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OU = Innovation Centre
EFFECTS OF GUIDED AND UNGUIDED INQUIRY TEACHING METHODS ON SECONDARY SCHOOL STUDENTS’ ACHIEVEMENT AND INTEREST IN BIOLOGY IN ENUGU STATE

BY

ANIAKU, OBIAGELI LORETTA
PG/M.ED/08/49002

DEPARTMENT OF SCIENCE EDUCATION
FACULTY OF EDUCATION
UNIVERSITY OF NIGERIAN, NSUKKA
EFFECTS OF GUIDED AND UNGUIDED INQUIRY TEACHING METHODS ON SECONDARY SCHOOL STUDENTS’ ACHIEVEMENT AND INTEREST IN BIOLOGY IN ENUGU STATE

A PROJECT REPORT PRESENTED TO THE DEPARTMENT OF SCIENCE EDUCATION UNIVERSITY OF NIGERIA, NSUKKA

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER IN SCIENCE EDUCATION

BY

ANIAKU, OBIAGELI LORETTA
PG/M.ED/08/49002

AUGUST, 2012
This project report has been approved for the Faculty of Education,

University of Nigeria, Nsukka.

__________________________  __________________________
PROF. (MRS.) U. M. NZEWI  INTERNAL EXAMINER
SUPERVISOR

__________________________  __________________________
EXTERNAL EXAMINER  PROF. D. N. EZE.

________________________
PROF. I. C. IFELUNNI
DEAN OF FACULTY

HEAD OF DEPARTMENT
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“To God Be the Glory, Amen”
DEDICATION

This work is dedicated to my lovely family and to the blessed memory of Late Prof. A. R. Ajayi my mentor.
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ABSTRACT

The problem of poor achievement of students in Biology in external examinations has been a matter of concern to the nation. As part of the contribution to arrest the situation, this study was designed to determine the effects of guided and unguided inquiry teaching methods on students’ achievement and interest in Biology. To carry out the study, four research questions and five null hypotheses were formulated. Design for the study is a quasi-experimental nonequivalent control groups pre-test and post-test design. The study was carried out in two purposely selected co-education secondary schools in Nsukka Education zone of Enugu state. Sample for the study consisted of 80 (SSI) students from two randomly selected intact classes in the sampled schools. Data for the study were collected through two researcher developed instruments: Biology Achievement Test (BAT) and Biology Interest Inventory Scale (BIIS). The two intact classes of 40 students each were assigned to experimental group I and II respectively. The experimental groups I and II were exposed to guided and unguided inquiry methods of teaching respectively. Data for the study were analyzed using mean, standard deviation and ANCOVA statistics. The null hypotheses were tested at 0.05 level of probability. Findings of the study revealed that guided inquiry enhanced students’ achievement in Biology more than unguided inquiry. However, both guided and unguided inquiry methods had equal effects on students’ interest (there was no significant different between the effects of guided and unguided inquiry) on students’ interest in Biology. Findings of the study also revealed that there was no significant difference in the achievement and interest of male and female students in Biology. Recommendation and suggestion for further study were made based on the findings of the study.
CHAPTER ONE
INTRODUCTION

Background of the study

Biology is a branch of natural science that deals with the study of living organisms, including their structures, functioning, evolution, distribution and interrelationships. (The American Heritage Dictionary of the English language, 2009). Biology occupies a unique position in the secondary school education curriculum because of its importance as science of life. In Nigeria the secondary school Biology curriculum is designed to continue students’ investigation into natural phenomena, to deepen students’ understanding and interest in biological sciences, and also to encourage students’ ability to apply scientific knowledge to every day life in matters of personal, community, health and agriculture among others (Federal Ministry of Education, 2009).

Biology is a very important science subject and stands as the bedrock upon which are based many other science courses like Medicine, Pharmacy, Nursing, Biochemistry, Genetic, Agriculture etc., that are of great economic importance to a nation. Besides, the importance of Biology to mankind as science of life, it is one of the science subject mostly preferred by many students in the secondary schools because it has less mathematical calculations unlike Physics and Chemistry and deals with non-abstract things. Because of these reasons, Biology has a very high enrolment of students in the external examination (Senior School Certificate Examination) more than Physics and Chemistry. Regardless of the high number of students’ enrolment in Biology in the senior school examinations conducted by
West African Examination Council (WAEC) and National Examination Council (NECO), reports from scholars and educators (Nwagbo, 1999; Biology Chief Examiner’s Report, 2007; Ige, 2009 and Opara, 2011) indicated that students’ achievement in Biology in the external examinations is poor.

The poor achievement of students in Biology in external examination is linked to the use of traditional method (lecture/expository method) in teaching secondary school biology (Isiugo-Abanihe; LongJohn and Ibiene 2010). The traditional/conventional teaching methods often used by teachers in teaching Biology include the lecture/expository method, demonstration and direct instruction etc. These traditional methods of teaching stress more on the transmission of knowledge in a manner that emphasizes memorization hence they have been characterized by some educators (Ibe and Nwosu, 2003; Sawa, 2011 and Kirshner, Sweller and Clark, 2006) as a poor method of teaching biology and other science subjects. The conventional/traditional teaching methods involve unidirectional flow of information/knowledge from teacher to the students and do not encourage process skill acquisition needed for proper understanding of biological principles, concepts and facts. Guisti (2008) referred to these traditional teaching methods as teacher-centered approaches to learning in the sense that the teacher and those up in the educational hierarchy are considered as the possessor of knowledge to be transferred to the students, and as such decides how the knowledge transfer takes place. The unidirectional flow of information in the traditional teaching method makes students passive and unable to construct meaningful knowledge in the teaching and learning of Biology.
The shortcomings of these traditional teaching methods resulted to the persistent search for an effective method of teaching and learning Biology which culminated to the discovery and suggestions by some researchers (Mandor, 2002; Ibe and Nwosu, 2003; Nwagbo, 2006 and Akpan 2010), for the use of innovative teaching methods such as inquiry method, concept mappings, simulations and games, constructivism, problem based learning etc. The innovative methods are considered as effective teaching methods that can improve on students’ achievement and interest in Biology. The innovative teaching methods are activity-based and characterized by students sharing some degree of responsibility for making decision in the learning process. In the innovative teaching methods the teacher is often described as a partner and a facilitator in the teaching and learning process and not the possessor of knowledge hence the innovative teaching methods are referred to as student-centered approach to learning (Campbell, 2006). Inquiry method is therefore considered necessary in this study, to determine its efficacy on students’ achievement and interest in Biology using two different types of inquiry teaching methods (guided and unguided inquiry) respectively.

A good number of researchers (Timothy and Awodi, 1997; Ibe and Nwosu, 2003 and Jensen, 2008 Opara, 2011 and Bybee 2011) indicated that inquiry method is an effective method for teaching Biology because it has much academic gains; it increases students’ understanding of science concepts, principles and facts, enhances students’ achievement and interest, encourages active participation of students in the teaching and learning process and enables students to construct meaningful biological knowledge. Inquiry is therefore deemed necessary for
teaching and learning biology because when students understand concepts and principles of a subject, knowledge of such subject can be constructed, sustained and transferred to a similar situation.

The inquiry method from a pedagogical perspective is often contrasted with the traditional expository methods and reflects the constructivists model of learning often referred to as “active learning” which combines different techniques and learning theories such as “constructivism”, “Blooms taxonomy”, “multiple intelligence”, “whole language learning” and “accelerated learning” (Onan, 2012). The inquiry learning techniques and theories involve a learning process aimed at increased student involvement, multiple ways of knowing and sequential phases of cognition which accommodate learning and cognition differences among students.

In view of the above, inquiry method of teaching is variously defined by different scholars; Kuhlthau, Maniotes and Caspari (2007) defined inquiry as “an approach to learning whereby students find and use a variety of sources of information and ideas to increase their understanding of a problem, topic or issue”. On the other hand, Educational Broadcasting Corporation (2004) defined inquiry as “seeking for truth, information or knowledge by questioning while Martin-Hansen (2002) referred to inquiry as “the work scientist do when they study the natural world, proposing explanations that include evidence gathered from the world around them as well as the activities of students such as posing questions, planning investigations and reviewing what is already known in the light of experimental evidence”. From the foregoing this study perceives inquiry method as a teaching method that encourages learners to apply scientific process
to explore and construct meaningful knowledge and skills. One of the major objectives of inquiry is to encourage investigation in students. When students are encouraged to investigate into natural phenomena, a meaningful and relevant knowledge is constructed and sustained.

