be incomplete and may provide only little context, however, students can succeed in using these resources by engaging their prior knowledge as they work with multiple primary sources to find patterns. Levstik and Barton advises students to not only make concrete observation of facts on the primary materials but have a questioning mind and also make inferences about the materials. Further, they note that inquiry into multiple sources of primary materials encourage students to wrestle with the contradictions of points of views presented in the materials and in the process the students construct knowledge and form reasoned conclusions, based on evidences found in various sources of information. In the process students also connect information they receive to the context in which the information material was created. That is, the student to synthesize the information fully. Students can integrate what they learn from research, glean from textbooks, other publications and their prior knowledge to construct new content knowledge and deepen their understanding. In using the primary sources from various sources approved by the Kenya Literature Bureau, Learners stand a greater chance of gaining better understanding and the opportunity to explore knowledge from various sources that has the potential of improving learner achievement in biology (Fink, 2013).

### 2.6.3 Using own words to explain concepts and learner achievement in biology

Concepts are like mental representations which can be expressed in words (Halford, 2014). Since students are able to form these representations, expressing them will be based on their language. During the instructional process, the students should be allowed to express their understanding of the concepts learnt using their own languages while the teacher assist the students in reconstructing their understanding of the concepts in formal languages. Vygotsky (1978), noted that language is accommodated as a learning medium and is also a tool for constructive thinking. Students internalize knowledge through learning in a social context related to the context of using language. Misconceptions of understanding language occurs when students are not competent in that particular language.

In the early 1990s, studies investigated the effect of using local languages as a mode of instruction based on the understanding that learners expressed their understanding of concepts best in their language (Rosenthal, 1996; Spurlin, 1995). These studies found that misconceptions in understanding arises from teaching the main courses such as science and mathematics though a foreign language. In support of the same, an education website (Personal.psu.edu, 2015), posits that students should be allowed explain concepts in their own language so as to enhance their understanding of the concepts and acquire higher abilities to explain the concepts on their own.

### 2.7 Elaboration, Learner Achievement in Biology

The elaboration phase is designed to extend students' conceptual understanding in areas of skills and behaviours. In a constructivist framework, the educator provides opportunities in which learners can practice and refine their skills and behaviours in authentic contexts (Hannafin, Hill, Land & Lee, 2014). Learners, are also given multiple opportunities to enable them deepen, broaden and integrate the knowledge they have into proper conceptual understandings and actions, both inside and outside of the classroom. Elaboration as an instructional strategy allows the student to spend time exploring and explaining the concepts with time for reflection exercises by providing numerous experiences upon which to synthesize information (Gregory & Chapman, 2012).

Through new experiences, the learners develop deeper and broader understanding of major concepts, obtain more information about areas of interest, and refine their skills. In classroom settings, during the elaboration time, constructivist educators will introduce variables that students can explain in deeper or in different ways. Issues can be looked at from multiple perspectives and even from cultural viewpoints (Tomlinson, 2014). The most important thing is to build on previous learning and to apply new learning in a meaningful context. Knowledge is as much about process as it is about content, and the two must be integrated effectively so that the learner sees the value of the content in a conceptually correct context (Hoehn, 1990). No real world issue is done compartmentally in a class. The impact of issues is felt throughout multidisciplinary domains and therefore learners, should be engaged and participate both in class and out of class learning as this is crucial in understanding the purpose and hence meaningful learning (Fink, 2013).

Constructivist teachers should actively promote and encourage positive group interactions and cooperative behaviours that fostering of thinking interactions that enhance the learning process (Bossert, 1989). Learning process should at its best proceed from insight to action, from content to concept, from a static situation with a single focus to dynamic activity with ever-changing myriad opportunities, which requires intense problem-solving, cooperative learning and critical thinking. During elaboration students should apply concepts and skills in new (but similar) situations and use formal labels and definitions. The teacher must remind learners of alternative explanations available and need to consider existing data and evidences as they explore new situations. Biggs and Collis (2014) explains elaboration phase as time for learners ask questions on previous information, interrogate decisions, experiments, and records of observations to arrive at meaningful and valid decisions.

### 2.7.1 Elaboration, application of ideas and learner achievement in biology

The primary aim of education should be to give practical knowledge that can be applied in real life situations. Michael (1997) stated that emphasis in the constructivist instructional methods should be put on use of activities during the instruction as the activities has the potential to engage learners' curiosity leading to more questions from the learners. Jeffery and Linda (2003) undertook a survey of application of ideas by mathematics and science students, the findings established that learner-cantered instruction methods do promote application of ideas. The study recommended for increased use of learner-centered instruction methods for learning must move from theoretical views to practical use usage for essential role of education to apply what is learned by formal education for solving real challenges.

Contextual teaching and learning (CTL) engages learners in important activities that enable them relate academic work to their context in real-life situation. By making these connections, learners see meaning in school work. Some of the activities learners involve in are; formulating projects or identify interesting problems, making choices and accepting responsibility, searching for more information and making conclusions and the activities make learners relate what they learn to real life (Satriani, Emilia & Gunawan, 2012). When learners actively choose, order, organize, touch, investigate, question and make decision, they connect what has been formally learned in class to real life situations and in that the learners discover meaning in what they are learning. The discovery of meaning is the central characteristic of CTL. When students are given learning tasks which appears to be of no value to them, they end up wondering why such tasks should be introduced in class. (Toshalis & Nakkula, 2012). Learners' primary concern is to involve in actitivities which are of interest and value and to avoid activities which are not interesting or of little value. Closely related to this fact is Turners’2012 report on neuroscience that human brain is constantly in search of meaning in what a person does.  When a person is confronted with new experience, the person will first try to recall into memory past experience related to the current experience. The brain attempts to relate the past and the current experience. If the two events are related in some way, brain quickly find meaning in the new experience, changes physical structure makes neurological connections (Diamond& Hopson, 1998; Greenfield, 1997).

Contextual teaching and learning (CTL) require learners to develop personal attachment to the learning material (Biggs, 2011). CTL demand that learners make connections which have meaning. The important characteristics of TCL strategies are problem based activities, application of multiple contexts, making use of learners’ divergent views, support of self-directed learning and application of assessment which are authentic to the learning environment (Butler, Schnellert & Cartier, 2013).

Darling-Hammond, noted that effective education must precisely focus on connecting subject-matter content and real life context for the students, and this involves a more realistic educational program. Even within the science course itself, many students fail to recognize that the topics they are studying apply to real-life situations. One reason proposed for this lack of transfer is that problem solving and learning have not taken place in real-world contexts (Engeström, 2014). Real life situations or simulations can be evidently demonstrated by the use of CD-Roms, Videotapes, DVDs (either alone or in tandem with mounted computers) this makes it easier and convenient to teach using real-world situations (Blake, 2013).

### 2.7.2 Elaboration, Communication new understanding with formal language and learner achievement in biology

Formal communication refers to the use of a language which conforms to established professional rules, standards and processes and avoids using slang terminology (Jandt, 2015). Since learners in a constructivist classroom are allowed to conceptualize ideas in their own language, the instructor at this point communicates the learner's ideas in formal language. The formal language allows the students to construct ideas in standard forms using standard language and terminologies (Hill & Miller, 2013). When students are helped to package their ideas in formal languages, it becomes easier for them to effectively use them without confusion. The formal language will also aid the students in sharing a common understanding (Biggs, 2011).

### 2.7.3 Elaboration, conceptual integration and learner achievement in biology

Outcome of the learning process or cognitive process can be considered as conceptual integration. (Hastie, Ostrom, Ebbesen, Wyer, Hamilton, & Carlston, 2014). As a cognitive process, conceptual integration is defined as background, of the sub-conscious mental process, which people use to construct meaning in different and unrelated concepts. Two concepts which are not related are integrated to form a third concept which contain some characteristics of the original two concepts the common characteristics from the original two concepts but now in the third concept forms the criteria for identifying the third concept formed (Lakoff, 2012). In the constructivist instructional approach, the conceptual integration process is significant since it determines the outcome of the instructional process.

Students at this phase of the instructional process should be able to make meaning from the various concepts which had been introduced to them so as to make logical conclusions on their own. When students are able to make these conclusions on their own, they not only participate in the knowledge creation but are also empowered to identify with facts so formulized. This can greatly improve learner achievement in biology and other science based disciplines (Kop & Fournier, 2015).

### 2.8 Evaluation, Learner Achievement in Biology

In the evaluation phase of constructivist instruction learners are required to carry out assessment of their own understanding and abilities. Similarly teachers are expected to evaluate students understanding of conceptual and skill development. According to Quinn, Amer, Lonie, Blackmore, Thompson & Pettigrove, (2012) self evaluation of students enable them to access their own abilities, identify areas of strength and weaknesses and use the information about their strength and abilities in learning. Teachers however access students learning achievement to know the level of knowledge integration resulting from presentations demonstrations and explorations.

Prince and Felder, (2006) define evaluation as methods used to establish and explain the amount of knowledge that a learner has acquired. From this definition, Tomlinson, (2014) clarifies that evaluation involves all means of assessment of learning ranging from simple to complex for example use of direct teacher observations of pupils in class and use of standardized tests respectively. Earl, (2012) recognizes that amount of knowledge that a student have constantly changes with time and it is therefore the teachers who are best placed to access and make judgment about a student's achievement in learning.

Salvia, Ysseldyke, & Bolt, (2012) remarks that good assessment provides accurate information of learners' performance which teachers can use to make important decisions concerning students' Such decisions include grading students, changing instructional methods, students advancement, placing students into careers and even curriculum change although assessment test are supposed to be objective, the test only measure student performance on the objectives of the test which are mostly what has been covered in class but such test give little knowledge on how students can perform in what they have now been taught. Constructivist teachers are aware that opportunities for evaluation are also with the learners who can carry out self assessment of their own abilities which they can do in project work, in discussion groups and from feedback they get from interacting with teachers and others. (Kumari, 2014). Students can peer-review the work of others, share their own work and get feedback from others and also self-assess their work based on strengths and areas that need to be strengthened. The important point is that the learner looks to understand what he or she knows and defend that construction of knowledge so that it is accepted as conceptually correct by the teacher and experts in the field (Cook-Sather, Bovill & Felten, 2014). Teacher should observe students' knowledge and/or skills, application of new concepts and a change in thinking. Students should assess their own learning. Ask open-ended questions and look for answers that use observation, evidence, and previously accepted explanations. Ask questions that would encourage future investigations (Eshach, Dor-Ziderman & Yefroimsky, 2014).

### 2.8.1 Evaluation, assessing understanding and learner achievement in biology

Learner evaluation can be conducted either by self, peer or teacher. Teachers can organize students into groups for evaluation or evaluate them individually. Students can take self evaluation as a group or on individual basis as a group students can fill self evaluation forms while on individual basis students may involve in journal writing taking tests, writing work summary, taking oral questions and though discussions with other students (Hattie, 2012). In Self-evaluation, students access what they already know and what they are yet to know against what they are required to know. Students identify their strengths and weaknesses such as their own beliefs and their misconceptions respectively. With knowledge of their strengths and weaknesses students can set goals which are achievable to themselves. (Stiggins, Chappuis, & Arter, 2014).

Teachers should encourage self-evaluation because self-assessment makes the students active participants in their education (Kelaher-Young & Carver, 2013). There are a variety of ways for teachers to provide the students with self-assessments. Research suggests that the simplest tools to encourage student self-assessment are evaluative questions that force students to think about their work (Boud, 2013). I t is important for teachers to model self-assessment too. Teachers need to show their students that it is important for everybody to self-evaluate by doing their own self-evaluations. Allow group members to evaluate their productivity during classroom activities. Brown, Bull& Pendlebury (2013), observe that self-evaluation is the best way to encourage students to evaluate, assess and understand their continuous progress.

### 2.8.2 Asking of open ended questions and learner achievement in biology

Posing insightful questions to secondary school students has profound benefits for professional teaching practice (cohen & Lotan, 2014). If the feedback is supposed to be spoken, written, dramatized, or relied in some other formal medium, it will depict the success in conveying the message on whether the intended lesson was stimulating in the students thought processes. The students will reflect on their learning through higher-level thinking processes such as analysis, evaluate comparison, or summation. Finally, students are more likely to remember what they have learned when they explore the implications of their learning (Orlich, Harder, Callahan, Trevisan & Brown, 2012). Benjamin bloom formulated a taxonomy to categorise knowledge at different levels of reasoning. The taxonomy of differentiate knowledge skills at different abilities which are hierarchical starting from the simplest knowledge ability of recall to the highest level reasoning which he called knowledge creation. Blooms taxonomy has at its base simple recall questions of low order reasoning and at the top question items of higher order reasoning ability.

Questions higher on the pyramid are more complex and demand higher cognitive skills from the students. Bloom's Taxonomy provides a structure for developing questions that encourage students to think on different levels (Oregon, 2012).

### 2.8.3 Self-evaluation and learner achievement in biology

Self- evaluation means that a person looks at his/her progress and developments in learning to find out areas of improvement and areas that still need improvement the process of self evaluation therefore requires a comparison of "before" situation and current situation (personal.psu.edu, 2015).

Chen, (2002), describe self-evaluation skills as products of education and self regulated long life education which is responsible for personality development. McKernan and McKernan, (2013) has underscored importance of self evaluation procedures in allowing teachers and students to reflect on learning methods and make appropriate adjustments where necessary. Black et. al, (2002) similarly noted the importance of self evaluation in providing more sense of ownership to the evaluation process and that schools should increasingly encourage its use.

Students should be made to understand the importance of self evaluation so that they can use it objectively, and enable them develop self esteem skills and attitudes. Teachers therefore should incorporate self assessment techniques systematically during instruction process at all levels in this way learners will have informed feedback of the objectives and skills for self evaluation for example teachers can have at end of term maximum scores from self assessment and scores from end term test. The purpose of assessment is to improve standards, not merely to measure them and that should be the case for all schools not only for special schools.

## 2.9 Conventional Instruction Methods

There are several conventional instructional methods used today. The basic feature of all the conventional approaches to instruction is fact that the teacher is the director of all the learning activities in class including goal setting, setting of performance standards for students and the pace at which students carry out their class work (Gijbels *et al.,* 2006). Teachers organize and present material information primarily in form of lectures, few demonstrations and some supplemental reading assignments. In class, students remain inactive and passive recipients of knowledge but are still required to reproduce the same knowledge or information in class assignments or at end of the course examinations. Information flow is in most cases one way from teacher to students (Neo, 2007). Questions from students are least accommodated and students' prior knowledge is not always used in the learning process, so misconceptions students may have in pre-instructional knowledge are not adequately corrected. Assessment of learning activity is done by the teacher mostly inform of class assignment or test which students do individually. The instructional environment is competitive as students compete individually for marks, teacher's attention and rewards (Conley, 2012).

As a whole, general activities in conventional instruction are similar to activities of direct instruction described by Slavin (2009). Slavin also points out that direct instruction is less effective when deep conceptual change is the objective of instruction or when the instruction is geared to foster discovery or exploration by the students.

## 2.10 Learner assessment

Assessing learner achievement means assessing the knowledge, skills, and attitudes/ values that learner's gain over a period of instructional process. Several models can be adopted as an approach to learner assessment (Earl, 2012). This study adopted Bloom's Taxonomy of Cognitive Levels as a model for assessing learner achievement.

Bloom's taxonomy of cognitive levels was designed by a committee of educators under the leadership of Benjamin Bloom in the 1940's and 1950's (Felder

& Brent, 2004) Since then, the taxonomy has been used in the education sector and especially for learner evaluation. The taxonomy outlines various levels of learning and application of retained knowledge in six major taxonomies (Biggs & Collis, 2014). When learners develop the capacity to apply understanding, use knowledge in new situation and construct own knowledge, they are considered to have developed sufficient skills implied in effective learning. The six levels of cognition according to Bloom's taxonomy are remember, comprehension, application, analysis, evaluate and create. According to Biggs & Collis (2014), Bloom's taxonomy of cognitive levels can be used to evaluate the quality of learning. The following explanations of the taxonomy is based on Guskey (2012) review of Bloom's taxonomy.

**Remember**: This involves recalling memorized information as presented or self-acquired. This may involve recalling a wide range of materials which may include specific facts as well as complete theories. This cognitive level requires that the learner is able to bring to the mind appropriate information prior acquired. This represents the lowest level of learning outcomes in the cognitive domain. Learning objectives at this level requires that the learners get acquainted with common terms, specific facts, methods and procedures, basic concepts and principles. In assessing learner achievement at this level, the learners are asked to define, list, state, identify, label and name.

**Comprehension**: This level require the learner to develop the ability to understand the meaning of the content the meaning of the be able to translate the content to provide an appropriate interpretation that enables prediction for future trends effects and consequences at this stage the learner is expected to move beyond mere remembering of the content. The objectives of the learning in this case must focus on understanding of facts and principles as well as interpretation and translation of verbal information in their respective domains. The learner should be able to interpret the charts, graphs and estimate the future consequences that are implied in the facts. The evaluation of learners at this level is determined by asking questions such as to explain, clarify, predict, interpret as well as to infer and summarise. The application stage demands that the learner applies the ability to use the learner's concept in a more concrete situation.

Application includes the development of the ability to use rules, methods, concepts, principles, laws and theories. The learner must be able to use the concepts and principles to understand new situations in a more practical and help solve problems scientifically. The learner should be able to construct graphs and charts and show the appropriate use of the method. The assessment of the learner can be determined by asking questions like as, how one would show, modify, make use of demonstrate or solve a problem.