Inquiry as a pedagogy is an ancient technique which predates Socrates and his way of leading students to self-knowledge through aggressive questioning. (Educational Broadcasting Corporation, 2004) Although inquiry method is believed to predate Socrates, Onan (2012) noted that Dewey’s child-centered educational reform learning system led to the first inquiry-based learning in the United States. In Nigeria the emphasis for student-centered learning and use of inquiry teaching method was intensified with the introduction of Universal Basic Education (UBE) scheme in 2004 with the aim of eliciting high cognitive process in student (Federal Ministry of Education, 2008). Today the Nigerian Science Educational Curriculum recommends inquiry teaching method as one of the innovative teaching methods that is needed for science teaching and learning because it contrasts the traditional cook book lecture/expository methods and likes commonly used to teach sciences. However the philosophy of inquiry teaching finds its antecedents in the works of some cognitive theorists like John Piaget, John Dewey, Vygotsky and Preire among others (Kirshner et al, 2006). Although these theorists advocate for child-centered learning their approaches vary.

In view of the different approaches of the inquiry advocates there are different types of inquiry. Some educators; (Secker 2002; Anyigbo, 2005; Guisti, 2008 and Bilgin 2009) classified inquiry into two broad types namely Guided and
Okoli (2001) identified three types of inquiry: Guided, unguided/open and heuristic method of inquiry while Martin-Hansen (2002) classified inquiry into four different types Guided, unguided/open/full inquiry, coupled inquiry and structured inquiry. Although these classifications vary, some similarities exist in the different methods as discussed in the subsequent chapter. However, this study is interested in the two types of inquiry (Guided and unguided) and intends to investigate the effects of these two methods of inquiry on students’ achievement and interest in Biology.

Guided inquiry is thus defined by Kirshner et al. (2006.03) and Guisti (2008.05) as the type of inquiry in which students are provided with direct instructional guidance by the teacher as regards to the concepts and procedures required by a particular discipline, requiring the students to make generalizations (i.e. the hypothesis), the teacher develops a working plan, while the students perform the activities, gather data and draw conclusion. On the other hand in Unguided or Open inquiry, the students state the problem for investigation formulates hypothesis and develop the working plan in line with stated generalization (i.e. student identify or pose questions, discover specifics construct essential information with reference to generalized principle). In view of the above definitions the major difference identified by the researcher between the two methods is in the degree of student centeredness: In the guided inquiry students are provided with some assistance and guidance from the teacher to enable investigation into a problem and construction of knowledge. In the unguided inquiry the students solely rely on their ability to utilize various scientific
processes to solve or arrive to a conclusive solution. Kirshner et al. (2006) also noted that the rift in these two methods of inquiry is in terms of the structure and guidance present in the classroom.

In a traditional biology classroom differences in the degree of guidance and assistance from the teacher as well as the degree of students’ participation in the teaching and learning process can influence to a great extent students’ achievement and interest in Biology. This study is also influenced by the educative arguments of two groups of educators; Bruner (1961), and Guisti (2008) who advocated that people learn best in an unguided or minimally guided environment which learners instead of being presented with essential information must discover or construct information for themselves and on the other hand; Kirshner, 2006 and Mayer, (2004) who advocated that people learn best when guided. In view of the above arguments, the present study intends to contribute to this educational debate to identify which of the inquiry methods guided or unguided inquiry will have more effect in enhancing students’ achievement and interest in Biology. This study therefore considers any teaching and learning process with prescribed procedures and assistance from the teacher as guided inquiry method and on the other hand all the teaching and learning processes with minimal or no prescribed procedure and assistance from the teacher as unguided inquiry method. Other important variables to be considered in this study include achievement and interest.

Achievement is an important academic factor that has been identified to be influenced by teaching methods. Achievement is the accomplishment of a goal (Wikipedia free encyclopedia, 2012). Hence academic achievement refers to the
accomplishment of academic goals, the educational outcomes of students or rather the extent to which a student, a teacher or an instructor has achieved the stated educational objectives. Previous Studies; (Ibe, 2004; Nwagbo 200) and Opara 2011) indicated that teaching method influences students’ achievement in Biology. Similarly, Jensen (2008) and Onan (2012) noted that inquiry method increases students’ achievement and interest in Biology. This study therefore intends to identify the effects of inquiry methods (Guided and Unguided) on students’ academic achievement and interest in Biology as well due to the correlational effects of interest on achievement.

Previous studies; (Obiekwe, 2008; Yong, 2009; Okoro, 2011 and Nasr, 2012) consistently show that interest is significantly correlated with teaching methods to enhance students’ achievement in Biology. Interest is “the feeling” that accompanies special attention to an object or activity, it is a motivational component characterizes by increased attention and concentration (Merriam Webster’s Learners Dictionary, 2011). Besides Okoro (2011) identified lack of interest and the use of traditional teaching methods such as lecture method as the major causes of students’ poor achievement in Biology. Whereas innovative teaching methods enhance achievement and promote students interest in Biology (Jensen.2008). This study therefore intends to investigate the different effects of inquiry methods (guided and unguided) on students’ interest in Biology respectively. Another variable intended to be considered by this study include the influence of gender on students’ achievement and interest in Biology.
Gender according to Okeke (2007) is a socio-cultural construct of ascribing characters and roles to sex such as male and females. Oludipe (2012) noted that the prevalent effects of gender bias and gender stereotypes in Nigeria affects certain vocations and professions such that traditionally professions like Medicine, Engineering, Architecture etc. are regarded as men’s while Nursing, Typing, Catering etc. as women’s. The stereotyping bias - that science is a “male” enterprise is of great concern in the field of science education and has resulted to a controversial issue and conflicting reports from different researcher. While previous studies; (Ibe and Nwosu, 2003; Nwagbo and Chukelu 2011 and Oludipe, 2012) inferred that there exist no significant difference in the achievement and interest of boys and girls in Biology.

Other studies, (Obiekwe, 2006; Yong, 2009; Nasr and Asghar, 2011 and Okoro, 2011) indicated that a significant difference exists in the achievement and interest of male and female students in Biology.

To the researchers best of knowledge there are limited studies on the effect of guided and unguided inquiry teaching method on students’ achievement and interest in Biology. In view of the limited studies the researcher considers it necessary to explore the efficacies of inquiry methods (guided and unguided) on students’ achievements and interest in Biology and also to contribute to the academic debate on the influence of gender on students’ achievement and interest in Biology.
Statement of the problem

Despite the recommendation for use of inquiry teaching method for teaching and learning science including Biology by the Federal Ministry of Education’s 6-3-3-4 curriculum reform, and suggestions by many Science Educators, reports from educators and researchers indicated that students’ achievement in Biology is still poor. The poor achievement of students in Biology has been associated with the use of poor methods of teaching, lack of interest and sometimes influence of gender. In view of these, researchers in science education have continually sought for better teaching methods that will enhance students’ achievement, promote their interest and bridge the gender gap in male and female students’ achievement and interest in Biology. Opara (2011) noted that inquiry teaching when fostered in different ways (guided or unguided) can ultimately and positively affects students understanding, achievement and interest in Biology. Some other researchers have also suggested using different forms of inquiry in teaching. The problem of this study posed as a question is which method of inquiry (guided or unguided) when fostered by teachers would enhance students’ achievement and promote interest in senior secondary school Biology?

Purpose of study

The main purpose of this study is to investigate the effects of guided and unguided inquiry methods of teaching on students’ achievement and interest in secondary school Biology. Specifically the study sought to:

1. determine the relative effects of the guided and unguided inquiry method of teaching on students’ achievement in Biology.
2. determine the relative effects of the guided and unguided inquiry method of teaching on students’ interest in Biology.

3. find out the influence of gender on the achievements of students taught Biology using guided and unguided inquiry method of teaching.

4. find out the influence of gender on the interests of students taught Biology using guided and unguided inquiry method of teaching.

5. find out the interactive effects of guided and unguided teaching methods and gender on students’ achievement and interest in Biology?

**Significance of the study**

The Nigerian curriculum: 6-3-3-4 recommends a student-centered pedagogical method that can assist in achieving the national educational goals; which include among others; the acquisition of appropriate skills, mental, physical and social abilities and competence that will equip an individual to live in, and contribute to the development of the society (Isiugi-Abanihe et al., 2010). The identification of a more effective approach of the inquiry method will be of immense benefit to the nation, students, teachers, science, educators, other researchers and curriculum developers.

To the nation, identification of a better method of inquiry will improve students’ achievement and interest in biology and increase the number of students who will go into the study of important science courses like Medicine, Pharmacy, Nursing and Agriculture. These courses of study will promote the national economic
development and also increase the number of scientifically skilled and literate citizens.

To the students, identification of a more effective inquiry method (guided or unguided) will help the students to achieve high in biology and have increased interest for biology which will make them to opt for science courses in higher institution and also appreciate the world of things around them.

To the teachers and science educators the identification of better inquiry methods will make teaching and learning process more interesting because students’ achievement will be improved upon and their interest sustained, thus enabling the realization of the stated instructional objectives which is the goal of any academic enterprise.

To other researchers; the findings and suggestions by this study will create an insight for researches into other methods of inquiry, it will also be a base-line data as well as a reference material for future studies and finally to the curriculum developers, the result from this study will provide bases for developing and implementing the use of the inquiry method (guided or unguided) that has a greater effect in improving students’ achievement and interest in Biology.

**Scope of the study**

The study was carried out in Enugu state, using senior secondary school one (SSI) students. The scope of the study is limited to all SSI students in Nsukka education zone. Nsukka educational zone consists of three local government areas:
Nsukka, Igbo-Etiti and uzo-uwani. The study will be specifically carried out in Nsukka local government area.

The choice of Nsukka Local Government Areas in because available record (see Appendix I) indicates that students’ achievement in Biology is poor despite the urban location of most schools in the area with appreciable number of qualified Biology teachers among others. The Senior Secondary One (SSI) students were chosen for the study because they are at the beginning stage of studying Biology. The content scope for the study is Animal Nutrition which includes: Food substances, Mammalian Teeth and Digestive Enzymes. This topic was selected due to the unifying role it plays in fostering students’ interest and understanding in Biology.

**Research Questions**

The following research questions were posed to guide the study:

1. What are the relative effects of guided and unguided inquiry methods of teaching on students’ achievement in biology?
2. What are the relative effects of guided and unguided inquiry methods of teaching on students’ interest in biology?
3. What is the influence of gender on the mean achievement scores of students taught biology using guided and unguided inquiry methods of teaching?
4. What is the influence of gender on the mean interest scores of students taught biology using guided and unguided inquiry methods of teaching?
5. What is the interactive effect of guided and unguided methods of teaching and gender on the achievement and interest of students in biology?

**Research hypotheses**

The following hypotheses were formulated to guide the study and were tested at a probability level of 0.05.

**HO\(_1\).** There was no significant difference in the mean achievement scores of students taught Biology using guided inquiry method and those taught using unguided inquiry method.

**HO\(_2\).** There was no significant difference in the mean interest scores of students taught Biology using guided inquiry method and those taught using unguided inquiry method.

**HO\(_3\).** There was no significant difference in the mean achievement scores of male and female students taught Biology using guided inquiry method and those taught using unguided inquiry method.

**HO\(_4\).** There was no significant difference in the mean interest scores of male and female students taught Biology using guided inquiry method and those taught using unguided inquiry method.

**HO\(_5\).** There was no significant difference in the interactive effects of guided and unguided methods of teaching and gender on achievement and interest of students in biology.
CHAPTER TWO

REVIEW OF LITERATURE

Related studies to this work were investigated under the following broad headings

Conceptual Framework

- Concept of Biology
- Concept of Teaching and Learning
- Methods of Teaching (teacher-centered and student centered approaches)
- Inquiry Methods of Teaching (guided and unguided)
- Students’ Achievement and Interest in Biology
- Gender Issues on Students’ Achievement and Interest in Science (Biology)

Theoretical framework

- Learning Theories and cognitivists’ views
- Constructivists’ views on Learning
- Cognitive and Social Constructivist’s Theories

John Dewey’s cognitive theory, L. S. Vygotsky learning theory, Bruner’s cognitive theory and Piaget’s cognitive learning theory

Empirical studies

- Studies on the Effects of Inquiry Methods of Teaching on Students’ Achievement in Biology
- Studies on Students’ Achievement and Interest in Science (Biology)
- Studies on Influence of Gender on Students’ Achievement and Interest in Science (Biology)

Summary of Literature Review

Concept of Biology

Biology is one of the fields in the natural sciences that studies living things. The word ‘Biology’ is coined from two Greek words; Bios meaning life, and logy (logia) which means study (Ezemoka, 2001). Thus the concept biology is
concerned with the study of life. Miller and Levine (2002) state that Biology in addition to studying life, studies also the structures, functions, growth, origin, evolutions, distributions, inter-relationships, problems such as diseases and adaptations of living things and proposes solutions where possible. However, Biology is the branch of science that studies life using inquiry methods and discoveries, hence North Caroline Standard Course of Study (2004) stated that since Biology involves inquiry and discovery that inquiry should be the central theme in Biology teaching and learning for students to experience the world of life around them and to actually do Biology as opposed to learning Biology.

Inquiry process involves asking questions that stimulate students to think critically which enables students to develop scientific knowledge and scientific habit such as curiosity, creativity, objectively, open mindedness etc that is needed for understanding biological concepts knowledge construction and knowledge transfer to similar situations. Biology as science of life provides potentials for the use of many inquiry methods. In view of this, the present study intends to identify among two types of inquiry teaching methods (guided and unguided) to determine the more effective method that will improve students’ achievements and interests in Biology.

**Concept of Teaching and Learning**

Teaching is a concept central to education and any academic setting. There are various definitions of teaching as well as many activities that are involved in the teaching and learning process. Nzeribe (2002) defined teaching as ‘the
conscious and deliberate effort by a mature or experiences person to impact information, knowledge, skills and so on to an immature or less experienced person, with the intention that the latter will learn or come to believe what is taught’. On the other hand Wikipedia-free encyclopedia (2011) explained teaching to mean ‘the various types of principles and methods of educating or instruction that is used to impact knowledge and skills on students by an instructor’. While Tharp and Gallimor (1991) defined teaching as ‘assisted performance beyond the zone of proximal development’ (assisting learners to perform beyond their current capacity). In view of the above assertions, teaching can be defined as a systematic activity designed by a teacher or instructor to facilitate learning in order to enable learners construct worthwhile knowledge and skills.

Teaching is an academic process that involves two groups of people: the teacher/instructor and students/learners and information which include knowledge and like that are transmitted. Due to these activities involved in teaching the concept of teaching are preferably discussed as teaching and learning. According to Sawa (2002) teaching and learning are considered as two sides of a coin, because teaching is meaningless without learning. Hence, teaching without learning is considered mere talking, for teaching to be meaningful it must be effective in promoting knowledge skills and values. In view of this, a document by Shawnee State University (2001) stated that the accepted criterion for measuring good teaching is the amount of learning outcomes demonstrated by the school age learners and also through the perspective of learners’ engagement in the teaching and learning process. Shawnee State University (2001) therefore characterized
effective teaching as: (a) teaching for understanding – teaching in ways that help learners understand ideas and perform proficiently and (b) diversified – teaching in ways that would help diverse learners to find productive path to knowledge and constructively also. Borich (2008) stated that an effective teaching and learning should:

(1) Be inquiry-based: teachers should build the subject program around inquiry process by (a) selecting content and adapting curricula to address students learning needs, interests and prior knowledge. (b) Developing activities and assessments that promote students’ depth of understanding (c) working together as colleague across disciplines and class levels

(2) Facilitate learning: Teachers should guide and facilitate learning with a variety of strategies such as (a) Helping students focus their inquiries and ideas (b) orchestrating student discuss (c) requiring students to share responsibility for their own learning (d) modeling curiosity, skepticism and the skills of inquiry.

(3) Provide learning environment: Teachers should create and manage learning environments that (a) provide enough time for extended inquiries (b) are safe but flexible and supportive of students activities and actions (c) features materials and tools for doing and use of resources outside school.

(4) Create classroom community: Teachers should develop communities of learner in which all members (a) respect the ideas and diverse experience of others (b) collaborate and make decisions about the contents and context of
their work (c) adopt the intellectual rigor and attitudes that make learning possible (d) engage in on-going formal and informal discussion.