**Analysis**: This stage entails that the learner is expected the learner is expected to demonstrate ability to break down materials into small component parts. Learning outcomes in this respect are focused in understanding of the both content and structure form of information the learning objectives at this level demands that the learner so recognises unstated assumptions and propositions, distinguish logical misconception in reasoning and distinguish between facts and insinuations. It also demands that the learner evaluates the relevancy of data. The learner should answer questions that focus on differentiating, comparing and contracting facts.

**Evaluatio**n: Evaluate refers to the ability to organise parts together to make anew whole. It takes into consideration the production of a unique communication plan of operation or a set of abstract relations. The learning outcomes in this area puts more emphasis on learner creative behaviour and the formulation of new patterns or structures of this level, the learner should be able to write an organized paper, propose a plan for an experiment, integrate leaning from different areas into a plan for solving a problem and formulate a new way of classifying objects. The evaluation of the learner at this level requires demonstration of the ability to design, construct, develop, formulate, imagine, create, change, the elements:

**Create**: The process of learning becomes complete when the learner is able to develop the ability to judge the value of information for a specific purpose. Judgement should be based on known criteria which may be based on organisation of the material or relevance of the material of the specific desired purpose. The learner may determine the criteria. The learning outcome at this level are high in the cognitive domain because they contain elements of all the other categories. They also include the conscious value judgement based on clearly defined criteria. The objectives of learning at this level requires the learners to demonstrate their ability to judge the logical and consistency flow of written material, it should also judge the adequacy with which conclusions are supported by data, the value of internal and external criteria of organisation and relevance respectively of the material must be seen by standards of excellence.

## 2.11 Comparing Learner Achievements between Constructivist and Conventional Instructional Methods

Studies comparing learner achievement in constructivist classroom and the conventional classrooms have indicated better results in favour of the constructivist learning. In a study conducted by Becker & Maunsaiyat (2004) Constructivist-instructed students had higher scores on the post-test and the delayed post-test, compared to those of the traditionally instructed students. This finding showed that the mode of instruction could greatly influence learner achievement. In another study conducted by Akar (2003), there was no statistically significant difference in learner achievements in short structured questions between the constructivists instructed students and the conventionally instructed students. However, the study found a statistically significant difference in the learner's achievement in knowledge retention of essay type questions between the constructivist and conventional groups. In the study, the constructivist-instructed student's retained more knowledge in essay achievement test as compared to those instructed through the conventional methods. The constructivist-instructed students equally performed better in essay type questions. This finding is in line with the preposition made by Daloğlu, Baturay & Yildirim (2009), that constructivist learning is effective in the retention of knowledge

Similarly, in a study conducted by Bimbola, & Daniel (2010), the results indicated that there was improvement in academic performance of students in constructivist group on pretest and delayed posttest. Their scores in topic specific topics considered, at the post test level, were higher than their scores at the pretest levels and that this was different from score obtained by colleagues in the conventional lecture group. When the same groups of students were subjected to a delayed posttest stage, students in constructivist group were able to retain about 80% of the concepts taught compared to their colleagues in conventional lecture group who could only retain about 10% of the concepts taught. The findings in the above studies therefore indicate that constructivist instructional methods consistently produced better learner achievements. This study compared the effects of constructivist and conventional instructional methods on learner achievement among secondary school students in Homabay County.

### 2.11.1 Gender differences in learner achievement under constructivist and conventional instructional methods

Gender is a socially ascribed attribute which differentiate feminine from masculine (Chinwe & Chinyere, 2010). Difference in biology achievement due to gender has caused a lot of concern to educationists. In some instances, it has been argued that girls do not perform better in mathematics and sciences as compared to boys. Some of these differences have been attributed to gender discriminations that are believed to be exhibited by the nature of teaching materials and environments as well as the dominant patriarchal worldviews in most societies. (Wai & Watt, 2009). Some scholars have concluded that girls think and learn differently as well as interact with equipment differently from boys. These differences occur also in the teaching and learning of biology. Studies reveal that girls and boys have different approaches to learning (Geist, & King, 2008; Eliot, 2013).

A study conducted by Chinwe & Chinyere (2010) on the effects of constructivist instructional approach on students' achievement in basic ecological concepts in biology revealed that while there was no statistical difference in the students achievement tests in the post-test evaluations between boys and girls, the pre-test exams revealed differences in the scores for girls and that of boys. From their study Chinwe & Chinyere (2010) concluded that constructivist instructional methods enabled the girls to achieve better learning outcomes. Earlier, Aiyedun (2000) who discovered that difference in the achievement of male and female students could be taken care of by using good methods, material and appropriate teaching strategies.

### 2.11.2 Class category differences in learner achievement under constructivist and conventional instructional methods

It is generally recognized that students at single-sex schools register higher learner achievement based on evaluations than those at co-educational schools (Crchealth.com, 2015). The reason for this is much disputed. Pitching the two groups advocating for single sex or co-ed schools is the argument for social advantage and the holistic approach to education. The former claim that students in single sex schools are ‘better’ educationally while the latter group argue that the students to the single-sex schools represent a more academic or socially advantaged group. In 2001, a British study concluded that nearly every girl regardless of her ability or socioeconomic status performed better in single sex classrooms than co-educational ones (Smithers & Robinson, 2006).

## 2.12 Learners’ Attitude towards Constructivist Learning Methods

Plotnik and Kouyoumdjian (2011), define attitude as; “Any opinion or belief that includes an evaluation of some objects, person, or event along a continuum from negative to positive and that predispose us to act in certain ways towards that object, person or event” (p.588). What is suggested here is that attitude influence a person’s way of thinking, feeling and general behaviour. The attitude, feelings or opinion a student has on particular subject area, the subject teacher and the instructional approach adopted by the teacher has a big influence on what is learned (Slavin, 2009). Students who have positive attitude towards a subject tend to perform better than students who hold negative attitude. Jurik, Gröschner & Seidel (2013) and Miheso-O’Connor (2002) are in agreement that students’ attitude can be manipulated in a learning environment to enhance achievement of the learning goals. Miheso-

O'Connor (2002) refers to students' attitude as a "symptom of the prevailing classroom learning environment as created by the teaching approaches used by the teachers". (p.78) and posits that in traditional classrooms dominated by lecture and few demonstrations, students' attitude are less positive compared to classrooms where interactive activities are prevalent. Constructivist learning methods create interactive classroom environment where students learn co-operatively, share feelings, and compare knowledge resulting into acquisition of high order thinking skills (Intel Corporation, 2008).

Becker & Maunsaiyat (2004) compared the learner attitude of two groups of students in constructivist and conventional instructional methods. In their study, the samples mean scores, standard deviation, percentages, and opinions on surveys were used to compare results for the students' attitude towards the two instructional methods. Their findings showed that there was a significant difference in student attitude towards the two instructional methods. Students had positive attitude towards the constructivist instructional methods than the conventional methods. In a study of learning biology, Donaldson (2001), found that high school students taught biology using constructivist method have positive attitudes towards biology as a subject. The students reasoned that hands- on- activities like projects, experiments, discussions, and use of models made them more interested in learning biology and provided them with skills to transfer in learning other subjects. The students also remarked that when biology is taught using lectures, lessons became long and boring. The present study adds a new dimension to the work of Donaldson (2001) by comparing the gender differences towards constructivist instruction method in learning biology.

Gender differences refers to the socially constructed expectations of boys and girls. Gender describes the characteristics that a culture or a society desalinates as masculine or feminine (Stoltzfus, Nibbelink, Vredenburg, & Hyrum, 2011). These socially delineated expectations play a role in individual self-concept as well as aspirations and expectations in life (Rudman, & Phelan, 2015). It has been postulated that gender plays a role in learner achievement (Crchealth.com, 2015). In other studies, attitude of learners has been indicated to be responsible for the difference in learner achievements across the two genders (Jones, Howe & Rua, 2000). Available literature indicates that girls have positive attitude towards the constructivist learning environment as compared to boys. A study conducted by Ongowo, Indoshi and Ayere (2015) compared the perception of learning environment between boys and girls and concluded that girls had positive perception about the constructivist learning environment.

## 2.13 Research on Constructivist Learning Methods

Wan–ju–Lin (1998) researched on the effects of restructuring biology teaching on high school students' performance in biology. The study aimed at exploring attitude of the students on the use of constructivist approaches to teaching biology. Study outcome revealed that students have positive attitude towards cooperative learning than transmission learning methods. Wan-ju-Lin found out that 95% of the students who participated in the study valued cooperative learning as 89% of them considered the outcomes of their learning better than before. The students understanding of nature of science increased as they were now capable of thinking critically about scientific concepts than before. The social constructivist learning approach adopted in this study involves a lot of cooperative learning aspects.

Lord (1999) compared the effects of teacher-centred and constructivist methods of instruction on performance of college students studying environmental science course. The study found significant difference on mean performances of unit examinations for the two groups. Students taught using constructivist method had a much better understanding of the information covered in the units than did students in the teacher-centred group. Again on test questions that required students to interpret results and project outcome, the constructivist group proved better. Lastly assessment of students' evaluation sheets revealed that students who participated in constructivist group found the course to be more informative and enjoyable than the students in teacher-centred group.

Origa (2000) researched on impact of constructivism theory in learning geometry among girls in Kenyan secondary schools. The aim of the study was to find out if differences exist in performance of girls who learned geometry through constructivist method and those who learned through other methods of instruction. The study found that girls who learned through constructivist instruction attained better scores in post-test compared to girls who learned through other instructional methods. Whereas Origa (2000) confined investigation on effects of constructivist to learning mathematics among girls, the present study extended the investigation to include; the effect of constructivist instruction on learning biology between boys' and girls' and also the effect of learning biology at different cognitive levels.

Miheso-O'Conner (2002) researched on relationship between interactive and conventional teaching methods on acquisition of high order thinking skills in learning mathematics among secondary school students in Nairobi. The study revealed that interactive methods of teaching are more effective and yield better results at higher order skills learning than conventional method of teaching. The interactive teaching methods discussed by Miheso-O Conner (2002) are essentially constructivist instruction learning methods.

Plourde and Alawiye (2003) researched on the impact of pre service teachers' beliefs of personal knowledge on constructivism and personal application of constructivist learning. The study revealed that as teachers' knowledge of constructivist theory increased, so do their attitude towards applying constructivist principles in classroom learning. Therefore, it is possible to conclude that learner centred approaches of teaching and learning require supportive polices for effective preparation of teachers. Student-teachers' need to experience constructivist methods of learning as they under take training to effectively apply the instructional method later in their teaching career. In Kenya today, the dominant methods of instruction used in teacher training colleges are lectures and demonstration while the graduating teachers are required to apply student centred instructional strategies in classrooms. According to Amolo (2005), many serving teachers feel ill prepared to use learner centred methods of instruction and this is possibly due to intricacies involved in preparation and implementation of the methods.

Wilder and Shuttleworth (2004) prepared a biology lesson activity to teach the topic cell inquiry to high school year one students. The researchers wanted the students to develop scientific inquiry attitude and an understanding of the topic. They decided to use 5E's learning cycle model of constructivist instruction for the 80 minutes period, aiming that the 5E's learning cycle would automatically structure the learning into inquiry based and at the same time address effective learning of the subject content. At the end of the lesson, the researchers found the instructional model very effective in promoting scientific inquiry and content learning leading them to draw the following conclusions: One, during the engagement stage, students should be presented with an activity which creates disequilibrium in their understanding to provide motivation for the exploration stage. The activity can be an experiment to carry out or a challenging question for the students to answer. Two, the explanation stage should provide learners with opportunity to freely discuss alternative understandings they hold with peers in the class and within the learners themselves resulting into effective knowledge construction.

Tien-Wu and Tsai (2005) conducted a study to compare the effectiveness of constructivist oriented instruction and traditional instruction on formation of cognitive structures by elementary school pupils. Educationists and cognitive scientists are in agreement that pre-acquired knowledge can be represented in terms of cognitive structures (Tien-Wu and Tsai, 2005).The constructivist group was presented with a combination of prediction, observation and explanation (POE) strategy and small group cooperative learning activity. The study found that constructivist oriented group attained better learning outcomes both in terms of concepts attained and riches with cognitive structures. Well organized cognitive structures help learners store more information in their long-term memory. Whereas Tien-wu and Tsai compared effects of constructivist and traditional methods of instruction amongst elementary school pupils, this study compares the two instructional methods on learning amongst students in secondary schools.

Bleicher and Lindgren (2005) researched on the relationship between conceptual understanding, self-efficacy and outcome expectancy beliefs of pre-service teachers by exposing them to six weeks of learning science through constructivist instruction method. The study found out that pre-service teachers made positive gains in self-efficacy, outcome expectancy beliefs and conceptual understanding of science. The researcher attributed the positive gains the pre-service teachers attained to many elements of constructivist instruction like hand-on, minds-on and discussion activities. The pre-service teachers felt they experienced success in learning and understood the science course well and would equally be comfortable teaching it.

Gijbels *et al.* (2006) compared the perceptions of two groups of law students based on instructional methods used in the class. One group studied in a problem-based curriculum and the other group of students in a lecture based curriculum. The study revealed that students on problem based curriculum perceived their learning environment to be more constructivist compared to students on a lecture based curriculum.

Prokop *et al.* (2007) conducted a study on Slovakian students' attitude towards learning biology with respect to age and gender. The students' attitude was investigated along six dimensions as attitude towards; interest in biology, career in biology, importance of biology, biology teachers as a role model, difficulty of biology as a subject and equipment used in learning biology. The study revealed that Slovak students have positive attitude towards biology lessons. Biology was most popular amongst girls and younger students. Study also found girls to have more interest in biology lessons and biology related careers than boys. The students' interest towards biology was found to be associated with handling live animals and plants during biology lessons. In terms of difficulty of the subject, 72% of the participating students described biology as an easy subject and most of the participants were students in grade nine where ecology is studied.  Kenyan students just like the Slovakians have interest in biology and would probably find ecology lessons interesting and easy to learn, however that will only be possible if teachers provide students with opportunity to learn in interactive environments.

In a study conducted by Ongowo, Indoshi and Ayere (2015) on the perception of constructivist learning environment in high and low achieving schools in Kenya , students from both low and high achieving schools have a high preference for constructivist learning environment and that they rated highly its personal relevance in the heir curriculum, uncertainty, critical voice, shared control as well as student negotiation than the learning environment they were experiencing under the conventional methods. Similarly, the same study indicated that the girls in high and low achieving schools perceived the constructivist learning environment highly compared to boys in high and low achieving schools and that low achieving schools had high preference for constructivist learning environment than the high achieving schools. The scholars therefore concluded that there is a difference between the students' perception of the constructivist learning environment and actual learning environment in favor of constructivist learning environment and that there are gender and school type differences in the perception of a constructivist learning environment.

In another study conducted by Khalid (2012), it was revealed that the students taught in a constructivist classroom not only learnt better but their rate of proficiency was also higher than that of the traditional or conventional learning environment. Constructivist group indicated a high level of satisfaction, and increased student participation. Students were more willing to volunteer answers and ask questions of the instructor in order to clarify material, and team discussions resulted in many new points being introduced. The findings of the study proved that constructivist teaching method is far better as compared to traditional method

In summary, the studies discussed in this section of the study indicate that constructivist method of instruction, compared to conventional or traditional methods of instruction seems to promote better learning outcome amongst high school students. Wilder and Shuttleworth (2004) used the 5Es constructivist instruction model for only 80 minutes to restructure biology lesson. This study considered the 80 minutes instructional period as too short to provide effective evaluation of effect of constructivist instruction and decided to extend the study duration to a period of 17 lessons. In the work of Tien-wu and Tsai (2005), investigation of the effect of constructivist instruction was on learning of elementary pupils. This study therefore chose to investigate effect of constructivist instruction on secondary school students. It is also evident from the studies that students' perception of learning environment is a powerful factor in influencing the way students' acquires new knowledge (Gijbels *et al*., 2006). The implication of these studies therefore is, educational policies released by the Government and Non-Governmental bodies like United Nations Educational, Scientific and Cultural Organization (UNESCO) should be coupled with means and ways of positively modifying students' perceptions and attitude towards achieving already identified educational goals.

## 2.14 Theoretical Framework

Learning theories provide clarity, direction and focus in instructional process by guiding formulation of specific instructional design procedures (Yilmaz, 2008).The present study is based on the concepts of individual constructivist theory of Piaget (1967) and social constructivist theory of Vygotsky (1978).Individual constructivist theory of Piaget (1967) provides a two pronged approach to knowledge construction. First, Piaget's cognitive structures (schema) responsible for adaptation processes of assimilation, accommodation and equilibrium are similar to use of prior- learning experiences in aiding new knowledge constructions. Second, learning occurs when an individual passes through four stages of cognitive developments as: Sensory-motor, pre-operational, concrete and formal operational stages. Concrete and formal operational stages are implied in constructivist learning. At the concrete stage, learning is by manipulation of objects, ideas and events which later transforms to formal reasoning. In constructivist learning, repeated manipulation of objects and ideas enables learners to construct meaningful concepts that can be transferred to logical abstract reasoning in a formalized manner.

The social constructivist learning theory proposed by Vygotsky (1978), consider learning as socially mediated exercise where a person constructs knowledge based on interactions with social and cultural environment. Knowledge formed by a learner is influenced by environment (context) and prior knowledge held by the learner (Borich, 2011). Therefore in social constructivist learning, teachers should provide learners with opportunity to negotiate meaning and to collaborate with peers and adults including teachers in knowledge construction (Straits and Wilke, 2007).The 5Es constructivist model adopted in the study is a social constructivist approach to learning and provide learners with opportunity to construct knowledge at individual and at social levels during group discussions.