(5) Be ongoing assessment: Teachers should engage in ongoing, assessment of instruction and learning by (a) using multiple methods to determine students understandings (b) guiding students in self assessment (c) using assessment information to guide their teaching and improve their practice. From the above assertions an effective pedagogy is that which engages students actively in the teaching and learning process and guides students successfully through exploration to become creative and critical thinkers as well as problem solvers. Effective teaching encourages students to grapple with the ideas which they need to develop their own understandings and construct meaningful knowledge. Pedagogy with these inherent qualities includes inquiry method of teaching among the innovative teaching methods.

Inquiry as an effective method for teaching biology encourages questioning or seeking for information about phenomena; it fosters and encourages scientific process such as:

Observation – Observing matters or phenomena
Measurement – Quantitative description of objects and phenomena
Experimentation – Testing Questions and ideas
Communication – Communicating results to the scientific community and the public. Inquiry involves mental process – such as inductive reasoning, formulating hypothesis and theories, deductive reasoning, analogy, extrapolation,
synthesis and evaluation which are needed in various activities in the teaching and learning of biological concepts. The secondary school biology curriculum involves a wide range of inquiry activities which may need guided or unguided inquiry methods. This study therefore intends to determine the effectiveness of guided and unguided inquiry methods on students’ achievement and interest in biology specifically in the content of Animal Nutrition.

**Methods of Teaching**

Teaching is a process of impacting knowledge which involves many activities on the part of the teacher and the learners (students). Teaching methods therefore includes these various means and activities of the teacher and learner in the learning process geared towards acquiring ideas, knowledge, skills and values that are built within the educational aims and objectives. According to O’Bannon (2002) teaching methods describes various ways information is presented to the students specifying the nature of the activities in which the teacher and the learner will be involved during the teaching and learning process. Sawa (2002) from another perspective defined teaching methods as ‘the framework on which what learners need to learn is conveyed to them by the teacher. In view of these definitions teaching methods can be asserted as primarily the description of learning objective oriented activities and the flow of information between teacher and students in the teaching and learning processes.

Teaching methods involve different activities of the teacher and the learner such as questioning, explanations, demonstration or directions. The activities can
be referred to as skills or techniques. Thus teaching methods involves different techniques. The use of these techniques vary with different teaching methods and depend on many factors such as type of learning objectives, nature of subject, age of students, number of students among others. Hence, there are different types of teaching methods: Lecture/expository method, discussion, demonstration, recitation, lecture/discussion, Games and simulations, problem-solving, Role-play, scaffolding, inquiry learning among others. These different teaching methods are grouped by some educators (Shawnee, State University, 2001; Sawa, 2002; O’Bannon, 2002 and Campbell, 2006) into two approaches: teacher-centered and student-centered.

- Teacher-centered Approach

Teacher-centered approach includes all the teaching methods that the teacher dominates in the lesson procedure and takes the lead in coordinating the classroom activities as regards to what to be done. O’Bannon (2002) stated that teacher-centered approach includes all the teaching methods grounded in behaviourism such as Lecture, demonstration, discussion and recitation etc. Teacher-centered classroom is thus rigidly structured and only factual information is conveyed to learners. For instance in the lecture method, the instructor presents fact and principles orally. In view of this, the lecture method has been criticized to be a poor method of teaching hand-on skills in sciences including Biology although it provides for the effective use of time and manpower especially in presenting ideas to a large group of people. Considering other teacher—centered
approaches O’Bannon (2002) described demonstration ‘as a teaching method that involves the teacher showing students a process or procedure involved in a learning process. The demonstration method has some advantages over the lecture method in skill acquisition, the disadvantage remains that the learners follow the rigidly prescribed probed procedure by the teacher and this makes it not effective for science teaching. Then the discussion method among other teacher-centered approach is a more advanced teacher-centered approach in which an issue in the learning content is posed as a question by the teacher and each of the students chips in different ideas etc. The discussion method also has its prone and cones with some degrees of student-centeredness as the teacher decide what is to be discussed. However, in all the mentioned teaching methods the teacher determines the content and the questions and takes upper control in the flow of information or knowledge hence they are considered as teacher-centered approach to teaching.

The term teacher-centered approach therefore comes from the roles of the teacher in the traditional classroom as possessor of knowledge and decision maker and decides know knowledge should be transferred to learners in the teaching and learning process. Ibe (2004) noted that the traditional teaching methods stress transmission of knowledge in a manner that emphasize and encourage memorization. In line with this view, Guisti (2008) described the approach as one fact laden text consisting of assign, recite, test and then discuss the text procedure. From the foregoing it indicates that teacher-centered approach includes teaching methods that involves only unidirectional flow of information from the teacher to
students and does not permit exchange of ideas that makes teaching and learning process active.

In view of these shortcomings Isiugo – Abanihe et al. (2010) characterized the traditional methods as poor methods of teaching sciences because it limits science skill acquisition and hands on activities that characterize science teaching and learning especially biology. The persistent use of traditional/conventional teaching methods has been reported to account for poor student performance Biology.

- **Student-centered Approach**

Student-centered approach include all teaching methods that underscore the teacher as a decision maker and problem solver in the classroom but rather see teachers as guides, facilitators, mentors, coach or consultants in the teaching and learning process. In the educational sector the term ‘student-centered’, ‘child-centered’ or ‘learner-centered’ are interchangeably used to refer to teaching methods that allow students to share some degree of responsibility and decision making in the classroom. The student-centered approach is opposed to the teacher-centered approach that characterizes the traditional teaching methods which rests classroom decisions solely on the teachers.

According to O’Bannon (2002) student-centered approach is grounded in constructivism, with the epistemological view that learners are the architects of their own idiosyncratic meanings of concepts and natural phenomena. In view of this student-centered approach is based on constructivists’ principles and ideas.
However Campbell (2006) inferred that the cognitive learning theory also advocate for student-centered idea. Thus student-centered approach is based on the constructivists as well as cognitive theories with the educational applications linked to the works of Dewey and Piaget among others. In discussing student-centered teaching methods, such terms like constructivism, inquiry and discovery learning are often interchangeably used. Kirshner (2006) noted although these terms share some commonalities experts in each field observe some important differences.

Nevertheless, in today’s educational discussions the term student-centered approach is a broad term that includes all innovative teaching methods that are usually activity oriented, where learners are expected to observe, analyze, synthesize and evaluate ideas or phenomena using materials or previous knowledge. Teaching methods emphasizing this approach include discovery, constructivism-related method (concept mapping, co-operative learning), problem solving, graphic organizers, know what to learn (KWL), role play, simulations and games and inquiry method etc. Educational Broadcasting Corporation (2004) noted that the principles of student-centered approach are linked to the philosophy of Rousseau’ work ‘Emile’ which stressed on the intuitive nature of children to investigation and learning naturally from the environmental experience.

The student-centered approach is relevant to Biology teaching because in biology teaching, creating an environment that will encourage students to interact with materials and specimens enables students to construct meaningful knowledge and learn Biology first hand. In view of the relevance of student-centered
approach to teaching and learning of Biology many researches in biology education: (Ibe and Nwosu, 2003; Ibe, 2004; Nwagbo, 2006 and Opara (2011) recommend for a shift from the use of traditional teaching methods (teacher-centered approach) of teaching biology to a modern/innovative teaching methods (student-centered approach) such as inquiry method. Evidences from the above studies also indicated that the inquiry method of teaching is superior to the traditional teacher-centered approach in improving academic achievement, acquisition of process skills and in promoting scientific literacy among biology students. Nevertheless these studies did not investigate the effects of different methods of inquiry on students’ interest which is another objective of this study.

**Inquiry methods of teaching**

Inquiry is a term often used in science classroom to express student-centered approach due to the fact that it employs the scientific process in the search and construction of knowledge (Guisti, 2008). Biology is inquiry in nature and should be studied through inquiry method using scientific process and habit if students are to achieve highly. Nevertheless, in the traditional classroom biology is taught mainly through teacher-centered approaches such as lecture/expository, demonstration methods etc. These traditional methods have been reported to be responsible for students’ poor achievement in Biology hence the inquiry teaching method is recommended and designed to turn the traditional ‘cook book’ approach to science teaching into hands-on minds-on which actively involve students in the teaching and learning process and promote their reasoning abilities.
Inquiry teaching method is variously defined by many educators: Martin-Hansen (2002) defined inquiry as ‘the work scientists do when they study natural world, proposing explanations that include evidence gathered from the world around them and the activities of students-such as posing questions, planning investigation and reviewing what is already known in the light of experimental evidence’, on the other hand, Education Broadcasting Corporation (2002) simply defined inquiry as ‘seeking for truth, information or knowledge by questioning’ while Bybee (2011) defined inquiry as an outcome of science teaching characterized by knowledge and understanding of the processes and methods of science’. Onan (2012) in another perspective defined inquiry as student-learning approach that encourages students to create personal knowledge by questioning and use of investigation process. From the above assertions, basic elements of inquiry method include questioning and investigation, Hence inquiry simply means teaching method that encourages investigation through questioning. In inquiry teaching; students ask questions and use investigations (scientific process) to discover or construct knowledge as scientist do.

Inquiry teaching method is therefore recommended for teaching Biology because it provides students with the opportunity to explore the world of things around them through the scientific process. Many researchers Ibe (2004) Chukwuemeka (2005) Nwagbo (2006) and Opara (2011) recommend the use of inquiry method for biology teaching because it promotes process skill development which is needed for scientific investigations. Similarly, Orlich, Haders, Collohan, Trevisan and Abbie (1998) identified inquiry as a better method
of teaching biology because it encourages active interaction between students, teachers, materials and environment and allows both the students and the teachers to become persistent askers, seekers, interrogators, questioners and ponders and combines all the learning processes that encourage knowledge discovery and construction. Educational Broadcasting Corporation (2004) noted that inquiry process starts from birth and continue till death; it begins with gathering of information and data through the application and use of human senses, to formulating questions that arouse the thinking process towards knowledge construction and problem solving. In support of the above view, Onan (2012) outlined the following inquiry process:

- Identification and selection of problems and conducting research
- Introducing process and problems and problem presentation
- Gathering data
- Developing theory and verifying theory
- Analyzing process and
- Evaluation

In science teaching and learning there is no authentic investigation or meaningful learning if there is no inquiry process because it provides motivation for activity, increases interest, generates curiosity make connections to prior knowledge and intensifying learning objectives and criteria for success in teaching. Martin-Hansen (2002) noted that although inquiry can be applied to other disciplines that it is more appropriate to teaching of sciences, hence it is effective for biology teaching and learning since Biology is inquiry in nature.
Jensen (2008) stated that ‘inquiry method promotes learning and achievement more in science encourages team-spirit which is an attribute of science.

To achieve a successful teaching through inquiry method, certain procedures are considered, these procedures are what Saskatchewan (2010) called inquiry approaches;

The teacher should present the followings:

- Present a problem or a puzzling event or situation which stimulates interest.
- Ensure that the students understand the problem, event of situation.
- Either structure the lesson, to develop specific predetermined generalization, thereby limiting the number of generalizations developed (guided inquiry) or
- Identify general problems or questions but not specific generalizations to be developed, thereby allowing unlimited number of generalizations to be developed, thereby allowing unlimited number of generalizations (unguided inquiry).
- Provide and structure appropriate materials, equipment, data, classroom and environment etc.
- Provide instruction about whether students work alone or in groups.
- Either act as class leader throughout the lesson and ask questions and suggest activities which will lead students to desired generalizations (guided inquiry) or ask only initial questions.
- Students interact with materials and with each other without further teacher’s guidance (unguided inquiry).
• Elicit observation and generalizations in whole class discussion or encourage individual or small groups sharing.

• Observe and listen to students throughout the lesson: note students activities, questions and hypotheses, note process which lead students to specific conclusions.

The above approaches include both guided and unguided inquiry. The teacher may decide on which type of inquiry to apply. However, whether guided or unguided inquiry teaching method has many benefits in teaching and learning. Okwor (2007) noted that the following educational benefits would be achieve by learners through inquiry teaching method (guided or unguided)

• Active participation of learners in the teaching and learning process,

• Building up self concepts and knowledge

• Retention and transfer of knowledge to new but similar situations

• Arousing interest and promoting intrinsic motivation

• Development of effective thinking, creative expression, critical analysis and logical reasoning.

Regardless the academic benefits of inquiry method of teaching there are some weaknesses of the inquiry method in teaching and learning. The shortcomings include:

• It is time consuming and limits content coverage of the syllabus,

• Too much work load and large class size make supervision of students difficult
It complicates and expands teachers work owning to the many interactions that are involved in the process.

As earlier stated to implement an inquiry process different inquiry approaches can be used (guided or unguided).

In view of the different approaches of inquiry many educators classified inquiry teaching methods into different types: (Martin-Hansen, 2007) classified inquiry into four types namely: Guided, unguided/open, coupled inquiry and structure/undirected inquiry.

(i) Guided inquiry: inquiry teaching where the teacher helps students to develop inquiry investigation by the teacher choosing the question for investigation while the students in large or small groups may assist the teacher with the decision on how to proceed with the investigation,

(ii) Open or full inquiry – inquiry teaching that begins with student questions, followed by the student or groups of students designing and conducting an investigation or experiment and communicating results to one another.

(iii) Coupled inquiry – inquiry teaching that combines a guided inquiry with an open inquiry, where by the teacher chooses the first question to investigate, specifically targeting a particular standard or benchmark after which it is followed up by an open inquiry i.e. student generated questions that closely relates to the standard or benchmark from the first investigation (starting with guided inquiry and move into unguided inquiry)

(iv) Structured inquiry/directed inquiry – a type of inquiry similar to guided inquiry and directed teaching. This type of inquiry is typically a type of
cook-book lesson in which students follow teacher’s directions to come up with a specific product/result.

On the other hand David (1993) and Okoli (2001) classified inquiry into three types: Guided, Unguided/full inquiry and heuristic method, David and Okoli explained

(i) Guided inquiry as inquiry where the teacher initiates a question for investigation and closely supervises the students towards working into the solution or answer to the asked question,

(ii) Unguided inquiry/full inquiry as inquiry where the students initiate problems or questions and independently investigate into the problems to find solutions and answers without the teacher’s assistance and

(iii) Heuristic method of inquiry as inquiry that involves steps, strategies and ways structured by the teacher, through which learners solve a particular problem or skill.

However, many researchers; Kirshner et al., (2006); Guisti (2008); Bilgin (2009); Sakatchewen (2010) and Opara (2011) classified inquiry into two types guided and unguided inquiry. In view of these two major classifications the researchers grouped any teaching and learning process by which the teacher initiates a question or problem and provides assistance by structuring the procedure for solving such question as guided inquiry, whereas any teaching and learning process which provides learners opportunity to initiate and ask their own questions, plan procedure for attempting and analyzing questions and discuss their findings with minimal or no assistance from the teacher as unguided inquiry.
Although the views of these three different schools of thought in the classification of inquiry vary, the variation is due to individual understanding and perception of ideas. The present study intends to investigate the effects of the two different inquiry methods (guided/unguided) of teaching on students’ achievement and interest in biology in line with the view of Kirshner (2006) which classified inquiry into two types: guided and unguided inquiry.

- Guided Inquiry

With respect to the present study, guided inquiry entails instructional process where the search for knowledge is initiated by the teacher’s questions; the teacher also provides assistance to learners during the teaching and learning process to enable the learner construct meaningful knowledge. In guided inquiry method, teachers and learners play crucial roles in asking questions developing answers and procedures that will enable learning to take place. Thus, Campbell (2006) defined guided inquiry as a range of investigative structured activities where an instructor provides problems or questions and encourages learners to work out procedure for solving problem or answering question. This definition indicates that in guided inquiry that the students are provided with the specifics, data or facts to solve a problem or answer a question but are allowed to discover the solution or answer with which to make generation. Due to these features of guided inquiry Bilgin (2009) asserted that guided inquiry is more of teacher-centered approach than unguided/full inquiry and that guided inquiry stands in-between the traditional teacher-centered approach and a more student-centered
approach – unguided/open inquiry. This is because although guided inquiry involves students at every stage in the teaching and learning process – from selecting what is to be investigated, formulating and presenting problem to evaluation. In guided inquiry the instructor through structured learning activities, states problem, formulates hypothesis thereby structuring the reasoning ability of the learner.

The followings are the prospects of guided inquiry:

- It provides students direction towards information location.
- It ensures success in the discovery of concepts and principles due to guidance and direction provided by the instructor.
- The structured questions compels students to think critically and analytically.
- It helps students to organize and facilitate learning.
- It ensures that students do not get frustrated and experience failure in the teaching and learning process.
- It connects the curriculum content to the learners’ world.