## 2.15 Conceptual Framework

This study has been conceptualized with constructivist and conventional instruction methods as the main independent variables while learner achievement at different cognitive levels forms the dependent variables. Figure 2.0 illustrates how the independent variables interact with the intervening variables resulting into different dependent variables.

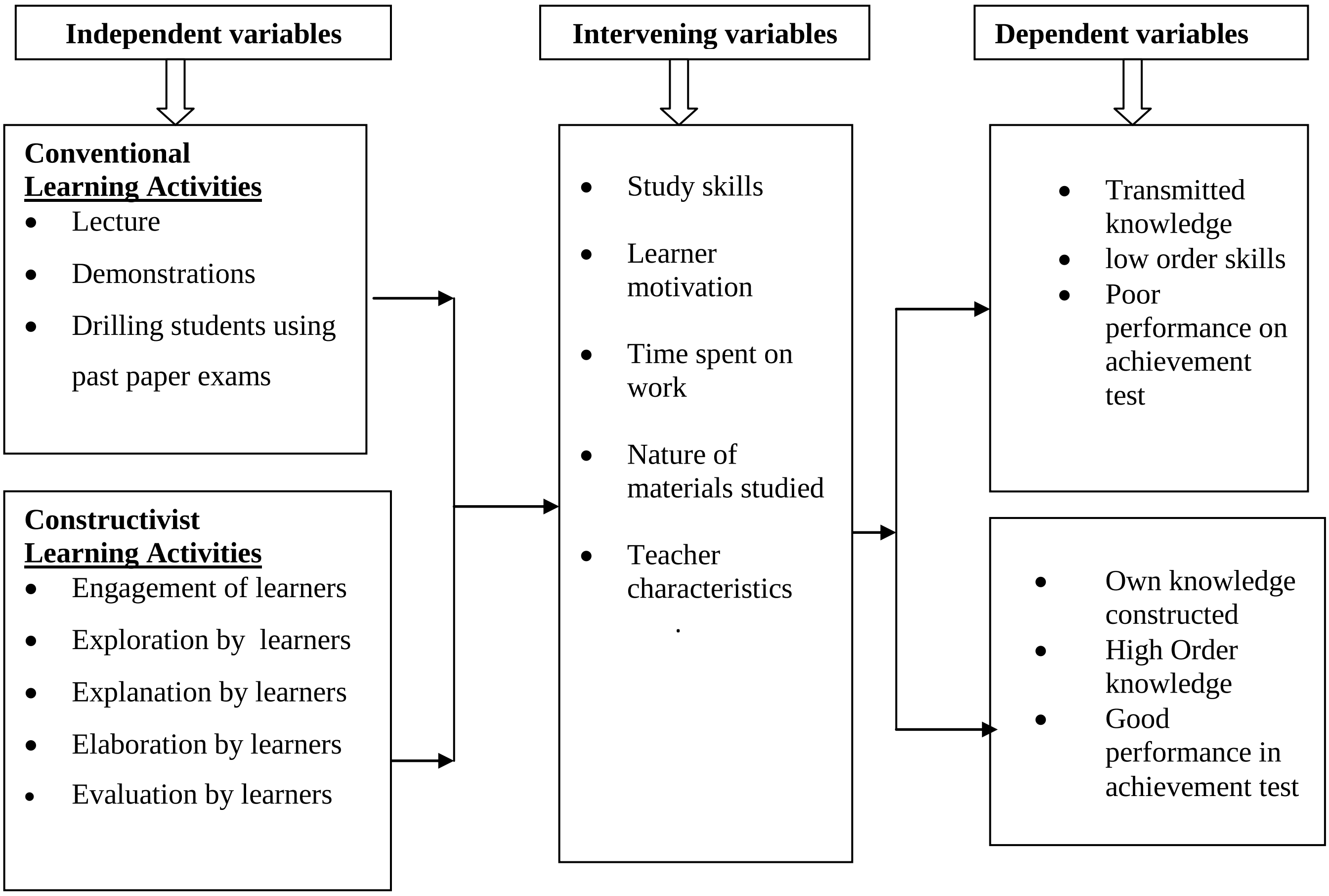


**Figure 2.1 : Conceptual framework**

# CHAPTER THREE: RESEARCH METHODOLOGY

## 3.1 Introduction

This chapter presents an over view of methodology applied in the study as discussed under the following section headings; research design, target population, accessible population, the sample size and sampling procedures, data collection instruments, pilot study, validity and reliability of the research instruments. The last section of this chapter contains brief discussion on ethical considerations and data collection procedures followed in the study.

## 3.2 Target Population

Target population for the study consisted of all the form three students in the Homabay County Secondary schools. The County had a total of 196 Secondary schools. The number of from three students at the time of the study was 14,320 students'. Of the 196 schools, 57 schools had a mean score of 4.5 to 6.4 in biology.

## 3.3 Sample Size and Sampling Procedures

Selection of the sample for the study involved multistage sampling technique. In the first stage, all schools in Homabay County which attained biology mean score of 4.5 to 6.4 in year 2010 KCSE were purposively selected from the 196 schools in the County which participated in the examination. From the selection, a list was prepared of 57 schools stratified into boys, girls and mixed schools. The schools met the biology mean score required for the study. In the second stage of selection, 12 schools comprising of four boys, four girls and four mixed schools were randomly selected from the 57 schools to participate in the study. The third selection stage, involved simple random technique and was done for schools with double or more streams to select the class to participate in the study. The whole selection process resulted into a sample of 477 students and 12 teachers who participated in the study.

### 3.4 Research Design

The study adopted quasi-experimental non-equivalent group design with a pre-test and a post-test (Gray, 2013). The design was used because participants selected for the study are intact classes existing in secondary schools and therefore assigning individual participants randomly into different treatment groups was not possible. Participants in the study were divided into two groups: Experimental and control groups. The experimental group participated in the constructivist method of instruction while the control group participated in conventional methods of instruction. The two instructional groups were further stratified in order to investigate on moderator variables like classroom category and gender of the participants. Based on classroom category, the experimental group was classified as participants in boys, girls, and mixed schools. However, based on gender, the participants were classified into boys and girls. In a similar way, participants in the control group were also stratified along classroom category and gender of the participant. Tables 3.1 and 3.2 represent design layouts of the experimental and control groups respectively.

**Table 3.1: Research Design for the Experimental Group**

| **Categories** | **Test** | **Treatment** | **Test** |
|---|---|---|---|
| **Boys (n = 70)** | $T_1$ | X | $T_2$ |
| **Girls (n = 79)** | $T_1$ | X | $T_2$ |
| **Mixed (n = 82)** | $T_1$ | X | $T_2$ |

**Key**

T1 – Pre-test

X – Experimental Treatment

T2 – Post-test

**Table 3.2: Research Design for the Control Group**

| Sample Categories | Test | Treatment | Test |
|---|---|---|---|
| **Boys (n = 91)** | $T_1$ | C | $T_2$ |
| **Girls (n = 74)** | $T_1$ | C | $T_2$ |
| **Mixed (n = 81)** | $T_1$ | C | $T_2$ |

**Key**

$T_1$ – Pre-test

C – Control

$T_2$ – Post-test

These were participants who took part in constructivist method of instruction. The group comprised of participants from six secondary schools out of 12 schools which were randomly selected to participate in the study. The six schools were purposively assigned to participate in the experimental instruction group because biology teachers of the schools accepted to participate in the experimental method of instruction. The schools which took part in the experimental instruction consisted of; 2 schools for boys with number of participants (n = 70), 2 schools for girls with number of participants (n = 79) and 2 mixed schools with number of participants (n = 82). In each school, only one biology teacher was selected to participate in the study. The total number of participants in the experimental instruction group comprised of 231 students and 6 teachers.

Activities of the experimental group formed the main focus of the study. Participants in the experimental group used the constructivist instructional manual prepared by the researcher to guide in delivery of the lessons. Lesson activities planned in the constructivist manual were designed on the format of the 5Es constructivist instruction model developed by Bybee (Trowbridge et *al*., 2004). Each lesson or double lessons progressed through five stages of activities. The stages are:

Engagement, Exploration, Explanation, Elaboration and Evaluation. Here follows brief explanation of activities that took place in the various stages during the lesson(s).

At the engagement stage, lesson activities were basically meant to engage the students into the activities of the day and involved an introduction to the lesson, presentation of the lesson objectives and presentation of the day's learning tasks to the participants. The engagement activities took a maximum of 10 minutes and then participants broke into groups for exploration stage.

In the exploration stage, participants carried out investigations on primary and secondary sources of information. Investigations on primary sources of information involved participants going out to the open fields to investigate activities of organisms in their natural habitats by use of quadrats, belt and line transects and by capture-recapture methods. Investigations on secondary sources involved participants searching for information on different textbooks, magazine and other materials like brochures' and pamphlets. From exploration stage, lesson activities moved to explanation stage.

During the explanation stage, members of a group discussed the challenges and outcomes of what they encountered during the engagement and exploration stages. Difficult terminologies and field experiences were the main challenges met by the participants during the engagement and exploration stages. However, all the challenges were pulled and collaboratively discussed in the groups during the explanation stage. All definitions, information and explanations are critically discussed in the groups for individual and group ownership.

From the explanation stage, different groups in the class converged for a whole class discussion shifting the lesson activity into the elaboration stage where each group presented its findings before the whole class. The shift from group to class discussion was guided by the class teacher who gave each group few minutes to present their findings to the whole class. Once a group had presented, a critique session by the whole class would follow and the group members elaborated on their findings. The teacher also presented new questions to the participants in addition to harmonizing the findings from different groups. Members of different groups presented their findings with the help of learning aids like tables and diagrams on manila papers or flip-charts. Elaboration stage provided participants with opportunity for individual and group reflection on the learning activities.

During the instructional period, the investigator visited the schools participating the experimental group every week to collect documentary evidence to confirm and ensure that the teachers were implementing the constructivist instruction methods as per the training they received.

Table 3.3 shows the category of schools which had biology mean score between 4.5 and 6.4 in KCSE year 2010 examinations in the county and were randomly selected to participate in the constructivist (experimental) method of instruction and the number of students in each of the sampled schools.

**Table 3.3: Participants in the Experimental Instruction Group**

| No. | No. of Schools | School category | Sample |
|---|---|---|---|
| **1** | 2 | Boys | 79 |
| **2** | 2 | Girls | 70 |
| **3** | 2 | Mixed | 82 |
| | **Total** | | 231 |

### 3.4.1 Control group

Control group were the participants who took part in conventional methods+ of instruction. The group comprised of participants from 6 secondary schools which were randomly selected from a stratified list of secondary schools (described earlier in section 3.2.1). The 6 schools were purposively assigned to the control method of instruction and they consisted of; 2 boys schools with participants (n = 91), 2 girls schools with participants (n = 74) and 2 mixed sex schools with participants (n = 81). A total of 246 students participated in the study as control group. Teachers participating in the control group were given an outline of the ecology topics to be covered during instructional process (refer to appendix 3), but were left free to prepare their own lesson plans. The teachers were also expected to cover the work in five weeks just like participants in the experimental group.

The Control group mostly adopted direct instruction procedures like lecture, demonstrations, direct use of textbooks in class and use of other supplemental reading assignments. Table 3.4 shows the category of schools which participated in the conventional (control) method of instruction and the number of participants.

**Table 3.4: Participants in the Control Instruction Group**

| No | No of schools | School category | No. of Participants |
|---|---|---|---|
| **1** | 2 | Boys | 74 |
| **2** | 2 | Girls | 91 |
| **3** | 2 | Mixed | 81 |
| | Total | | 246 |

## 3.5 Study Area

The study was conducted in Homabay County in the former Nyanza Province. Geographically the county is allocated in southern part of the Nyanza gulf of Lake Victoria and covers an area of proximately 3,541Km$^2$. There are six administrative districts (Sub-Counties) in the county. Such include; Rachuonyo North and South, Homabay, Ndhiwa, Suba and Mbita (Homabay.go.ke, 2016). (See appendix 7)

## 3.6 Data Collection Instruments

The instruments used for collection of data in the study included manual for constructivist instruction, a biology achievement test and an attitude questionnaire

### 3.6.1 Manual for Constructivist instruction Methods

Manual for constructivist instruction method (see appendix 1) was prepared to serve as a guideline to biology teachers participating in the experimental method of instruction. The manual contained activities expected to take place in a constructivist learning environment and all the work in the manual was organised to be covered in a period of twenty five lessons as per syllabus and regulation. The 25 lessons ware considered enough time to cover all the work which had been organised for the study. Instructional objectives for the lessons were clearly stated. Earl (2012), advises that objectives should be included in a lesson plan to identify important learning outcomes, guide instructional approaches towards the learning outcomes and identify appropriate learning assessment procedures. The objectives were designed to guide instruction geared to meet specific learning outcomes and more so help the participants to achieve high order thinking skills. Other lesson activities in the manual included; lesson introduction, lesson development activities and lesson evaluation. Lesson activities in the manual adopted the format of the 5Es constructivist instruction model. In preparation of the manual the researcher consulted on the works of (Origa, 2000; Brooks and Brooks, 2001 and Fosnot, 2005).

### 3.6.2 Biology Achievement Test

The Biology achievement test (see appendix 4) was used to measure learner's achievement in Biology. Test was taken at the beginning and at the end of the instructional period by experimental and control group of participants. At the beginning the biology achievement test was referred as the pre-test and was meant to measure participant's prior knowledge in the topic of study. At the end of the study, the Biology achievement test was referred to as post-test and was meant to measure the amount of learning that took place during the instructional period. Cohen (2014) explains that achievement tests are used purposely in measuring specific knowledge that is acquired through classroom learning. The items in the Biology Achievement Test were designed to measure specific objectives covered during the instruction process. The biology achievement test had items which were designed to assess participants' achievement by discriminating learning at six different cognitive levels as; remember, comprehension, application, analysis, evaluate and create. Item number one measured learning achievement at knowledge level, item number two at comprehension level, item number three at application level, item number four at analysis level, item number five at synthesis level and lastly, item number six at evaluation level. Here follows a brief description of the nature of each of the six biology achievement test items

Item number one was used to test learning at remembering level. Remembering skills represent the lowest level of learning outcome required in science. The item required participants to define terms like population, synecology, ecosystem etc. Participants had to recall into memory specific terms learned earlier.

Item number two, was used to test learning outcome at comprehension level. At comprehension level, students are required to have an understanding of information and ability to use the information. In the post-test, item number two was divided into five parts and each of the parts required participants to demonstrate ability to explain differences between two concepts, for example, explain the difference between pyramid of numbers and pyramid of biomass.

Item number three was used to test learning outcome at application level. Application level questions require students to apply concepts or principles they have learned to solve novel or real life problems. The question item had two parts; part one of the item required participants to describe situations where transects, capture-recapture and quadrats methods of population estimation can be applied. Part two of the item required participants to explain how to get accurate results when using capture- recapture method to estimate insect population.

Item number four was testing learning at the analysis of skills level. At this level of learning, students are required to be conversant with knowledge underlying structure of complex information and they should also be able to break down the complex information into simpler parts. The question item had three parts. Part one of the questions required the participants to isolate and construct two food chains from the diagram of the food web given. Part two of the question required participants to use the diagram and infer from it how the ecosystem could be affected by prolonged drought. In part three, participants were required to analyse the implications of removing tilapia (secondary consumer) from the food chain given.

Item number five was used to test learning achievement at evaluation level. Learning at evaluation level requires students to be capable of developing a new idea or product. The new idea formed should be an innovative way of solving a problem. The question item had five statements describing feeding relationships in a national park. In part one of the questions, participants were required to use information in the five statements given to construct a food web. In part two of the question participants were required to use the diagram they constructed to identify and name organisms occupying different trophic levels. Part three required participants to explain what could happen if some organisms in a given food web are eliminated.

Item number six was used to test learning achievement at creation level. Learning at this level requires students to make judgement against some given criteria. The question item was essay in type and required participants to suggest and describe any method that can be used to estimate the population of safari ants in a grassland area. Part two of the question item, required participants to explain advantages and disadvantages of the method they suggested. Both part one and two of the question required participants to judge the adequacy of the method of choice and how effectively it could be used. By explaining advantages and disadvantages of the method, participants were actually putting value judgements.

### 3.6.3 Attitude questionnaire

An attitude questionnaire of 16 statements was completed by students participating in the study (refer to appendix 5). The questionnaire was Likert type and was meant to measure students' attitude towards constructivist method of instruction. Participants responded to each by marking a choice on a five point scale of Strongly Agree, Agree, Undecided, Disagree and Strongly Disagree. Some of the question items in the questionnaire were positively stated and some were negatively stated. Positive statements favoured instructional methods or activities that agreed with constructivist beliefs and principles while negative statements favoured teacher centred instructional methods. An example of a positive statement is item number 14 which states: *Biology teachers should always give assignments that require students to look for answers in the library or from community resources.* Likewise an example of a negative statement is item number one which states: *In biology class, teachers should give students notes to copy*. In scoring for positive statements, Strongly Agree responses carried five points while Strongly Disagree responses carried one point. In scoring for negative statements the order of scoring was reversed so that Strongly Agree responses carried one point while Strongly Disagree responses carried five points.

A total of 296 participants completed the attitude questionnaire and out of whom, 150 were girls and 146 were boys. Only the student participants drawn from boys' and from girls' schools completed the attitude questionnaire while student participants drawn from mixed schools did not.

### 3.7 Pilot test

Richey & Klein (2014), recommend that experimental procedures should be pilot tested to reveal if there are any problems in the design, ambiguous instruction and incorrect timings. Since the constructivist instruction method was an experimental procedure, it was pilot tested in a purposively chosen sample of students in form three of a mixed sex school. The total number of students who participated in pilot test were 46. During the pilot study two sub topics of the topic Ecology viz; concepts of ecology and energy flow in an ecosystem was taught in seven lessons. The pilot study was done to confirm if the constructivist instruction manual could be used to effectively deliver the constructivist instruction lessons. Other tools used in the study and also pilot tested on the same sample included a Biology Achievement Test and Attitude Questionnaire. Orodho (2009) recommend that instruments for a study should be pilot tested to ascertain if the wordings are clear and if questions are measuring what they are supposed to measure. From the pilot study, timing adjustments and language suitability was made on all the tools used in the study. Pre-test and post-test results from the pilot study were used to work out the reliability coefficients of the Biology Achievement Test.

#### 3.7.1 Validity

Fraenkel and Wallen (2006), define validity of a tool as the "appropriateness, meaningfulness and usefulness of inference" (p. 150) of data collected by the tool. In order to collect appropriate and meaningful data for the study, all the tools used were validated. The Manual for Constructivist Instruction, in preparation, adopted the 5E instructional model for constructivist learning (Trowbridge *et al.*, 2004; Wilder and Shuttleworth, 2004). Construct validity of the Manual for Constructivist instructional was also improved by aligning learning objectives, activities and materials in it closely with the KICD and KNEC syllabuses and regulations. In order to ascertain content and face validity, the instructional manual was given to three biology teachers to judge on the format and suitability of its content. Corrections of expert researcher were incorporated before the manual was pilot tested.

The validity of the Biology Achievement Test was established by having the instrument critiqued by three expert biology teachers at secondary school level. The teachers independently judged on the suitability of the language used in the tool, format of questions, test instructions, timing allowances and length of items. Also to improve the validity of the assessment tool, the design of the tool considered the instructional objectives of the Biology syllabus and regulations. Items in the Biology Achievement Test formed representative sample of content domain covered during the instruction programme.

The attitude questionnaire was developed in Likert form and its validity was established by seeking the opinion of three expert researchers experienced in attitude scales (Frankel & Wallen, 2006). The expert researchers gave their opinion independently. Comments from the experts were incorporated in the final draft of the attitude questionnaire before it was pilot tested. From response of the pilot test, adjustments were made on the wordings, length of the items and relevance of constructs. According to Denscombe, (2014), a good questionnaire requires review by an experienced researcher.

### 3.7.2 Reliability

In order to improve the reliability of the Biology Achievement Test and the attitude questionnaire, the instruments were prepared with clear instructions for implementation. Clear instructions create uniformity in understanding of test requirements by all the participants taking part in the study. The instruments had enough test items to provide good coverage of the topic of study. All the teachers who participated in implementation and scoring for responses used common scoring keys. Pre-test, post-test and attitude scale instruments were administered in conditions which simulated normal school environments so as to remove any fears from student participants. The pre-test and post-test were presented as any other biology test that the participants took in the course of their study.

Reliability coefficients for the Biology Achievement Test was calculated using the split-half procedures described by (Fraenkel and Wallen, 2006; Beckstead, 2013). The split-half procedure used to work out reliability involved scoring odd and even numbered test items separately for the 46 students who participated in the pilot test and then working out the correlation coefficient. Using correlation coefficient worked out for the half tests, the Spearman-Brown prophecy formula was then used to calculate the reliability coefficient (r) of the whole test. Spearman-Brown formula is:

$$\textbf{Reliability Coefficient (r)} = \frac{\textbf{2x reliability of ½ test}}{\textbf{1+ reliability of ½ tests}}$$

The correlation coefficient worked out for half tests was 0.858. So Substituting 0.858 into the Spearman-Brown formula resulted into reliability coefficient r = 0.926. In addition to ascertaining the reliability coefficients of the instrument for workability, the researcher also reminded the teachers participating in the study to follow the laid down procedures for administering the tests. However, to achieve reliability of the Attitude questionnaire, the students were given enough time to respond to the items with no pressure of time limits but they were not allowed to consult each other. The questionnaires had clear instructions on how students were expected to make responses and thus limiting any ambiguity and hence improving response rate.

### 3.8 Data collection procedures

The investigator made visited all the schools participating in the study. Arrangements were made and all the teachers who participated in the experimental group were sufficiently trained on the manual for constructivist instructional method. The training was based on how the teachers were to administer the pre-test, post-test, attitude questionnaire and the instructional programmes in their schools. The study was done in a period of five weeks. In the first week of the study, the pre-test was administered to all the participants in the experimental and control treatment groups. After the pre-test, implementation of the instructional programmes took a period of five weeks during which the topic ecology was taught. Before the instruction exercise began, the researcher met and trained all the teachers participating in the experimental program on how to use the Manual for Constructivist Instruction. The experimental group were taught using the constructivist instruction method as outlined in the Manual for constructivist instruction. The control group were however taught using the conventional instruction methods (usual methods of instruction commonly used in the classrooms). Both groups were taught by their regular class teachers.

Within one week after the instructional programmes were over, the Biology Achievement Test (post-test) and the attitude questionnaire were administered to all students participating in the study. The Biology achievement test was given by the class teachers while the attitude questionnaire was administered by the researcher. At the end of the exercise, the researcher collected the pre-test scores, post-tests cores and attitude questionnaires responses from the biology teachers for scoring and data analysis.

## 3.9 Data Analysis

The study used descriptive statistics and statistical tests of significance to analyse and compare data from different treatment groups. For the achievement test, descriptive statistics was used to summarise, present, compare and explain results of the treatment groups in terms of mean score and standard deviation values. Tests of significance was used to find out if mean score differences of the pre-test and post-test results between treatment groups were significant at $\alpha = 0.05$ level. The tests of significance used in the study are the dependent samples t-test and one way ANOVA t- test.

For the attitude tests, descriptive statistics was used to summarise, present, compare and explain results of the treatment groups in terms of mean score and standard deviation values. T-tests was used to compare mean score difference in pre-test and post-test, the t-test. T-test was used to compare mean score values involving two treatment groups while one way ANOVA- tests was used where there are more than two treatment groups to be compared (refer to appendix 9).

## 3.10 Ethical consideration

After obtaining authorization from the National Commission for Science, Technology and Innovation (NACOSTI) to conduct the research, the researcher visited all the schools that had been sampled for the study to make formal request. During the visits, the researcher discussed with all the teachers who participated in the study the modalities of how the study was to be conducted.

# CHAPTER FOUR: FINDINGS AND DISCUSSIONS

## 4.1 Introduction

This chapter presents analysis and discussion of results of the study. The analysed and discussed results are presented in different sections of this chapter as per the objectives and hypotheses of the study.

## 4.2 The effects of Constructivist and Conventional Instructional methods on Learner Achievement

In order to compare learner achievement in biology between the constructivist and the conventional instructional method groups, their post-test biology achievement results were analysed and compared. Analysis of the post-test results to compare effects of constructivist and conventional methods instruction was done in two ways. In the first way of analysis, total post-test results for all participants in the constructivist group and total post-test results for all participants in the conventional groups was analysed and the results compared using descriptive statistics (refer to Table 4.1). In the second way of analysis, post-test results of the participants in constructivist and conventional groups were analysed and compared at each of the six cognitive levels (refer to Table 4.2). To test for any significant difference in mean between the two groups, independent sample t-tests were used. The analysed results are presented in Tables 4.1 and are in form of mean score, standard deviation and t-test values.

**Table 4.1: Post test results for the constructivist and conventional groups**

| Instructional group | Number of candidates | M | SD | t-test | P-Value |
|---|---|---|---|---|---|
| Constructivist | 231 | 45.84 | 15.05 | | |
| Conventional | 246 | 40.26 | 13.96 | 4.17 | 0.001 |

Results in Table 4.1 indicate that participants in the constructivist instruction group attained a mean score and standard deviation of (M=45.84; SD=15.05) while participants in the conventional instruction group attained a score of (M=40.26; SD=13.96). Participants in the constructivist group had a higher mean score than participants in conventional instruction group, indicating that participant's in constructivist group performed better than their peers in the conventional instruction group. T-test runs on mean score difference on performance of participants in the two groups produced the following results; $t\ (475) = 4.17$, $p<0.001$, suggesting a significant difference between the two instructional groups at $\alpha=0.05$level. The results implied that participants who were exposed to constructivist method of instruction had a better understanding of the information covered during the period of instruction than the participants who were exposed to conventional methods. The conclusion made was that constructivist method of instruction is more effective in promoting learning of biology amongst students at secondary school level compared to conventional methods of instruction. The better result produced by the constructivist group compared to conventional group was probably due to many activities the constructivist group was engaged in during instruction. Participants in the constructivist group formed working groups and collaboratively worked on task items once the classes were engaged.

Discussions, Presentations, Elaborations and critique activities that formed key aspects of constructivist instruction enhanced understanding and memory of participants in the constructivist group. The engagement phase provided learners with opportunity and much needed scaffolding which made them more focused and clear on how to carry out investigations and what to discuss in the groups. During the discussions, participants constructed own knowledge and tested it within the groups hence providing them with room for immediate feedback and motivation to seek for more information from a variety of sources possible. During elaboration phase, participants were presented with new tasks but the tasks were related to what they learned earlier hence Participants got opportunity to expand their horizons of thought as they reflected on the new tasks.

The idea of teachers building on learners prior knowledge was similarly elaborated by Conley (2012) who advises that the teachers should make it their responsibility to assist students make meaningful connections between prior knowledge and new information as opposed to drilling students on the 'basics' in an isolated manner. In this study, the 5E constructivist model provided teachers with opportunity to help the students' make connections between prior knowledge and new knowledge experiences leading to better performance in post-test compared to pre-test. Conley also recognised the importance of cooperative element in constructivist instruction as a way of promoting competition between groups in a class thus, providing students with motivation and excitement resulting into improved performance. Barkley, Cross and Major, (2014) similarly explained superiority of constructivist instruction over traditional instruction methods on its ability to allow for group discussion and interaction, thus allowing positive interdependence among student's with individual accountability which results into better learning outcomes.

### 4.2.1 Comparing the effects of the Constructivist and Conventional Instructional Methods on Learning Biology at Different Cognitive Levels

The study also compared effects of the two instructional methods on learning biology at each of the six cognitive levels discussed by Bloom *et al. (*1956) in their classification of the cognitive domain. Table 4.2 presents the analysed post-test results for participants in constructivist and conventional instruction groups' .The results are presented as; mean standard deviation, t-tests and p-values for each item of the post-test. The analysis was aimed at revealing and comparing performance of constructivist and conventional instruction at different cognitive levels. At each of the six cognitive levels, t-test and p-values has been worked out to compare performance of the two instructional groups.

**Table 4.2: Posttest Results for participants at Different Cognitive Levels**

| Cognitive Levels | Group | M | SD | T-value | P-value |
|---|---|---|---|---|---|
| **Remember** | Exp.(n=231) | 56.41 | 31.75 | 4.189 | <0.001 |
| | Control(n=246) | 44.67 | 29.41 | | |
| **Comprehension** | Exp.(n=231) | 38.57 | 24.87 | 5.355 | <0.001 |
| | Control(n = 246) | 27.23 | 21.32 | | |
| **Application** | Exp.(n=231) | 37.45 | 28.05 | 4.778 | <0.001 |
| | Control(n = 246) | 25.73 | 25.49 | | |
| **Analysis** | Exp.(n=231) | 60.13 | 23.69 | 0.0906 | 0.928 |
| | Control(n=246) | 60.33 | 23.37 | | |
| **Evaluate** | Exp.(n=231) | 55.45 | 29.08 | 3.023 | <0.003 |
| | Control(n = 246) | 63.41 | 28.69 | | |
| **Create** | Exp.(n=231) | 27.06 | 28.42 | 3.004 | <0.003 |
| | Control(n=246) | 20.16 | 21.40 | | |

Results for control group at analysis and create levels were: Analysis (M = 60.33; SD = 23.37) and create (M=63.41; SD=28.69) while results for experimental group were analysis (M = 60.13; SD = 23.69) and Evaluate (M=55.45; SD=29.08). T-tests revealed the following results; Remember, t (475) = 4.19, p < 0.001; Comprehension, t (475) = 5.36, p < 0.001; Application, t (475) = 4.78, p < 0.001 and Create, t (475) = 3.00, p < 0.003. These results reveal significant difference in learning achievement between participants in constructivist and conventional methods of instruction. At analysis and synthesis levels, T-test runs on mean difference between the two methods of instruction at analysis and synthesis levels produced the following results: At analysis, t (475) = 0.09, p <0.93 and at Evaluate t (475) = 3.02, p < 0.003.

The results presented in Table 4.2 further show that in this study, there was decrease in performance mean score from lower to higher cognitive level items as is generally expected in achievement test, however, mean scores for the analysis and the synthesis skill level items defied the trend and were higher than mean scores participants attained at lower cognitive skill items.

Finally, the results in Table 4.2 indicates that participants who received constructivist instruction (experimental group) produced higher mean scores at the remember, comprehension, application and evaluation levels compared to participants who received conventional instruction (control group). T-test runs on performance mean difference between participants in the constructivist and conventional groups of instruction at the four cognitive levels produced the following results.

These results revealed that at the analysis level the mean difference in performance between control group and experimental group of participants was insignificant while at the evaluation level the mean difference was significant in favour of the control group.

This study explains the higher mean scores participants attained at the analysis and evaluation level items based on Lake Wobegon effect (Thorndike & Thorndike, 2010). Lake Wobegon effect is an attempt to explain causes of inflation of a test result based on experience of participants before taking a test. In this study, either the biology teachers revised with participants' some items similar to items four and five in the post-test or the participants' themselves engaged on self-revision of question items on topic ecology before the post-test thus resulting into inflated scores for the two items.

### 4.3 Effectiveness of Constructivist Instructional Methods on Learner Achievement in Biology

In order to compare the effect of constructivist instructional method amongst participants in different class categories, pre-test and post-test results of the groups participating in constructivist instruction was analysed and presented by use of descriptive statistics of mean and standard deviation values. T-test was also used to find out significance in mean difference in performance between different class categories. The analysed pre-test and post-test results for the three categories of participants in the constructivist group are presented in table 4.3. In the Table, post-test--pre-test mean difference for the three categories of participants are also presented.

**Table 4.3: Pre-test and Post test Results of the Constructivist Group**

| Class category | Pre-test | | Post-test | | Posttest-pretest |
|---|---|---|---|---|---|
| | $M_1$ | SD | $M_2$ | SD | $M_2 - M_1$ |
| **Boys(n = 71)** | 29.15 | 13.53 | 38.45 | 11.96 | 9.3 |
| **Girls(n = 78)** | 14.14 | 11.32 | 54.27 | 14.69 | 40.13 |
| **Mixed(n = 82)** | 20.93 | 11.90 | 44.23 | 14.60 | 23.30 |

As shown in Table 4.3, the analysed pre-test results of participants in the constructivist group indicate that boys with a mean and standard deviation of (M = 29.15; SD = 13.53) performed better than participants in the mixed sex classes with (M = 20.93; SD = 11.90) and girls with (M = 14.14; SD11.32). The pre-test was taken before the participants received the instructional information and most items in the pre-test were testing understanding at the level of knowledge as per Blooms classification of cognitive Knowledge (Bloom *et al.*, 1956). The pre-test results therefore seem to suggest that before instruction, participants in boys' classes had more knowledge of facts and concepts of the topic ecology than participants in mixed sex classes and girls' classes.

To explain the disparity, it is possible to reason that participants in boys' classes were somehow motivated to 'read a head' for an impending test. All participants in the study were informed of the pre-test examination in advance. And since all the participants had not received any instruction on the topic at the time pre-test was taken, the better performance of boys can only be explained on the basis of a more organized revision boys made for the announced test. Otherwise the study expected all the three groups of participants to have similar results.

Data in Table 4.3 indicate that in post-test, performance of the participants in constructivist group took a different pattern. Participants in girls' classes attained the highest mean score and standard deviation of (M = 54.27; SD = 14.69) followed by participants in the mixed sex classes who scored (M = 44.23; SD = 14.60) and lastly participants in boys' classes with a score of (M = 38.45; SD = 11.96). All the Participants took the post-test after receiving instructional information for a period of five weeks. The same piece of information was given to all the participants. However, the results suggest that the amount of learning achievement registered by participants in the three categories of classes was not the same. Post-test ANOVA results also reveal a significant difference in the mean score values between the participants in the three class categories i.e. $F(2,228) = 25.0393$, $p = 0.001$ at $p=0.05$ level of significance. The null hypothesis was rejected and conclusion made was that constructivist method of instruction produce different learning effects in different class categories. Students in girls single sex schools learn significantly better than boys or students in mixed sex classes when teachers use constructivist methods of instruction.

The pre-test to post-test mean gains ($M_2$-$M_1$) indicate that girls' in girls single sex schools had the largest mean gain of (40.13%) followed by participants in mixed sex classes with mean gain of (23.30%) and lastly boys' with a mean gain of (9.3%). Girls' registered the highest mean score in the post-test and at the same time the highest pre-test to post-test mean gain compared to participants in mixed sex classes or boys'. It can be reasoned from the results that girls readily customised the constructivist method of instruction and therefore gained from it more than participants in mixed sex class or boys. Jurik, Gröschner and Seidel (2013) Miheso-O'Connor (2002) found girls to be more positive and to readily customize interactive methods of instruction. Newby *et al.* (2010), argue that a pre-test focuses learners on important aspects of instruction and may be girls took advantage of the pre-test and used it better than boys or participants in mixed sex classes to recognize and remember some concepts during the instruction process. Also, the poor performance of girls in pre-test may have motivated them to focus more on objectives of the instruction. This line of reasoning is supported by Rudolf (2012) who stated in his work that it is expected of the girls to have higher self-expectation and work harder to compensate for what they believe are personal inadequacies.