Nevertheless, Martin-Hansen (2002) maintained that guided inquiry does not include much of true inquiry because

- Its structured nature makes it follow the directions in a cook-book manner.
- It does not involve much of students critical thinking.
- It limits students’ creativity unlike the unguided or open inquiry etc.
• Unguided Inquiry

Unguided inquiry includes all instructional process by which questions or problems and procedure for investigation are carried out by the students with little or no form of assistance from the teacher; in which case the questions are open-ended and less structured. Bilgin (2009) defined unguided/open inquiry as a student-centered approach to learning that begins with students designing questions, conducting an investigation and communicating results to others. Unguided inquiry is referred to as full inquiry in the sense that learners are given freedom to carry out all the inquiry process; select the research questions, carry out method of investigating the hypothesis and draw conclusions. The teacher may control only the materials provided or encourage student-initiated materials. Unguided inquiry allows students to work directly with the concepts, materials and environment in order to discover the specific and facts that is used for generalization. Bilgin (2009) noted that unguided inquiry is intellectually challenging for learners and difficult to implement by teachers but has the benefit of making students not to perform experiments in a routine-like fashion but actually think about the procedure and the results they obtained and what the results mean (conclusion). The benefits of unguided include also that:

• It encourages no wrong results
• It enables students to obtain results and decide the values
• It encourages high engagement of students in the learning process
• It involves high order thinking thus it promotes critically and creativity in students.
On the other hand Kirshner (2006) noted that unguided inquiry may be detrimental to students because of the following problems:

- It can generate a heavy working memory load that is detrimental to learning especially to novice learners who lack proper schemes to integrate new information with their prior knowledge.

- It takes a lot of time of the learning process etc.

The classification of inquiry into these two types guided and unguided is based on academic dispute and controversy about the impact of instructional guidance during learning. One of these arguments; Mayer (2004) and Kirshner et al., (2006) advocated that people learn best when guided whereas Bruner (1961) and Guisti, (2008) advocated that people learn best in an unguided or minimally guided environment. However, both guided and unguided inquiry are important in Biology teaching and learning because some principles of unguided inquiry help students to work like real scientists; encouraging students to develop research skills and understanding of the nature of science the guided inquiry, provides procedure and guidance needed for skill and knowledge acquisition necessary in Biology. Bilgin (2009) believed that guided inquiry seems to be a transitional method that stands somewhere in-between the traditional teaching method and a more student-centered approach (the open or full inquiry, unguided inquiry). Guided and unguided inquiry have intra-effect on each other in the teaching and learning process though with different degrees of student-centeredness which may account for the varying effect they may have on students’ achievement and interest in Biology. In the spectrum of student-centered approach, guided inquiry is at one
end of the spectrum while unguided is at the other end. In-between these two lies discovery learning, problem solving and constructivism. The degrees in the variation of student-centered teaching methods are illustrated below:

**Spectrum of student-centered techniques**

<table>
<thead>
<tr>
<th>Guided inquiry</th>
<th>Discovery learning</th>
<th>Open/unguided inquiry</th>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heuristic learning</td>
<td></td>
<td>Constructivism</td>
</tr>
</tbody>
</table>

After Guisti (2008)

The student-centered spectrum diagrammatically illustrates the different degrees of student-centered teaching methods which includes guided inquiry, hands-on, discovery, unguided and constructivism. While guided inquiry is at one extreme starting the student-centered approach, the discovery method is at the middle while unguided and constructivism are at the other end. It is also remarkable to note that those methods in the same axis such as guided inquiry and hands-on method emphasize the same degree of student-centeredness while unguided inquiry and constructivism also emphasize the same degree of student-centeredness. Some researchers Kirshner (2006) and Bilgin (2009) in view of the similarities between these student-centered teaching methods refer interchangeably to these student-centered methods as discovery learning, problem solving, constructivism and inquiry method etc.
This study therefore intents to determine the effects of two inquiry methods which are at the opposite edges of the student-centered spectrum, (guided and unguided inquiry) on students’ achievement and interest in biology.

**Students’ Achievement and Interest in Biology**

- **Students’ Achievement in Biology**

  Achievement is an important educational variable that expresses the success or failure of a teaching and learning process. Campbell (2006) referred to academic achievement as the outcome of a teaching and learning process. The extent to which a student, teacher or institution has achievement their educational goals’. Similarly Adeyemi (2008) described academic achievement as the scholastic standing of a student at a given moment which states individual’s intellectual abilities; which can be measured by grades obtained from examinations or continuous assessments (tests or quiz). In Nigeria, the level of students’ academic achievement in the senior school secondary school is determined by grades obtained from external examination Senior School Certificate Examination conducted by external examination bodies WAEC and NECO respectively. The pattern of grading candidates score in the examination is such that distinction grades were represented by A₁-B₂, credit grades C₄-C₆, ordinary pass D₇-D₈ and failure grade F₉ (Adeyemi, 2008). A sample of students West African School Certificate Examination result in biology in the study area 2005-2010 indicate that majority of the students obtain grades within the range of D₇ – F₉. This result indicates poor achievement in Biology since the least
requirement for further studies in the tertiary institutions is $C_6$. The poor student achievement in Biology is linked to the use of traditional lecture/expository method in the teaching and learning of biology (Nwagbo, 2006 and Isiugo-Abanihe et al., 2010).

Available studies Ibe and Nwosu (2003); Ibe (2004) and Opara (2011) indicated that inquiry teaching method improves students’ academic achievement as opposed to the traditional teaching methods. Nevertheless, these previous studies did not determine the effects of different types of inquiry on students’ achievement and interest. The limitations of these previous studies therefore call for the present study which intends to determine the effects of guided and unguided inquiry on students’ academic achievement and interest. Another important variable in this study is students’ interest in Biology.

- Students’ Interest in Biology

Unlike achievement which is of the cognitive domain, interest is an education concept that determines some aspects of students’ affective domain which is very important in the teaching and learning process. Merriam-Webster’s Learner’s Dictionary (2011) defined interest as ‘a feeling of wanting to learn more about something or to be involved in something’. In education interest is characterized by increased attention and concentration in classroom and academic activities. It is a motivational variable and emotionally oriented trait which determines the vigor of the learner in tackling educational activities. Okoro (2011) stated that interest reflects a central feature in the knowledge value system of a
learner, meaning that learners’ interests are influenced by the value they have for an activity or knowledge. Interest guides and encourages students to think critically and to keep trying until success is achieved. Interest and achievement correlate in teaching and learning process and have intra influence on each other; high interest improves students’ achievement while high achievement promotes interest on the other hand low interest retards learning and results to poor achievement etc. Jensen (2008) noted that interest co-relates with intelligence and some factors like teaching methods in determining students’ academic achievement and when lacked by students results to poor academic achievement and most often students dropping out from school. Obiekwe (2008) and Okoro (2011) indicated that students’ interest and achievement can be influenced by innovative teaching methods such as constructivist instructional approach and interaction learning patterns, while Onan (2011) noted that inquiry teaching method promotes students’ interest and achievement in Biology. In view of this, the researcher intends to determine how guided and unguided inquiry methods will promote student interest in biology to improve students’ achievement in biology. A review of some studies on students’ interest in Biology; Yong (2009) and Nasr and Asghar (2011) indicated that students’ interest in Biology can also be influenced by gender.

Gender issues on Students’ Achievement and Interest in Science (Biology)

Gender is a socio-culturally constructed concept of ascribing some characteristics and roles to sex such as male and female within the society. The
concept of gender is equivalent to class and race and has many social construct just as class and race (Robert, 1996). In Nigeria the issue of gender and gender stereotyping permeate every aspect of human endeavour. Okeke (2007) observed that the circumstances of gender have strongly interacted with culture to produce sex role-stereotypes which cut across social, economic, political and educational development especially in the areas of science and technology. Nzewi (2010) explained sex role-stereotypes as the socio-cultural classification of human activities by sex in line with what the society considers as appropriate for one sex or the other.

The arbitrary assigning of roles and expectations to different sex (male and female) within the society has given rise to such misconception of perceiving science as ‘masculine’ and of male domain only. Oludipe (2012) observed that in Nigeria that certain vocations and professions have traditionally been regarded as men’s (Medicine, engineering and architecture etc) and others as women’s (nursing, catering, typing etc). The society’s socio-cultural construct of females as weaker sex together with females self perception of themselves as weaker sex, inferior and subordinate to the males have impose some socio-cultural limitations on female aspirations and achievement in sciences (Ojobo, 2008). Similarly, Nzewi (2010) inferred that the socio-cultural upbringing of females within most Nigerian homes tends to shape the girl-child away from science and science related disciplines. For instance in most homes what are regarded as complex and difficult tasks are allocated to boys whereas girls are expected to handle the relatively easy and less demanding tasks. Consequently fewer females opt for
science subjects thereby creating some differences in the number of males and females in science discipline in favour of the males. Nevertheless, Chang (2003) reported that although there is a decrease in the gap in gender difference in student performance in sciences, but female representation in sciences is still low in comparison with their male counterparts.