## 4.4 Effectiveness of constructivist instructional methods on learner achievement in biology between boys and girls

In order to find out if constructivist method of instruction can discriminate learning of biology at different cognitive levels between girls and boys, performance of girls and boys was measured and compared on each of the items of the post-test and results presented in Table 4.4. The results in Table 4.4 are in terms of mean score and standard deviation values at each cognitive level. T-tests and p-values at each cognitive level are also presented in the table.

**Table 4.4: Post test Results for Boys and Girls at Different of Cognitive Levels**

| Cognitive level | Sex | No | M | SD | T-value | P-value |
|---|---|---|---|---|---|---|
| **Remember** | F | 117 | 70.94 | 30.05 | 7.94 | 0.001 |
| | M | 114 | 41.49 | 26.11 | | |
| **Comprehension** | F | 117 | 44.19 | 26.33 | 3.57 | 0.001 |
| | M | 114 | 32.81 | 21.92 | | |
| **Application** | F | 117 | 46.58 | 29.19 | 5.30 | 0.001 |
| | M | 114 | 28.07 | 23.49 | | |
| **Analysis** | F | 117 | 62.65 | 25.94 | 1.64 | 0.102 |
| | M | 114 | 57.54 | 20.93 | | |
| **Evaluate** | F | 117 | 50.94 | 27.20 | 2.45 | 0.151 |
| | M | 114 | 60.09 | 29.55 | | |
| **Create** | F | 117 | 24.77 | 28.79 | 1.23 | 0.210 |
| | M | 114 | 29.39 | 27.98 | | |

The results in Table 4.4 indicate that girls had higher mean scores in items measuring at the knowledge (M = 70.94), comprehension (M=44.19), application (M = 46.58), and analysis (M = 62.65) compared to boys whose mean scores were; knowledge (M = 41.49), comprehension (M = 32.81), application (M = 28.07) and analysis (M = 57.54). These results imply that girls performed better than boys in the four items of post-test. T-test runs on mean differences between girls and boys performances on the four items discussed above produced the following results; knowledge, $t(299) = 7.94$, $p < 0.001$; comprehension, $t(299) = 3.56$, $p < 0.001$; application, $t(299) = 5.30$, $p < 0.001$ and analysis, $t(299) = 1.64$, $p = 0.102$. These results are at $p=0.05$ level of significance. The results revealed a significant difference in performance between girls and boys at knowledge, comprehension and application levels. Girls performed significantly better than boys in items measuring at knowledge, comprehension and application levels. However, at the analysis level, the difference in performance between girls and boys was insignificant. At evaluation levels, although boys attained better mean score than girls, the t-test runs on mean difference revealed insignificant difference. From these results it was concluded that constructivist method of instruction enable girls to learn better than boys at lower cognitive levels. But at higher cognitive levels, constructivist method of instruction did not discriminate learning between girls and boys. Since constructivist instruction is interactive, it can be reasoned that girls compared to boys learn better in interactive class. The reasoning that girls learn better in a constructivist environment is supported by findings in section 4.5 of this piece of work where results of analysis of attitude questionnaire revealed that girls as opposed to boys are more interested in class environments that support constructivist principles.

## 4.5 Attitude of students towards the constructivist instructional methods

In order to ascertain the overall attitude of students towards the constructivist instructional methods, responses from all the students who took part in the constructivist and conventional methods of instruction and also responded to the attitude questionnaire were analysed. Analysed results were as follows; girls had a mean score and standard deviation of (M=58.30; SD=9.15, N=150) while boys had a score of (M=53.14; SD=8.24, N=146). T-test runs on mean score differences for the groups revealed a significant difference between girls and boys attitude i.e. $t(294) = 5.18$, $p<0.001$.The results were as presented in Table 4.5 below.

**Table 4.5: Attitude of Students towards the Constructivist Instructional Methods**

| Gender | Mean | Std. Dev. | t-value | p-value |
|---|---|---|---|---|
| **Girls(N=150)** | 58.3 | 9.15 | 5.18 | <0.001 |
| **Boys(N=146)** | 53.14 | 8.24 | | |

These findings led to the rejection of the null hypothesis formulated for this objective of the study, thus leading to the following conclusion. Secondary school students have a positive attitude towards the constructivist instructional methods. Secondly, generally secondary school students are more positive towards use of constructivist method of instruction than the conventional method of instruction commonly used in biology class. This reasoning is based on the fact that considering the performance of boys' and that of girls', each of the two groups of participants scored over 50% in the attitude questionnaire, implying that both boys' and girls' like learning in environments where they have opportunity to actively participate in knowledge construction.

### 4.5.1. Attitude of students towards Specific aspects of constructivist Instructional methods

The attitude of boys' and girls' towards specific aspects of constructivist learning environment was also compared. This was done by analysing the participants' responses to some of the items on the attitude questionnaire. The items were purposively selected for analysis because the researcher considered the items as either strongly favouring constructivist or teacher-centred learning environments. The results are presented as percentages of participants who responded on the various scales of the response categories.

### 4.5.1.1 Attitude towards evaluation of basic concepts

The students' questionnaire had the following question testing on students' attitude towards teachers introducing lessons by asking questions from a topics which have not been covered in class. Q4. *A biology teacher should not introduce a lesson by asking questions on the topic he / she is yet to teach.* Figure 4.1 presents responses of the participants' attitude towards the idea of teachers introducing lessons by asking questions on topics which have not been taught in class.

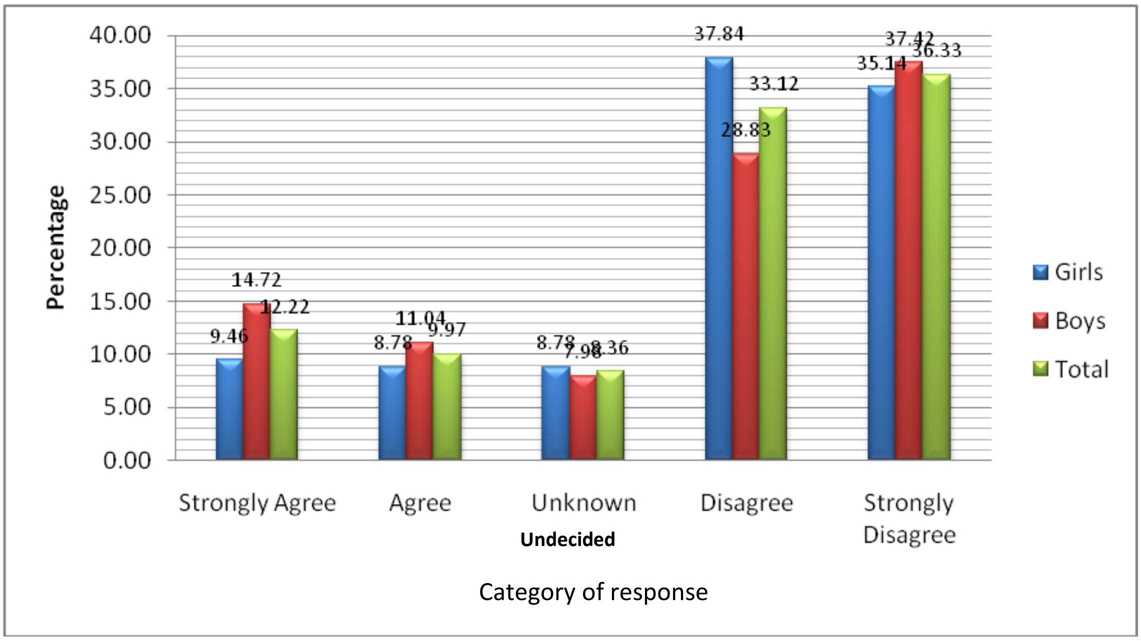


**Figure 4.1: Students attitude towards evaluation of basic concepts**

The results presented in Figure 4.1 indicates that 22.19% i.e. (12.22% + 9.17%) of the total participants were agreeing with the idea that teachers should not introduce a lesson by asking questions on topics yet to be taught while 69.45% of the total population were disagreeing with the idea thus indicating that teachers are free to ask such questions.

#### 4.5.1.2 Attitude towards sitting arrangements

Data on students' attitude towards sitting arrangements in a biology class was collected from participants' responses to the following question in the questionnaire: Q5. All the time students are in a biology class, they should sit facing the blackboard. Figure 4.2 indicate responses of participants' attitude towards sitting arrangement in a biology class.

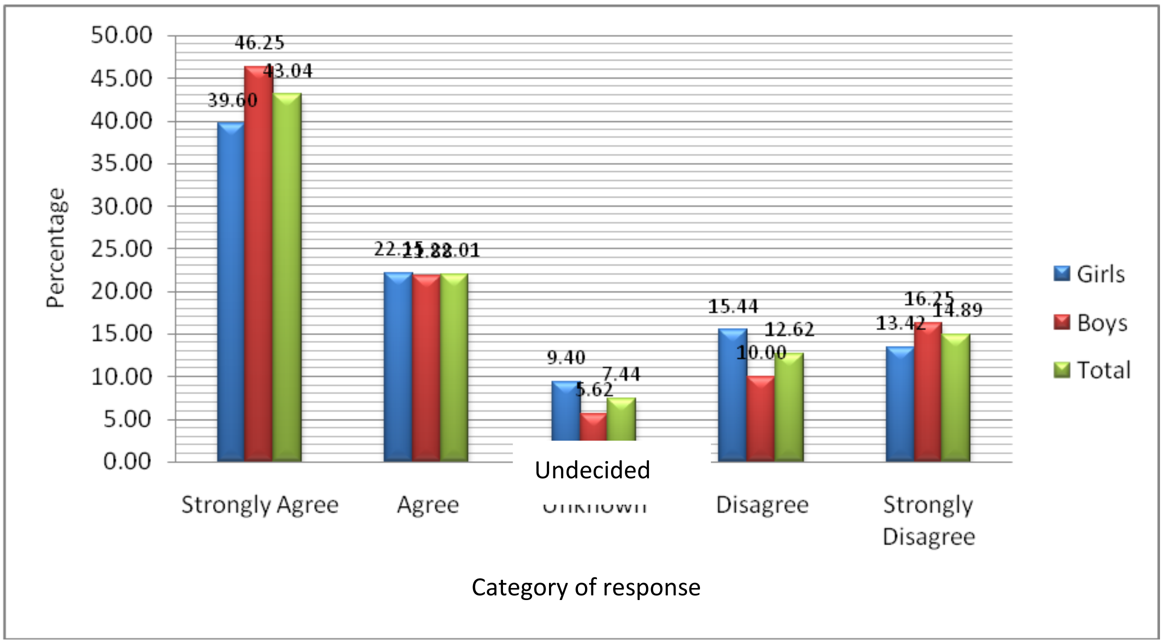


**Figure 4.2: Attitude of students towards sitting arrangements**

The results in Figure 4.2 indicate that 65.05% i.e. (43.04 + 22.01) of the total participants were agreeing with the idea that students in a biology class should always sit facing the blackboard while 17.51% were disagreeing with the idea. On comparing responses of girls and boys, it was found that 61.75% of girls and 68.10% of boys who participated in the study were agreeing that students should always sit facing the blackboard. At the same time, 28.86% of girls and 26.62% of boys were disagreeing. These results might imply that high school students always expect to sit facing the blackboard when in class. Facing the blackboard in class is the common way of siting in many classrooms (Straits and Wilke, 2007). It is a direct indication of transmission learning models taking place in many classrooms. In transmission learning' students acquire information transmitted through lectures, text books and few teacher demonstration (Slavin, 2009). In such scenario,students always sit when facing the blackboard with intension of reaping the maximum information from the teachers. The siting arrangement inhibits students from face to face contact and diminish learning Santrock (2004).

Siting when facing the blackboard is a silent rule in many classrooms. Girls readily accomodate changes in classroom and particularly changes that favor collaborative learning experiences. In this study, the experimental group of participants sat facing the blackboard for only few minutes during the introduction of the lesson after which the participants settled into various class activities where they sat in groups facing each other to allow for collaborative learning amongst themselves.

#### 4.5.1. 3 Attitude towards personal relevance of biology

In order to find out students' attitude towards personal relevance of what they learn in biology to their life in and out of school, participants responded to the following question: Q7**.***What is learnt in biology is to enable students pass examinations only.* Figure 4.3 indicates the results of responses of participants' attitude towards personal relevance to what is learnt in biology.

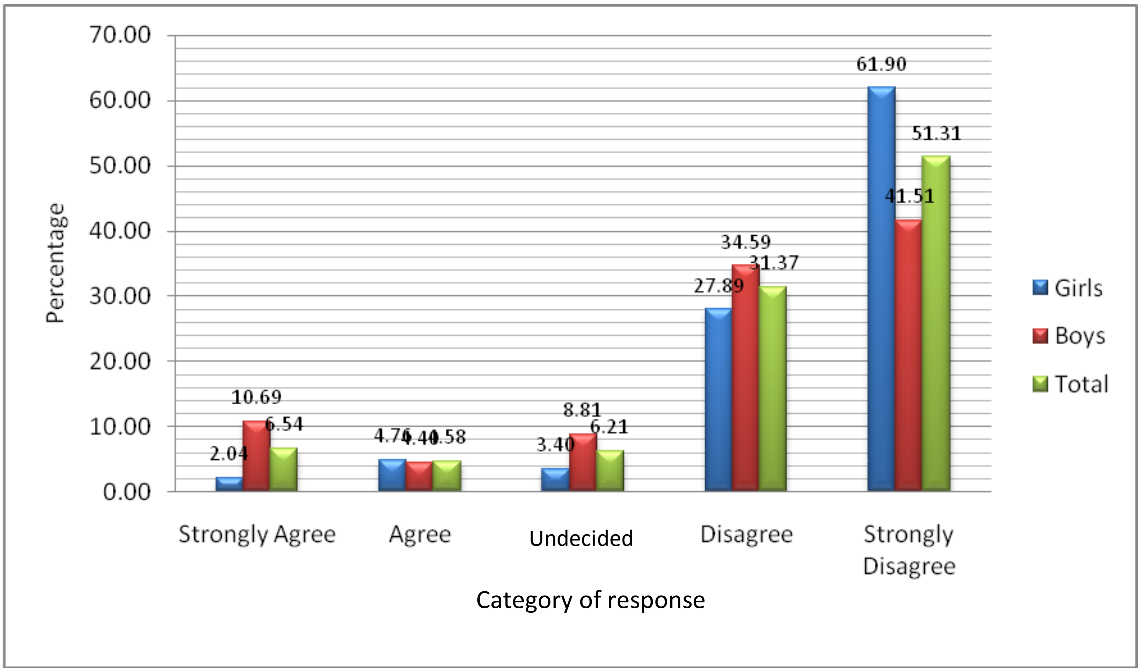


**Figure 4.3: Attitude of students towards personal relevance of biology**

The results in Figure 4.3 indicate that 11.12% of the total participants were agreeing with the idea that what is learned in biology class was only for passing examinations while 82.68% were disagreeing with the idea implying that most students find relevance and value of what is learned in biology as helping in understanding and solving problems in and out of school. In support of this, Prokop *et al.* (2007) found Slovak students to believe in importance of knowledge of biology but in contrast to Kenyan students, Slovak students do not consider knowledge of biology as useful and necessary to their daily life. On comparing the attitude of girls' and boys' towards this aspect of a learning environment, it was found that 6.8% of girls and 15.09% of boys were agreeing while 89.79% of girls and 76.10% of boys were disagreeing with the idea that biology they learn in school is only for passing examinations. These results indicate that girls seemingly have more relevance of what they learn in biology as useful to them in future life. Airasian (2000) states ‘knowledge takes on added meaning when it can be used in real life situations...” (p.111).

### 4.5.1.4 Attitude towards nature of assignments

Data on students’ attitude towards teachers giving assignments that require reference to library or community resources was collected from participants’ responses to the following question: Q14. *Biology teachers should always give assignments that require students to look for answer from library or from community resources.* Figure 4.4 presents responses of participants’ attitude towards students being referred to the library and community resources to do assignments.

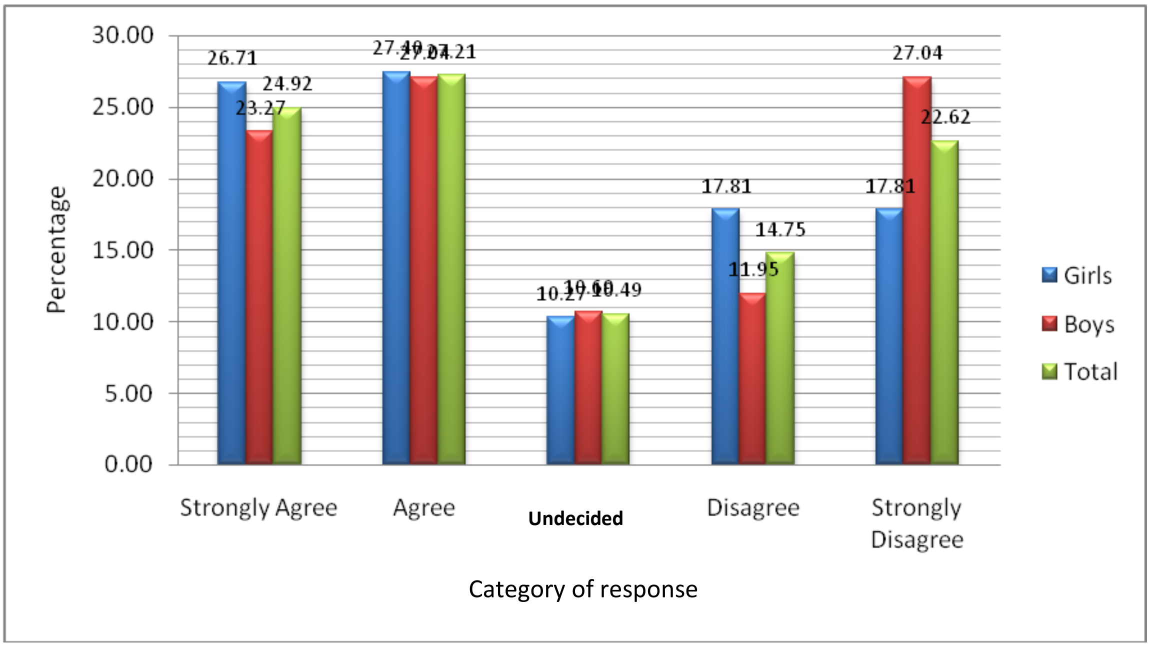


**Figure 4.4: Attitude towards nature of assignments**

The results presented in Figure 4.4 indicates that 52.13% of the total participants were agreeing with the idea that biology teachers should always give assignments that require students to seek answers from library or community resources while 37.37% were disagreeing with the idea. When girls’ and boys’ responses, was compared, it was found that 54.11% of girls and 50.13% of boys were agreeing with the idea while

35.62% of girls and 38.99% of boys were disagreeing with the idea. These results implied that girls, unlike boys seem to like the idea of being active and creative in the learning process. Girls also seem to like the idea of being responsible for their own learning. A greater percentage of participants in the study were agreeing with the idea of searching for answers to biology assignments from different resources in libraries and community resources. From the results, it was concluded that students seems to be interested in biology assignments that are thought provoking, require divergent reasoning and which can only be answered effectively from library and community resources.

Searching for answers from library and community resources is an active and creative process, a phenomenon of constructivist learning theory. Assignments that require divergent reasoning allow teachers to assess students learning in the context of daily teaching experiences (Fink, 2013). According to Fosnot (2005), constructivist teachers should provide learning environments which are innovative, allow students to think and explore. Such assignment would naturally require students to explore different source in search for an answer. In addition, such questions are generally of high level and answering them involves critical and creative thinking, an indication of better understanding of concept (Trowbridge *et al.,* 2004). Another implication of these results is that the students are in favour of classroom practices changing from direct teaching to students learning with little guidance from the teacher. According to Entwistle, (2013) traditional methods of teaching are not intellectual, they do not stimulate thinking and do not consider students diverse ideas.

#### 4.5.1.5 Attitude towards evaluation process

In order to find out the attitude of students towards evaluation of assignments by other students, participants responded to the following question in the questionnaire: Q15**.** *In Biology class, students can be allowed to evaluate other students' work.* Figure 4.5 presents participants' responses towards the evaluation process.

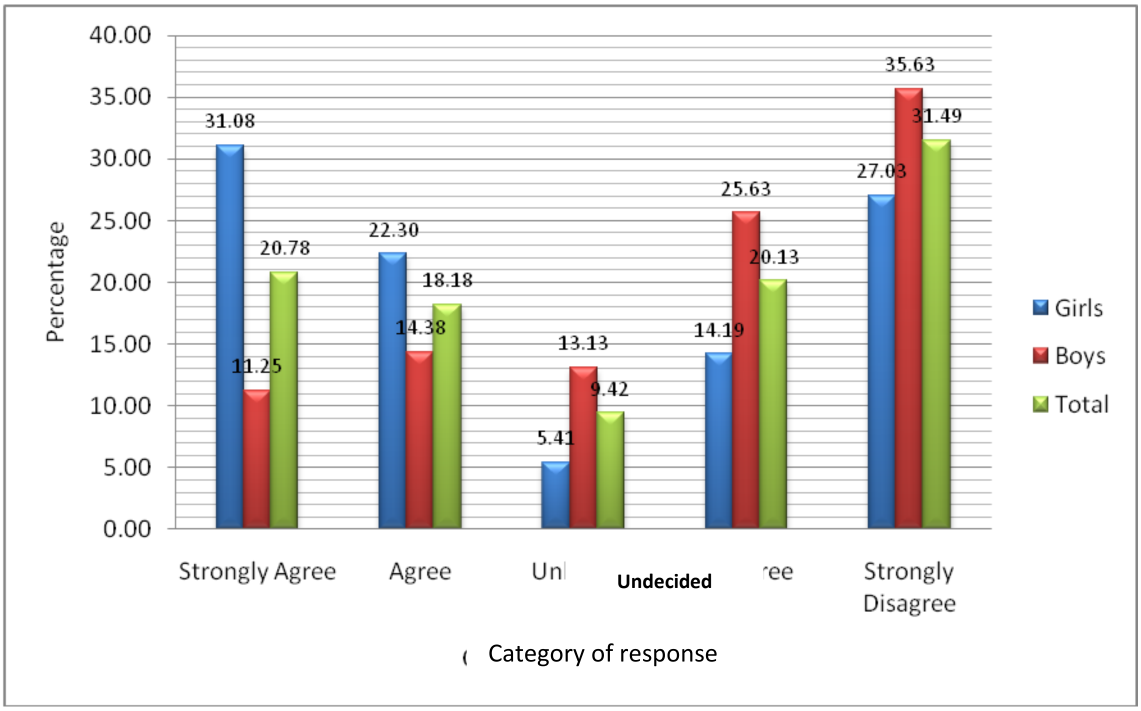


**Figure 4.5: Students' attitude towards evaluation process.**

The results in Figure 4.5 indicates that 38.96% of the total participants agreed that in class students can be allowed to evaluate other students' work while 51.62% of the total participants were disagreeing with the idea. In comparing girls' and boys' responses, it was found that 53.38% of girls and 25.63% of boys were agreeing while 41.22% and 61.26% of girls and boys respectively were disagreeing. The undecided category was made up of total participants (9.42%), girls (5.41%) and boys (13.13%). These results suggest that high school students dislike the idea of classmates or fellow students evaluating their assignments. When responses of girls and boys were compared, girls seem to be more tolerant to idea of evaluation by fellow students than boys. In a constructivist learning environment, students do assignments mostly in groups as they carry out investigations, discussions and presentations. Also when it comes to assessment of learning, group products are assessed by exhibitions and group presentations. These assessment procedures attract comments from all students in class, a practice which boys might not like. Girls who seem to be more tolerant to evaluation by fellow classmates have indeed embraced constructivist learning principles. Brooks and Brooks (2001) argue that:

Differentiating between teaching and assessment is both unnecessary and counterproductive. Assessment through teaching, through participating in student/teacher interactions, through observing students/students interactions, and through watching students' work with ideas and materials tells us more about students learning than tests and externally developed assessment tasks (p. 97).

Social constructivists recognise the social dimension of learning as exposed by Vygotsky (1978). Vygotsky opines that a learner's environment and the words used in learning process help in shaping the learner's understanding. The social dimension is provided when students have opportunity to discuss other students' work. Therefore boys who seem to dislike the idea of other students evaluating their work are in favour of transmission methods of teaching where assessment of learning activities is mostly separated from teaching and done mostly through testing using achievement tests. The achievement tests are very competitive because students primarily work on the tasks individually.

#### 4.5.1.6 Attitude of students towards copying notes

In order to find out the attitude of boys and girls towards copying notes from teachers, participants responded to the following question in the questionnaire: *Q1. In biology* *class, teachers should give students elaborate notes to copy.* Figure 4.6 indicates how the participants responded to the idea of teachers giving students notes to copy.

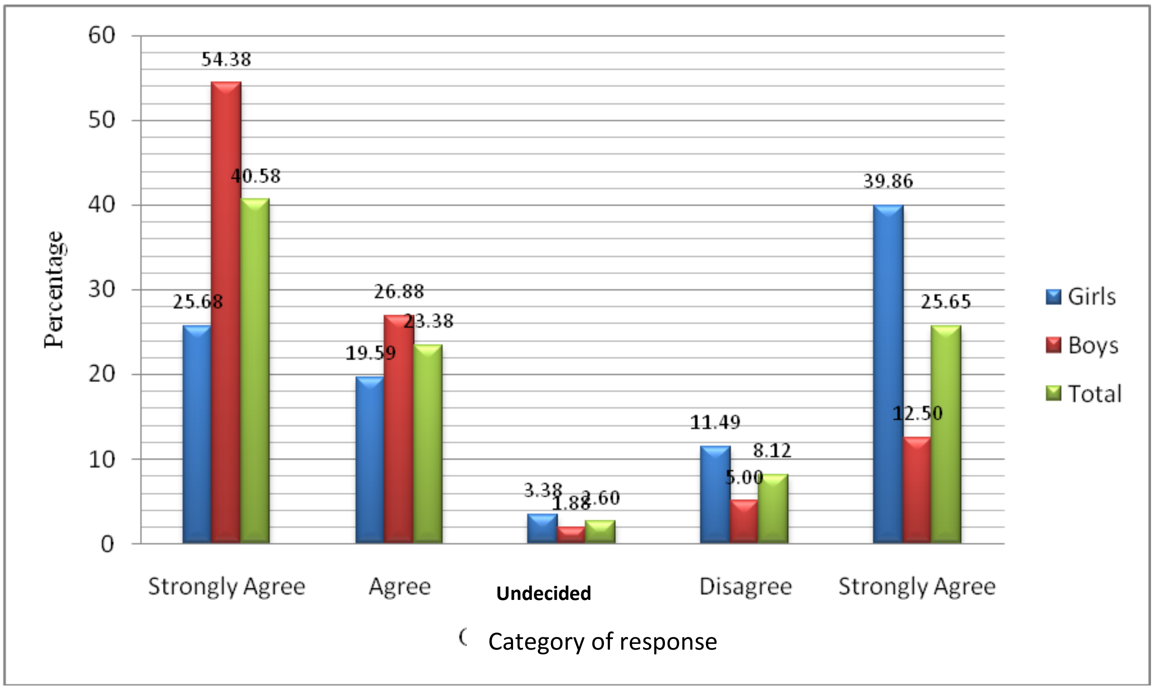


**Figure 4.6: Students attitude towards copying of notes.**

The responses in Figure 4.6 indicates that 45.27% of girls and 81.26% of boys' who participated in the study were agreeing with the idea, while 51.35% of girls and 17.50% of boys who participated were disagreeing. Total participants who responded as undecided were (2.6%), while girls and boys who were undecided are (3.38%) and (1.88%) respectively.

In this aspect of learning environment it was concluded that most participants in the study agreed with the idea of teachers giving notes to students. Most boys participating in the study also agreed with the idea. However, for girls who participated most disagreed with the idea of teachers giving notes to students. These results indicate that boys are more in favour of teacher-cantered methods of instruction compared to girls. Boys favour teacher-cantered methods of instruction probably because lecture notes from teachers seem easier to revise and understand.

This reasoning is supported by the work of Rudolf (2012) who concluded that learning of boys can be improved by providing highly structured lessons, detailed instruction, firm presentation with clearly stated objectives, while learning in most girls is supported by environments that provide opportunity for open ended activities, individuality in presentation and self-developed learning strategies.

# CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Introduction

This chapter summarises the findings, conclusions and recommendations of the study under the following sections: Summary of findings of the study, conclusions, recommendations based on the study findings for policy and recommendations for future research. The study was guided by the following objectives; To examine the influence of constructivist and conventional instructional methods on learner achievement in biology, to compare the effectiveness of constructivist instructional methods on learner achievement in biology among students in different class categories, to determine the effectiveness of constructivist instructional methods on learner achievement between boys and girls, and to examine the difference in attitude towards constructivist instructional method on the attitude of between boys and girls towards constructivist methods in learning biology. All the summaries of findings, conclusions and recommendations are presented as per the study objectives and hypotheses.

## 5.2 Summary of findings

The study revealed the following findings which have been presented as per the study hypothesis. The first hypothesis of the study stated that: *There is no significant difference in biology mean score achievement between learners instructed through constructivist and those instructed through conventional methods.* After instruction using constructivist and conventional methods, participants who received information through constructivist instruction had higher mean scores in post-test than participants who received information through conventional instruction. T-test runs on mean performance between the two groups revealed significant differences in favour of constructivist method of instruction.

The second hypothesis of the study stated that: *There is no significant difference in biology mean score achievement of students in different class categories instructed through the constructivist methods.* The results revealed that girls attained higher mean scores followed by participants in mixed sex class and lastly boys'. When pre-test to post-test mean gains were compared, girls had the highest mean gain followed by participants in mixed sex class and lastly boys with the lowest mean gain. ANOVA test runs on the mean difference revealed a significant difference in favour of girls.

The third hypothesis of the study stated that: *There is no significant difference in biology mean score achievement between boys and girls instructed through constructivist instructional methods.* The results revealed that girls attained higher mean improvement in achievements as compared to the boys in the post test exams. Independent sample t-test runs on the mean difference revealed a significant difference in favour of girls.

The fourth hypothesis of the study stated that: *There is no significant difference in attitude between boys and girls towards constructivist instruction methods in learning biology.* Participants' attitude towards constructivist instruction methods was measured and compared using an attitude questionnaire. Results revealed that 58.99% of girls and 51.89% of boys were in favour of constructivist method of instruction. The results implies that boys just like girls are in favour of constructivist method of instruction. Analysed results of the attitude questionnaire revealed that girls attained higher mean score (58.99%) compared to boys (51.89%). T-test runs on the mean score differences on girls and boys performance revealed a significant difference in favour of girls.

### 5.3 Conclusion

The findings of this study revealed that constructivist instructional approach has positive influence on learner achievement in biology. In the same vein, there was a significant gender difference between male and female students achievement in biology when constructivist instruction is used. Further, students in single sex girls schools achieved the highest gain in mean , followed by students in the category of mixed boys and girls with the least gain registered by the students in single sex boys schools and thus indicating that constructivist instructional methods leads to higher achievement in single sex girls schools. On the other hand, the findings of this study reveals that students had positive attitude towards the constructivist instructional methods and that girls were more positive towards the constructivist instructional methods as compared to the boys.

This study therefore concludes that the constructivist instructional methods is effective in improving learner achievements in biology at secondary school level and should therefore be adopted for practice for schools realise improved performance in biology in KCSE examination. Also, for students to develop interest in careers related to biology at post-secondary school level.

### 5.4 Recommendations for Policy

From the results of the study, the following recommendations were suggested for policy makers in the field of education to consider; biology teachers should be encouraged to use constructivist method of instruction, since the method is more effective in learning biology compared to conventional methods that most teachers are currently using.

### 5.5 Recommendation for Practice

In order to improve the performance of girls in biology, teachers should consider using the constructivist instructional methods and this should as well be implemented in mixed secondary schools if performance in biology exams is to be realized. Since learner attitude is important and has implications on performance, biology teachers should be able to adopt the constructivist instructional methods of instruction since it eliminates some of the classroom practices that do not encourage students to develop positive attitude towards biology. Finally, school administrators should be encouraged to improve on management of academic programmes by providing necessary facilities required for instructional purposes specifically variety of text-books, apparatus and equipment for practical lessons to promote constructivist methods of learning. These recommendations could be effectively implemented at the beginning of biology syllabus so as to improve the attitude of the students as they have their first encounter with biology in secondary school.

### 5.6 Recommendations for Future Research

In this study constructivist method of instruction was delivered through the 5Es constructivist model with use of pretest and posttest methods of assessment to measure learning achievement. However, the study recommends further investigations into constructivist learning using some other assessment strategies other than the 5Es instructional model.

The study was carried out in the rural schools of Homabay County; participants in the study might have projected a rural attitude inclination. This study recommends for similar study conducted in schools located in urban areas to compare attitude of students in rural and urban schools. This recommendation is supported by Conley (2014) position regarding learning as a construct which differ from culture to culture, as well as among individuals' students and possibly on the basis of rural to urban patterns.

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# APPENDICES

## APPENDIX 1: MANUAL FOR CONSTRUCTIVIST TEACHING METHOD

This manual contains guideline for biology teachers on how to conduct biology lessons based on constructivist teaching method. It has a total of seventeen biology lessons on the topic ecology. The objective for each of the lessons has been clearly stated. Guidelines on how teachers will introduce the lessons and the class activities to be performed by the students for each lesson are also included. Teachers participating in the constructivist teaching group are kindly requested to adhere to the instructions in the manual. Sequence of the lessons should be followed as laid out in the manual.

### Instructions to teachers participating in constructivist instruction method

The following instructions will serve as blue print for implementation of constructivist instruction:

1. Redirect questions to other students in the class to answer. If no clear answer is found then refer the students to seek for answers in the library. Avoid giving direct answers to questions from students.

2. When you identify that a particular discussion group is not right in approach to an activity, inform them that they are not right, but do not give the answer.

3. In order to encourage students to make good use of their own time, avoid receiving worksheets from the groups before time for the activity ends.

4. As students settle in their groups, have them elect group leaders such as; chairperson, secretary, timekeeper and a reporter. These duties should be rotational in subsequent groupings.

5. Visit all the groups during exploration and explanation stages, glancing at the students worksheets and checking on their answers. This will enable you understand each student's current conceptual framework.

6. Let all students be fully engaged and active during the exploration and explanation stages (Hands-on and minds-on activities) and also during class presentations.

7. Ask students thought provoking questions to enable them reflect on and even change their own conceptual framework.

8. Allow students to discuss within groups and amongst groups in the class. This will create an environment of student to student interaction both in and out of the classroom.

9. Continuously ask probing questions like: Why do you think that way? Can you justify your answer? These kind of questions should be asked throughout the class period to enable the teacher understand students current conceptual framework and possible areas of misconception.