Gender issues and its effects in students’ academic achievement and interest in science has persisted over the years with contradicting results and stands out as a controversial issue in science education due to varying reports from different researcher. Some researchers: Ibe (2004); Iweka (2006); Obiekw (2008); kolawole (2007 and Okoro (2011)) are of the view that males perform better than females in sciences whereas some other educators: Okeke (2007), Nzewi (2010) and Oludipe (2007) are of the view that both males and females achieve equally in science when given equal opportunity and facilities.

Nevertheless, Okoro (2011) specifically maintained that some teaching methods that involve students’ competition such as individual learning favours male students more than female students while those other teaching methods that encourages group work such as co-operative learning favours females more than males. However, this report may be in line with observations of Nzewi (2010) which stated that males tend to be dominating in competitive activities while females are always shy and may prefer working in group or under male counterparts. In view of the inconclusive issues of the effects of gender on achievement and interest and some reports that innovative teaching methods influence gender achievement and interest in Biology, this study therefore intends
to contribute to the on-going academic argument and controversy on the effects of gender on students’ achievement and interest, by investigating the effects of two types of inquiry (guided and unguided) teaching methods to determine the interactive effects of these methods and gender on students’ achievement and interest in biology.

**Theoretical framework**

**Learning Theories and the Cognitivists’ Views**

Learning is a pervasive concept that cuts across all human endeavours. It is a long life process that starts from birth and continues till death. In education there are many learning theories which include: Behaviorism, cognitive and social learning theories etc. The views and perceptions of these theories on knowledge construction acquisition vary. According to Ngwoke (2008) the behaviorists perceived learning as habit formation on the other hand, the social learning theorists understand learning simply as imitation while the cognitive theorist view learning as change in perception that involves active mental processes. Besides, Bello and Abimbola (2012) stated that the newer idea of the cognitive psychologists about learning is that learning is an active internal process of construction where learners’ prior knowledge plays a significant role in further conceptual learning.

The newer ideas of the cognitive psychologists and the constructivists’ epistemological views formed the cornerstones of inquiry teaching and are linked
to the works and philosophies of Dewey, Vygotsky, Bruner and Piaget among others.

**Constructivists’ Views on Learning**

Constructivism according to Educational Broadcasting Corporation (2004) is not a teaching theory but rather a theory of learning which argued that human beings generate knowledge and meaning from interaction between their experience and ideas’. Thus to the constructivists learning is simply the experience gained by learner’s interaction with the environment. Hence, the Constructivists like the cognitive theorists see learners as active creator of knowledge. To construct knowledge Orlich et al., (1998) noted that learners must ask questions, explore and assess what are known – which are the elements of inquiry teaching methods.

In view of the application of inquiry process into knowledge construction (constructivism), inquiry and constructivism are interrelated and share some common characteristics which are summarized by Orlich et al., (1998) as follows:

- The focus is on the student
- The pace of instruction is flexible not fixed
- Students are encouraged to search for implications
- Students are encouraged to generate multiple concessions
- Students must justify their methods for problem solving
- Neither constructivism nor inquiry sees itself as the sole learning model for content
• Nature provides the object and humans classified them.

Considering the interrelationship of inquiry and constructivism, this study poses as a question. How constructive can a learner be when guided or unguided? To provide an answer to the above question, the researcher intends to review the ideas and philosophies of John Dewey, Jerome Bruner and Jean Piaget and as well the idea of a social constructivist of Lev. S Vygosky, as the base for this study.

**Cognitive and Social Constructivist’s Learning Theories: John Dewey’s cognitive Theory**

John Dewey was a philosopher, psychologist and educational reformer who contributed and influenced education and social reforms especially in such topic like inquiry teaching and learning among others. Dewey states that ‘knowledge emerges only from situations in which learners have to draw them out of meaningful experience’. Dewey argued that education and learning are social and interactive processes and that the school as a social institution provides an environment in which social reforms can and should take place. He sees the classroom as a social context where students can take part in manipulating materials and thus form a community of learners who construct their knowledge together. Dewey believed in one permanent frame of references; namely the organic connection between education and personal experience. He maintained that every experience enacted modifies further experience and results in positive attitude and growth of understanding. Another vital issue raised by Dewey is that, he believed that students thrive in an environment where they are allowed to
experience and interact with the curriculum, as such Dewey emphasized that all students should have the opportunity to take part in their own learning.

Educational Broadcasting Corporation (2004) maintained that Dewey was of the view that the primary responsibility of educators is to assist shaping the experience by providing environing condition that will help students to utilize their surrounding to build up experiences that interact with personal desires of the students to make learning take place. Dewey encouraged hands-on learning and states that it is impossible to procure knowledge without the use of objects which impress the mind. As a constructivist Dewey believed that teachers/instructor are partner in the learning process whose guidance and assistance help learners to construct their learning and independently discover meaning within the subject area (Wikipedia, 2011).

The obvious implication of Dewey’s theory in this study is that in the learning process, students must be engaged in meaningful activities that induce them to apply the concepts they are trying to learn. The teacher’s role should be to provide enabling environment for active learning to take place such an environment could be the guided inquiry approach.

L. S. Vygotsky’s learning theory

Vygotsky also referred to as social constructivist believed that learning takes place through social interaction. Vygotsky believed that the zone of proximal development of a child is the distance between the actual developmental level as determined by independent problem solving and the level of potential
development as determined through problem solving under guidance or in collaboration with more capable peers. In view of this, Vygotsky sees teaching and learning as what cannot be judged by what the child can do when working alone but rather how far ahead the learner can go when offered some assistance by a more experienced person (teacher).

(Crain, 1992. 217) states:

Vygotsky recognized the importance of intrinsic development but states that ‘children do grow and learn from their inner maturation promptings and active curiosity but it cannot take them very far. Hence for a child to fully develop the child needs intellectual tools and assistance which provides a new search light that illuminates not only those function that have already matured but those that are in the process of maturing.

Vygotsky seriously believed that through a process of ‘scaffolding’ a learner can be extended beyond the limitations of physical maturation to the extent that the developmental process lags behind the learning process. He further maintained that instruction in scientific concepts is very helpful because it provides children with broader frame work in which to place their spontaneous concepts (every day concepts). In view of the above points Tharp and Gillmore (1991) state that ‘instruction is good only when it proceeds ahead of development. Then it awakens and rouses to life the entire set of function in the stage of maturity
which lies in the zone of proximal development, it is in this way that instruction plays an important role in development’.

The implication of Vygotsky’s theory to this study is that it is the teacher’s job to move the child forward in the academic process. Through guided inquiry the child’s zone of proximal development can be reached as the teacher provides assistance and structures the learning objectives.

**Jerome Bruner’s cognitive theory**

J. S Bruner was a cognitive theory developmental Psychologist who conducted an in-depth study in such areas likes human perceptions motivation, learning and thinking (Nnachi, 2007). Bruner viewed human beings as information processor, thinker and creator of ideas, whose cognitive developments occurs through the interaction and exploitation of the environment. Bruner believed that learning is effective when learners are given the opportunity to discover facts by themselves. He thus laid emphasis on discovery learning. Bruner sees the acquisition of knowledge as an active process and thus encouraged learner’s autonomy and personal involvement in the learning process. To Bruner, learner’s independence fostered through encouraging students to discover new principles on their own accord lies at the heart of effective education. Bruner advocated for a spiral curriculum which can enable students to build upon what they have already learnt in the order of these principles:

- Instruction must be commensurate with the experiences that make the students willing and able to learn (readiness)
• Instruction must be structured so that it can be easily understood by the student (spiral organization).

• Instruction should be designed to facilitate extrapolation (going beyond the information given).

The implication of Bruner’s theory to inquiry approaches is that teachers should create situations that would help learners to discover facts by themselves. Discovery according to Guisti (2008) stands in between guided inquiry and unguided inquiry, hence to discover facts by learner’s, principles of unguided inquiring are applied.