10. Allow students to use textbooks and other resources during their group discussions (Explanation Stage).

**Summary**

Ensure that your instructional strategies encourage: -

1. Student Autonomy, student reflection of their work, student – student interaction in and out of classroom, collaborative work.

2. Use methods that help students develop, reflect on, evaluate and modify their own internal conceptual framework.

3. Provide the students with opportunity for interdisciplinary exploration.

4. Develop tasks that demand for higher order thinking skills on learners. That is questions requiring learners to make predictions, Interpretation and analysis.

5. Always allow students to participate in activities such as; visit to a museum, performing a skit/ experiment/ investigation.

**Lesson One and Two**

**Engagement Stage** (10 Minutes).

Introduce the lesson by presenting to the class the objectives of the topic and objectives of the lesson.

**Objectives of the Topic (Unit)**: In this topic you will learn about the following:

1. Loliondo Wonder

2. How organisms relate with each other and with the physical environment

3. How physical factors affect distribution and abundance of organisms in a nature.

4. How to estimate the population of organisms in a given region / area of study.

5. How plants are adapted to living in different habitats

6. How an environment can be polluted and some ways of preventing pollution.

**Lesson Objective**

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

Describe the importance of study of ecology.

**Exploration and Explanation Stages** (30 Minutes)

Divide class into groups of four to five students and each group to discuss the following question:

How the knowledge gained from the study of ecology help us to improve our life?

**Elaboration Stage** (30 Minutes)

Each discussion group is provided with few minutes to present a report of their findings.

Group reports should be critiqued by the teacher and other students in the class, immediately after the presentation.

**Evaluation stage (**10 Minutes) The group secretaries to capture all key points arising from the class discussion.

## Lesson Three

**Concepts of ecology**

**Engagement Stage:** (10 Minutes)

**Lesson objective**: -

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

Define the term ecology and name at least three places where organisms live.

**Introduction**

-Teacher asks three students to give their personal understanding of the word ecology.

-Students in class form groups and each group move out of class to investigate on places where organisms live in the school compound.

**Exploration Stage** (30 Minutes)

-Students collect materials for capturing and collecting organisms (Sweep nets, small bottles, polythene bags and shovel).

-Students working in groups investigate possible places where organisms live in the school compound and record their findings in a table form.

## Lesson Four and Five

**Engagement** (20 Minutes)

**Objective**: By the end of the lesson, the learner should be able to: Define the following terms; Habitat, Ecological niche, Population, Community, Ecosystem, Biomass and Carrying Capacity.

Teacher present to the class questions to be discussed in the groups.

Teacher advice students' to make reference on secondary biology form three students' book by Kenya Literature Bureau (KLB, 2009)

**Explore and Explanation Stages** (35 Minutes)

Discuss the following questions in your groups. The discussion should be guided by findings of investigations from the previous lesson.

1a) Name organisms you found living in the school compound.

b) Did you find all organisms named in 1(i) above living in isolation?

c) What term is given to a group of similar organisms living together in a place?

2 a) Do you think organisms have a role to play where they live?

b) Briefly explain roles of any two organisms investigated.

3 a) Do all organisms live in one place?

b) Where in particular did you find the following organisms: Earthworms, termites and grasshoppers?

C) If you go out now, are you likely to find the organisms in the same places?

4 a) of all the organisms you found in the school compound, do they interact with each other in anyway? Give examples.

b) Do the organisms interact with the physical environment in anyway? If yes, give examples.

5 a) Name any three non-living things in places where you found organisms living?

b) How do plants and soil depend on each other?

**Elaboration Stage** (20 Minutes)

- Presentation of discussion reports from different groups the class.

-Teacher and other students critique the group reports.

-Teacher will ask leading and probing questions to enable students elaborate fully their knowledge and understanding.

-Teacher harmonizes use of ecological terms to create correct scientific meaning to students.

**Evaluation Stage** (5 Minutes). Draw a concept map showing the relationship between the following concepts; Ecology, interaction, plants, animals, biotic, abiotic and environment

## Lesson Six and Seven

**Energy Flow in an ecosystem – Food Chains**

**Engagement Stage** (10 Minutes)

**Objective**: By the end of the lesson, the learner should be able to and construct a food chain from a given list of organisms.

Introduce the lesson by asking four students to name four organisms they know and what the organism feed on/ eat.

Tell students that some of the organisms they have mentioned are producers and some are consumers at different levels.

Present the learning task to be done in groups.

**Exploration and Explanation Stage** (30 Minutes)

Students go into discussion groups to:

Discuss the meaning of the following terms, giving examples in each case:

- Producers, Primary consumers, Secondary consumers, Tertiary consumers, Quaternary consumers, Trophic level, Decomposer, ‘Food to the eater.

**Elaboration Stage** (20 Minutes)

Each group present its findings for class for discussion. The discussion includes harmonization of the group findings by the teacher.

Groups are allowed to present their work in charts.

**Evaluation stage** (10 Minutes)

## Lesson Eight

**Energy Flow in an ecosystem – food webs**

**Engagement Stage** (5 Minutes)

**Objective**: By the end of the lesson, the learner should be able to construct a food web.

Teacher introduces the lesson by asking students to:

i) Explain the relationship between food chain and food web ii) explain how food web is constructed.

- Teacher presents the learning tasks for the lesson.

**Explanation and Elaboration Stage** (20 Minutes)

Students will discuss the following questions:

1.Form two students of Oyugis Secondary school observed the following organism in their school botanical garden: Aphids, Moths, Caterpillars, Mouse, Locusts, Grasshoppers, Spiders, Lizards, Snakes, Rats, Chameleons and Praying Mantis.

i) From the list of organisms given, construct five food chains.

ii) Join the food chains to form a wood web

iii) What did you put into consideration when constructing the food chains and food webs?

iv) Construct a food web where all the consumers are vertebrates.

**Elaboration Stage** (10 Minutes)

Discussion groups present their findings to the whole class for discussion.

Group reports are presented inform of food chains and food webs drawn on manila charts.

**Evaluation Stage** (5Minutes)

Teacher gives assignment:

**Journal Activity:** At your free time, reflect and write down what you have liked and what you have not liked in the biology class in the last one week (Your work should be one page only).

## Lesson Nine and Ten

## Pyramid of numbers and pyramid of biomass

**Engagement** (10 Minutes)

**Objective**: By end of the lesson, the learner should be able to construct; i) pyramid of numbers ii) pyramid of biomass.

-Introduce the lesson by asking some two students to explain what a pyramid is.

-The students can explain in words or in form of a diagram.

-Teacher to guide a brief discussion of the word pyramid presents the learning task to be done.

**Exploration and Explanation** (40 Minutes)

The exploration and explanation activities are in form of questions for group discussion.

Discuss the following questions.

a) What is a pyramid of numbers?

b) Briefly describe how you can construct: i) a pyramid of numbers ii) a pyramid of biomass

The following table represent the estimated numbers of organisms recorded in a dam.

| **Organism** | **Number** |
|---|---|
| Small fish | 4,000 |
| Microscopic algae | 12,000 |
| Crocodile | 80 |
| Large fish | 1,000 |
| Mosquito larvae | 9,000 |

Use the information in the table to answer the following questions;

i) Construct a food chain for organisms in the dam.

ii) Construct a pyramid of numbers for the organisms in the dam.

Iii) Explain shape of the pyramid of numbers drawn

**Elaboration Stage** (20 Minutes)

- Different groups present their findings for class discussion.

- Pyramids of numbers drawn by different groups are presented in charts and displayed for comparison.

-Teacher presents a different type of pyramid of numbers for class discussion.

**Evaluation Stage** (10 Minutes)

Teacher asks the students go to the library and search for more information concerning food chains and food webs from different text books. Students 'should prepare a list of reference books they have used.

**Lesson Eleven and Twelve**

**Methods of estimating population**

**Engagement** (10 Minutes)

**Objective**: By the end of the lesson, the learner should be able to name and briefly explain five methods of estimating population.

-Teacher will ask students to briefly describe how they can estimate the number of the following organisms:

-All the students in their class.

-All students in the school.

-All the people living in the school compound.

**Exploration and explanation** (40 Minutes)

-Students will discuss the following questions in groups:

Describe how the following methods can be used to estimate the population of organisms.

a) Quadrat method

b) Line Transect method

c) Belt Transect method

d) Capture- Recapture method

**Elaboration** (20 Minutes)

-Groups' present discussion reports which is critiqued by the whole class.

Students elaborate on how the method can be practically applied.

**Evaluation Stage** (10 Minutes)

**Lesson Thirteen and Fourteen**

**Estimating population of a shrub using quadrats method**

**Engagement** (10 minutes)

**Objective**: By the end of the lesson, the learner should be able to explain how quadrats can be used to estimate population of organisms.

-Teacher presents the activity for the lesson and refers students to search for more information about user of quadrats in the book; Explore biology form 3 by Kadasia and Ngulu (2004).

-Students pick Quadrats, Specimen bottles, Polythene bags, Tape measure, Forceps and Writing materials.

- Teacher asks students to briefly explain how they are going to use each of the items they have picked.

-Students go out to perform the lesson activity.

**Exploration Stage** (30 Minutes)

-Students go out to an open field and estimate population of shrubs.

-Each group must pick at least three different types of shrubs to investigate and record the results.

**Explanation Stage** (20 Minutes)

Students will discuss the following questions in their groups:

a) Estimate the density of the plant species you investigated. Show your work.

b) Briefly explain how the quadrat was used.

c) Which of the two quadrats will give a more accurate result? 30cm x 30cm or 1m x 1m, if equal number of throws are made, explain your answer (the question is adopted from Kadasia and Ngulu, 2004).

d) Work out the average number of each species of shrub from the total throws made.

e) Calculate the total population of plants you investigated in the study area.

f) Suggest possible limitation in the use of quadrat sampling technique.

**Elaboration Stage** (10 Minutes)

-Each group present its results for class discussion .The results presented should include charts showing frequency distribution of organisms or tables of distribution of organisms investigated.

-Teacher ask critical and thought provoking questions from the results presented.

**Evaluation Stage** (10 Minutes)

Students evaluate and rank work presented by different groups.

## Lesson Fifteen and Sixteen

**To estimate population of organisms using a line transect**

**Engagement Stage** (10 Minutes)

**Objective**: By the end of the lesson, the learner should be able to explain how to use a line transect to estimate population of organisms.

-Students collect materials to be used for investigations / Class activity. The materials include: Long string / rope, tape measure and writing materials.

-Teacher presents the learning tasks for the lesson.

**Exploration Stage** (30 Minutes)

- Students go out to an identified field and lay ropes to make line transect to estimate the population of plants and animals.

**Explanation Stage** (20 Minutes)

In your groups discuss the following questions.

a) Work out the population of plants and animals along the line transect.

b) Briefly explain the distribution of plants and animals along the transect

c) Determine the frequency of each species of organisms you investigated.

d) Relate the population size at each station to the abiotic and biotic factors found in the place.

e) When is line transect method suitable to use in estimating population of organisms s? Explain.

**Elaboration Stage** (15 Minutes)

-Group present their result for whole class discussion. The class discussion must involve rigorous critique of the results.

**Evaluation Stage** (5 Minutes)

Teacher presents question for library work to be collected in the next lesson.

Q. Compare and contrast use of quadrat and line transect as methods of estimating population of organisms.

**Lesson Seventeen and Eighteen**

**Estimating population of organisms using a belt transect**

**Engagement Stage** (10 Minutes)

**Objective**: By the end of the lesson, the learner should be able to explain how to use belt transect to estimate population of organisms.

-Students to collect materials to use in the field .The materials for each group are; two long ropes, tape measure and a quadrat.

- Teacher asks two students to explain briefly how they are going to use each of the items collected .After the students explanations, teacher refer the students to search for more information about the line and belt transects in the book: Longhorn secondary biology form 3 by Akatsa et al. (2004) for more information about the belt transect

-Students move out to carry the activity.

**Exploration Stage** (30 Minutes)

-Students lay the ropes to make a belt transect in a place earlier identified for the investigations.

**Lesson Eighteen and Nineteen** (Continuation of Lesson Seventeen)

**Engagement Stage** (10 Minutes)

Teacher asks students few questions about the investigation activities they carried out during the last lesson.

**Explanation Stage** (30 Minutes)

Students in discussion groups answer the following questions:

a) Draw sketch map of the study area indicating your belts.

b) Work out the area covered by the belts.

c) Calculate average the number of selected organisms in $1m^2$

**Elaboration Stage** (30 Minutes)

-Groups present their results for whole class discussion.

-More questions and clarifications come from teacher and other students. During the discussion students are allowed to refer to textbooks.

**Evaluation Stage** (10 Minutes)

Assignment:

Discuss advantages and disadvantages of estimating population of organisms using;

i) A line transect

ii) Belt transect

**Lesson Twenty and Twenty One**

**Estimating the population of grasshoppers using capture - recapture method**

**Engagement Stage** (10 Minutes)

**Objective**: By the end the lesson, the learner should be able to explain how to use capture - recapture method to estimate the population of organisms.

- Teacher asks one student to briefly describe how to use capture re-capture method to estimate population of organisms. After the student's explanation, teacher advice the students to get more information about capture –recapture method from the book comprehensive secondary biology form 3 by Maina and Kelemba (2004).

- After the brief exposition students collect materials for the activity and go out to field.

**Exploration Stage** (30 Minutes)

Students capture grasshoppers, mark and release the marked grasshoppers. Students carry out the activity until the lesson end.

**Explanation Stage** (10 Minutes)

Teacher asks students to mention challenges faced in capturing and marking grasshoppers.

Students pick materials and go to the field to carry on with the capture –recapture activity (re-visit the same place previously studied).

**Exploration Stage** (30 Minutes)

Students revisit the study area after at least 12 hours and carryout capture re-captures process.

The activity should last until the end of the lesson.

**Lesson Twenty Four and Twenty Five**

**Engagement Stage** (10 Minutes)

Students go into various groups to discuss activities related to capture re-capture method.

**Explanation Stage** (30 Minutes)

Students discuss the following questions:

a) Calculate the estimated population of grasshoppers in the area of study.

b) Is the population you got accurate actual population size? If no, explain the difference.

c) Outline the assumptions made when calculating the population size using capture re-capture method.

d) Other than grasshoppers, name other organisms whose population can be determined by capture re-capture method.

e) Suggest other possible ways that can be used to capture organisms for this kind of study.

**Elaboration Stage** (30 Minutes)

Group's presents results for whole class discussion and critique.

**Evaluation Stage** (10 Minutes)

Individual assignment:

Describe how any of the methods of population estimation we have studied can help you out of school.

**How to use quadrat method**

-Select a suitable area of study (a teacher can suggest an area having surveyed it earlier)

-Mark the area of study and measure its size.

-Draw a sketch map of the area.

-Standing at various points in the area of study, randomly throw the quadrat several times.

-Where the quadrat lands, identify and count all the organisms within the quadrat.

-Record your results in a table form.

**How to use a line transect**

-Select a suitable area of study.

-Mark the study area boundary and work out its area in meters squared ($m^2$).

-Lay down a string of 30m long across the selected area (the area should preferably cut across different habitats).

-Select points along the line transect at regular interval (can be 3m apart). The points are called **stations.** You can lay quadrat at each station.

-Count and record the number of organisms of each species in every station.

-In at least three stations, measure also the following:

-Soil PH.

-Temperature of the air and temperature of the soil.

-Wind direction

-Humidity of air.

**How to use a belt transect**

-Select a suitable area of study (if possible should be across a stream or two habitats)

-Estimate size of the selected area in meters squared ($m^2$)

-Lay the two ropes to run parallel along the area of study. They should be 1m apart.

-Count the number of **selected** organisms in between the two lines and record. As you record include the belt in which they are found.

-You can lay the belt three or more times in the area of study.

-You can also divide the belt into squares.

**How to use capture - recapture method**

-Select a suitable area of study.

-In the selected area of study use the sweep nets to capture as many grasshoppers as you can and keep the grasshoppers unharmed in transparent polythene bags.

-Using ink or paint put a mark on the grasshoppers carefully without harming any of them. Count and record the number of grasshoppers caught and marked and release all the grasshoppers to the environment.

-Return to the previous area of study (at least after twelve hours) and capture as many grasshoppers as possible .Record the newly captured grasshoppers and the recaptured grasshoppers.

-Use the formula given below to estimate the population of grasshoppers.

$$N = \frac{n1 \times n2}{n3}$$

Where:

N = Total population size

$n_1$ = Number of marked grasshoppers released in the first capture

$n_2$ = Total number of grasshoppers captured in the second capture

$n_3$ = Number of marked grasshoppers recaptured.

## THE 5E INSTRUCTIONAL MODEL

(5E – Engagement, Exploration, Explanation, Elaboration and Evaluation)

**Engagement Stage:**

This is the introduction stage in a lesson.

Teacher presents objective of the lesson and the learning tasks.

Students focus on the problem or learning task.

The learning task can be presented as a question, short story, picture or any other form but should motivate and challenge the students.

During this stage, the teacher set rules and procedures for doing the task.

Students are active both physically and mentally.

Teacher gets students prior knowledge experiences.

**Exploration Stage:**

Students make use of direct concrete experiences when making observations, collecting data and testing predictions.

Learning is directed by objects, events or situations for example students doing a practical activity.

Teacher facilities and monitor interactions between students and instructional materials.

Activities in this stage provide both mental and physical experience needed to accomplish the learning task given.

There is open inquiry, open questioning so that students uncover their alternative understandings.

**Explanation Stage:**

At this stage, processes, concepts or skills are made comprehensible and clear.

It provides the students and the teacher room for common use of terminologies.

Appropriate scientific vocabulary is introduced at this stage.

Students use their skills and express their attitude.

Teacher uses students' data to create scientific explanation and to clarify misconceptions.

The explanation can be done by the teacher, textbook or it can be technology directed.

Teacher: - Oral explanation

Textbook: - Reading

Technology: - Video, film, simulation.

Students explain what they have done and the result of their activities.

**Elaboration Stage:**

One of the most powerful ways for one to demonstrate level of knowledge and understanding is to present it to someone.

Students have opportunity to present and discuss their current understanding and to demonstrate their skills.

Activities should provide experiences through challenges, repetitions, new activities, practice and time.

New experiences provided enables students to develop deeper and broader understanding.

Additional problems given to students enable them to apply new knowledge and draw reasonable conclusions.

Elaboration can be informed of another inquiry, extension of exploration and questions.

**Evaluation Stage:**

During this stage, students assess their understanding and abilities.

Teachers evaluate students' progress towards achieving the instructional objectives.

Students examine the adequacy of their explanations and attitudes to new situations.

Variety of formal and informal assessment procedures is employed.

Evaluation process makes learning open ended and open to change

## APPENDIX 2: SYLLABUS GUIDELINE FOR ECOLOGY

Sub Topics to be covered are the ones listed below:

1. Concepts of Ecology

   - Habitat
   - Ecological niche
   - Population
   - Community
   - Ecosystem
   - Biomass
   - Carrying capacity

2. Energy flow is an ecosystem

   - Food chain
   - Food web
   - Pyramid of numbers and pyramid of biomass

3. Methods of estimating population

   - Quadrat
   - Line transect
   - Belt transect
   - Capture -Recapture

## APPENDIX 3: CONSUMABLES SUPPLIED TO SCHOOLS OF EXPERIMENTAL GROUP

The following materials were supplied to each of the schools which participated in the experimental method of instruction.

| No. | Material | Quantity supplied per school |
|---|---|---|
| **1** | Quadrat | 10 |
| **2** | Sweep net | 10 |
| **3** | Marker pens | 10 |
| **4** | Sisal twine | 1 medium size roll |
| **5** | Flip chart | 1 |

## APPENDIX 4: BIOLOGY ACHIEVEMENT EXAM

**TIME 1HR**

**INSTRUCTION**

*Attempt all questions in this paper*

1. Define the following terms

   i. Population

   (2mks)

   ii. Synecology

   (2mks)

   iii. Carrying capacity

   (2mks)

   iv. Ecosystem

   (2mks)

   v. Ecological Niche

   (2mks)

2. a) Explain the difference between the following

   i. Pyramid of numbers and pyramid of biomass

   (2mks)

   ii. Food chain and food web

   (2mks)

   iii. Biotic factors and abiotic factors

   (2mks)

   iv. Producer and a consumer

   (2mks)

v. Phytoplankton and zooplankton (2mks)

b) State three possible limitations of a quadrat as a sampling technique(3mks)

c) Name three biotic factor that are found in any named ecosystem (3mks)

3. a) Briefly describe situations where the following methods of investigations are applied? (The question was adopted from Hayward, 2006, p...83).

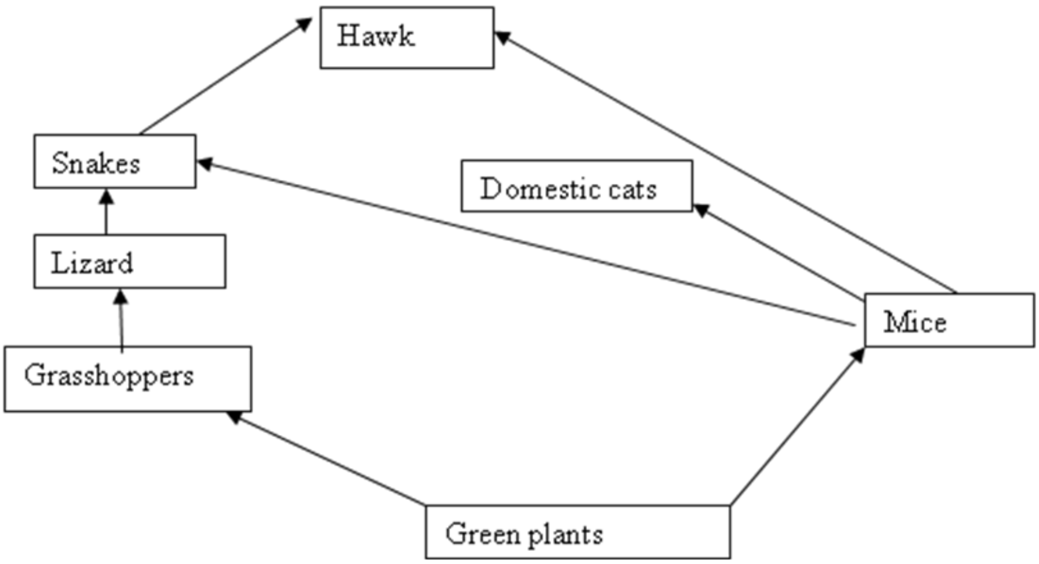
i. Transects (2mks)

ii. Capture recapture (2 mks)

iii. Quadrats (2mks)

b) How can you get a more accurate result when using capture recapture method to estimate insect population? (4mks)

4. a) The following diagram shows a feeding relationship in a certain habitat. Use it to answer the following questions below (The question was adopted from Maina and Kelemba, 2004, p...62)




i) From the diagram construct two food chains ending with tertiary consumers in each case. (2mks)

ii) Suggest three ways in which the ecosystem would be affected if there was prolonged drought. (3mks)

b) Study the food chain given and answer questions that follow.


Suggest what is likely to happen should tilapia be removed from the food chain. (5mks)

5.The following observations were made by students in a National Park (The question was adopted from Hayward, 2006, p...57)

a) Lion feed on gazelles, Zebra and Impala

b) Gazelle, Impalas and Zebras feed on grass

c) Dik Dik feed on grass

d) Leopards feed on Dik Dik and Impala

e) Vulture feeds on dead lions, Leopards, Zebras and Gazelles.

i). Use the information given to construct a network of feeding relationships in the National Park (5mks)

ii). From the diagram you have drawn, which organisms are found in the 1st, 2nd, 3rd and 4th trophic level (2mks)

1st

2nd

3rd

4th

iii) If the vultures were removed from the food wed, would there be any effect in the park?

(1mk)

Give reason(s) for your answer (2mks)

6. i) Suggest and describe any method you can use to estimate the population of safari ants in a grassland area.

(5mks)

ii) Give advantages and disadvantages of the method named in 6(i) above (5mks)

## APPENDIX 5: STUDENTS' ATTITUDE QUESTIONNAIRE

**Directions**

This questionnaire contains statements about practices that can take place in your biology classroom. Please circle the choice that indicates your opinion after each statement.

Remember there are no 'right' or 'wrong' answers. Your opinion is what is wanted.

**Key:**

| | | |
|---|---|---|
| ıgly Agree | - | AS |
| Agree | - | A |
| Undecided | - | U |
| Disagree | - | D |
| Strongly Disagree | - | SD |

| | | | | | |
|---|---|---|---|---|---|
| 1. In biology class teachers should give students notes to copy | SA | A | U | D | SD |
| 2. In class, teachers should allow students to ask many questions. | SA | A | U | D | SD |
| 3. Classes can be more interesting if there are many activities which students do in groups. | SA | A | U | D | SD |
| 4. A biology teachers should not introduce a lesson by asking students questions on the topic he/she is yet to teach. | SA | A | U | D | SD |
| 5. All the time students are in a biology class, they should sit facing the blackboard. | SA | A | U | D | SD |

| | | | | | |
|---|---|---|---|---|---|
| 6. In Biology class, teachers should always give assignment to be done in groups. | SA | A | U | D | SD |
| 7. What is learnt in school is to enable students pass examinations only. | SA | A | U | D | SD |
| 8. Teachers should allow students to respond to questions from peers in class. | SA | A | U | D | SD |
| 9. In Biology class, students should always be given enough time to explain their answers. | SA | A | U | D | SD |
| 10. Discussion groups have little help in learning science. | SA | A | U | D | SD |
| 11. Teachers should not ask students questions which are difficult to answer. | SA | A | U | D | SD |
| 12. Students should always be given time to work individually in a project. | SA | A | U | D | SD |
| 13. Teachers should give questions which require students to debate the answer. | SA | A | U | D | SD |
| 14. Biology teachers should always give assignments that require students to look for answers in the Library or from community resources. | SA | A | U | D | SD |
| 15. In Biology class, students can be allowed to evaluate other students' work | SA | A | U | D | SD |
| 16. In Biology class, teachers should do all the reference required in the Library and give to students inform of hand-outs. | SA | A | U | D | SD |

# APPENDIX 6: TEACHERS' QUESTIONNAIRE

Welcome and thank you for sparing your time to fill this questioner. The purpose of this questionnaire is to find out your opinion about methods you apply in teaching ecology and challenges you face in teaching the topic. Please complete each section as instructed.

**SECTION A: Teacher Biographical Data**

Please tick your chosen response (√) where appropriate.

1. Sex : i) Male [ ] ii) Female[ ]
2. Age : i) 20- 30 years [ ] ii) 31-40 years [ ] iii) 41-50 years [ ] iv) Over 50years[ ]
3. What is your highest academic qualification?

   i) Certificate [ ] ii) Diploma [ ] ii) Bachelor's Degree [ ] iii) Masters [ ] iv) Ph.D [ ]
4. Which subjects do you teach (i) Major ………….... ii) Minor ………………
5. For how long have you taught Biology?

   i) Less than 12 mouth [ ] ii) 1-5 years [ ] iii) 6-10years [ ]

   iv) 11-15 years [ ]v) 16- 20 years [ ]vi) 21 years and above years [ ]

**Section B: Factors affecting teaching and learning of Biology**

6. How would you rate your students' ability in learning biology?

   i) Excellent [ ] ii) Good [ ] iii) Fair [ ] iv Poor [ ]
7. a) Which of the following statements best describe the common method you always apply when teaching the topic ecology? Please indicate your choice by a tick (√)

i) Lecture method with elaborate notes given to students, followed with tests. ☐

ii) Lecture method followed with activities given to students to do individually and few practical lessons. ☐

iii) Few minutes lecture followed with many class practical activities given to students to be done in groups followed with class discussions and presentations. ☐

b) Please briefly give reasons why you have always used the methods above.

…………………………………………………………………………………………

…………………………………………………………………………………………

8. Please indicate by putting a tick (√) whether the following materials and equipments for teaching ecology are available in your school.

| Materials and Equipments | Available in school (Number) | Not Available |
|---|---|---|
| Quadrats | | |
| Sweep nets | | |
| Open field | | |
| Manila or sisal ropes | | |
| Flip charts or Manila papers | | |
| Indelible ink | | |

| |
|---|
| **Variety of Biology Textbooks** |
| **Panga / Jembe / Shovel** |
| **Specimen Bottles / Polythene bags** |
| **. Tape measure / Meter ruler** |
| **. Cobalt chloride paper** |

9. Please indicate using a tick (√) if you have read any of the following KCSE Reports on biology performance released by KNEC.

i) Year 2010 Report

ii) Year 2009 Report

iii) Year 2008 Report

iv) Year 2007 Report

v) Year 2006 and below reports

10. Are there any sub topics (s) of ecology syllabus that you have not always covered in class during your teaching?

i) Yes

ii) No

iii) If yes, name the sub topic(s) and give reasons for your answer.

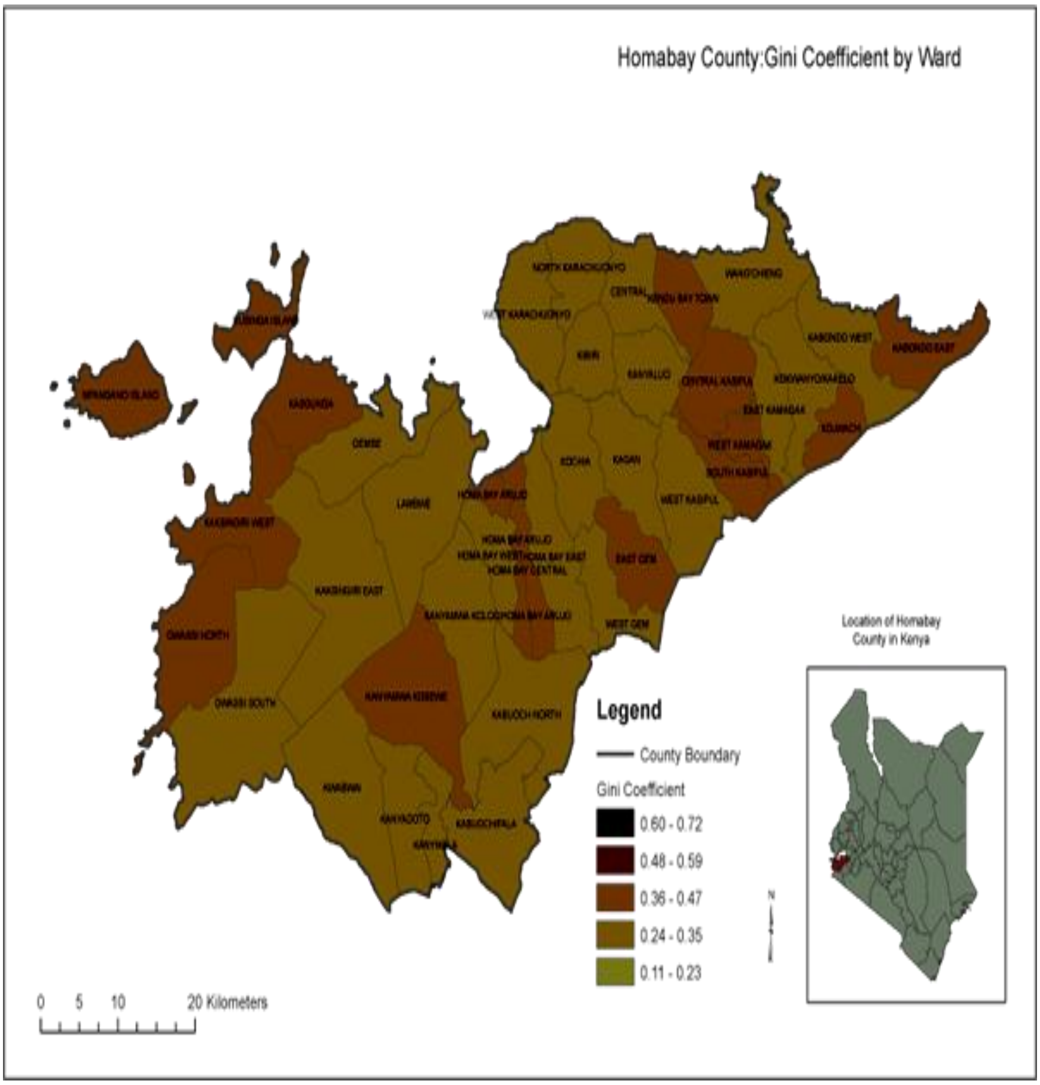
11. Mention in order of descending impact, three challenges you have often met in teaching the topic ecology.

………………………………………………………………………………………………

………………………………………………………………………………

Good Bye. Thank you.

## APPENDIX 7: MAP OF HOMABAY COUNTY



## APPENDIX 8: RESEARCH PERMIT

PAGE 2

THIS IS TO CERTIFY THAT:
Prof./Dr./Mr./Mrs./Miss/Institution
Gideon Magak Mwanda
of (Address) University of Nairobi
*P.O. Box 92, Kikuyu*
has been permitted to conduct research in

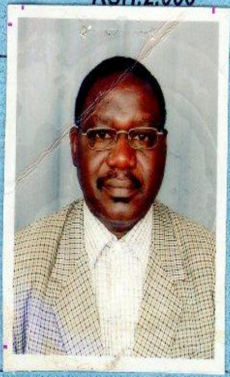
| | |
|---|---|
| | Location |
| Homa bay | District |
| *Nyanza* | Province |

on the topic: Effect of constructivist method of instruction on learning Biology in secondary schools in Homa Bay County, Kenya

for a period ending: 31st December 2012.

PAGE 3

Research Permit No. *NCST/RCD/14/012/135*
Date of issue *24th February 2012*
Fee received *KSH.2,000*



Applicant's Signature

FOR: Secretary
National Council for
Science & Technology

**APPENDIX 9: RESEARCH AUTHORIZATION**

DHEMO
T.N.A
26/6/12

REPUBLIC OF KENYA

HARAMBEE

# NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Telephone: 254-020-2213471, 2241349
254-020-310571, 2213123, 2219420
Fax: 254-020-318245, 318249
When replying please quote
secretary@ncst.go.ke

P.O. Box 30623-00100
NAIROBI-KENYA
Website: www.ncst.go.ke

Our Ref: **NCST/RCD/14/012/135/4**

Date: **24th February, 2012**

Gideon Magak Mwanda
University of Nairobi
P. O. Box 92
KIKUYU

**RE: RESEARCH AUTHORIZATION**

Following your application for authority to carry out research on "***Effects of constructivist method of instruction on learning Biology in secondary schools in Homa Bay County, Kenya***" I am pleased to inform you that you have been authorized to undertake research **in Homa Bay County** for a period ending ***31st December 2012.***

You are advised to report to **the District Commissioners & the District Education Officers in Homa Bay County** before embarking on the research project.

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

Hussein.
**SAID HUSSEIN**
**FOR: SECRETARY/CEO**

Copy to:

The District Commissioners
Districts in Homa Bay County

The District Education Officers
Districts in Homa Bay County