**Jean Piaget cognitive learning theory**

Jean Piaget proposes that the basis of all learning is the child’s own activity as the child interacts with the physical and social environment. To Piaget knowledge does not and cannot have the same purpose of representation of an independent reality but instead has adaptive function. Piaget recognized that human beings are born as active exploratory information processing organisms and actively construct their own ways of thinking about things based on their current level of maturation, actual experiences with objects, people and ideas. Piaget believed that the child’s mental activity is organized into a structure called ‘schema’ or pattern of behavior which develops as the child passes through stages of mental development, through the sensory motor, preoperational concrete and formal operational stages (from infancy to maturation). Thus as children grow and develop, they go through stages in which they accept ideas that they may later
discard as wrong. Understanding is therefore built up step by step through active participation and involvement.

Piaget used the term assimilation, accommodation and reorganization to explain his views about the learning processes in children. The child assimilates new objects by making accommodation that build new cognitive structures. Nnachi (2007) observe that although Piaget recognized the importance of environment in child development but he laid much emphasizes on the role of cognitive structure which helps the child to build experience from important event to be superior to the environmental influences. To Piaget true learning is not something handed down by the teacher, but something that comes from the child through the process of spontaneous invention and discovery. Piaget then maintained that the basis of learning is discovery hence ‘to understand is to discover or reconstruct by rediscovery and such conditions must be complied with, if in the future individuals are to be formed who are capable of productivity (critical thinkers) and creativity and not simply repetitions’.

Relevance of Piaget Theory to this study

Piaget theory is in favour of unguided inquiry. Piaget sees the teacher as a facilitator or a guide in the teaching and learning process whose role is to provide a rich environment for spontaneous exploration of the students. In line with Piagets’ view Okebukola (2002) stated that a science classroom filled with materials to explore encourage students to become active constructor of their own knowledge. Piaget like unguided inquiry sees learning as active process in which
students should be given freedom to understand and construct meaningful knowledge at their own pace through personal experience.

From the views and ideas of the cognitive psychologists and the social constructivists’ theories, there are two different perceptions in the degrees in which learners should be allowed to construct knowledge in student-centered teaching methods. One of these groups; Dewey and Lev. S. Vygotsky are in support of guided inquiry method whereas the other group: Bruner and Piaget theories and views support unguided inquiry method. This research therefore intends to support either of these two groups of philosophers by investigating the effects of guided and unguided inquiry method on students’ achievement and interest in biology.

**Review of Empirical Studies**

**Studies on Effects of Inquiry Methods of Teaching on Students’ Achievement**

Available studies; (Nwagbo, 1997; Timothy and Awodi, 1997; and Ibe, 2004 etc) indicated that inquiry method improves student’s achievement in sciences more than the traditional teaching methods like lecture, demonstration etc.

With regards to the above statement, Nwagbo (1997) carried out a study on the Effects of Guided Inquiry and Expository teaching methods on the Attitude and Achievement in biology of students of different levels of scientific literacy. A pre-test, post- test non-equivalent control group design was used for the study. One hundred and forty-seven (147) SS 11 students from 4 secondary schools (two
school assigned to treatment and the other two schools assigned to control) in
Nsukka Urban area of Enugu State, were selected through simple and stratified
random sampling techniques. Three instruments: Scientific Literacy Test (SLT),
Attitude to Biology Scale (ABS) and Biology Achievement Test (BAT) were used
to collect data. The data were analyzed using mean, standard deviation and
ANCOVA. The findings of the study indicated among others that the guided
inquiry approach favoured the students in the high level group better than the
medium and low level groups respectively in enhancing achievement in biology
more than the expository method. The researcher concluded that guided inquiry
approach was significantly better than expository method of teaching in enhancing
cognitive achievement in biology for all levels of scientific literacy students.

In a related study Timothy and Awodi (1997) on the Effects of Inquiry and
Lecture Methods on the Performance of High and Low Achievers in senior
secondary school biology, the sample consisted of one hundred and ten (110) SS1
students randomly selected from two senior secondary schools in Niger State. The
students were randomly assigned to experimental and control groups. Those in the
experimental group were taught using the inquiry approach while those in the
control group were taught using lecture (conventional) method. The students were
classified into high and low achievers based on their performance in past biology
exams and continuous assessment scores. The data obtained were analyzed using
mean and analysis of variance (ANOVA). The findings revealed a significant
difference between inquiry and lecture methods in improving student’s
performance in biology Achievement test in favour of the inquiry approach. In
addition the inquiry approach improved the low achievers’ performance in the Biology Achievement test (BAT).

In a study carried out by Secker (2002) to investigate the Effects of Inquiry-based Instructional practices on Academic Excellence and Equity among 10th grade biology students in Longitudinal study (NELs) Columbia, using population of 4,377 students randomly sampled from 1,406 classes. Data for the study were collected through the demographic data available, 10th-grade science achievement of students 1989-1990 academic years and standardized science test developed by the Educational Testing service. The data were analyzed using within-class Hierarchical Linear Model (HLMS). Result obtained from the study on students’ achievement provided empirical evidence that inquiry-based teaching is associated with higher achievement in biology (science).

In another study, Ibe and Nwosu (2003) investigated the Effects of Guided Inquiry and Demonstration Methods of teaching on Science Process Skills Acquisition among secondary school biology students. The design for the study was quasi-experimental, specifically the non equivalent pre-test, post-test. One hundred and fifty (150) senior secondary one biology students in co-educational schools formed the sample. Three (3) co-educational schools were randomly drawn from the seventeen (17) co-educational secondary schools in Nsukka Local Government Area of Enugu State. Intact classes were randomly assigned to two experimental groups. Groups one and two were taught using guided inquiry and demonstration methods respectively. The control group was taught using conventional (lecture) method only. A test of science process skills Acquisition
(TOPSA) of twenty (20) items was developed and used in obtaining data on student’s acquisition of the process skills of science. The data was analyzed using mean, standard deviation and ANCOVA at 0.05% level of significance. Result obtained from the study revealed that the students taught through guided inquiry method performed significantly better than those taught through demonstration and conventional (lecture) methods. The researcher recommended that teachers should use guided inquiry method of teaching as it challenges students to be actively involved in the classroom.

A similar study was carried out by Ibe (2004) on the Effects of Guided Inquiry and Demonstration on Science Process Skill Acquisition among senior secondary one (SS1) biology students in Nsukka Local Government Area of Enugu State, the design for the study was quasi-experimental. The non-equivalent pre-test and post-test was used. One hundred and fifty (150) senior secondary one biology (SS1) biology students in co-educational schools were randomly drawn from seventeen (17) co-educational schools in Nsukka Local Government Area. The intact classes were randomly assigned to experimental and control groups. The experimental group I was taught using guided inquiry, Experimental group 2 was taught using the demonstration method while the control group was taught using the conventional lecture/demonstration methods. Findings from the study revealed that students taught using the guided inquiry method performed significantly better than those taught using the demonstration and lecture methods.

In a study carried out by, Obiekwe (2008) to investigate the Effect of Constructivist Instructional Approaches on Students’ Achievement and Interest in
Basic Ecological concepts in Biology. The study adopted a quasi-experimental design of pre and post-tests non-equivalent control group. A purposive random sampling technique was used to select 4 schools (2 girls’ and 2 boys’ schools) from (94) schools in Ogidi Education Zone of Anambra State. Out of the four (4) schools, one male and one female school were assigned as the experimental groups while the other one male and one female school were assigned as the control group. The experimental group was taught ecological concepts using constructivism instructional approach while the control group was taught using conventional (lecture) method. Biology Achievement Test on Ecological Concepts (BATEC) and Biology Interest Inventory on Ecological Concepts (BIIEC) were used to collect data. The data were analyzed using means, standard deviations and ANCOVA. Results from the data on Biology Interest inventory on Basic Ecological Concepts indicated that constructivist instructional approach was more effective in facilitating student’s achievement and interest in Ecological concepts more than the conventional (lecture) method.

In a related study, Okoro (2011) investigated the effects of Interaction Pattern on Students’ Achievement and Interest in Biology Among secondary school students. The design for the study was quasi-experimental pre-test and post-test non-equivalent group. The study involved 3 intact classes that were randomly assigned to co-operative, competitive and individualistic groups respectively. The sample for the study consisted of one hundred and fifty four (154) SS11 students from four (4) schools in Obollo- Afor Education zone of Enugu state, the sample was selected through purposive and random sampling.
Four single schools (2) male (2) female schools were purposely used. Data for the study was collected using researcher constructed Biology Achievement Test (BAT) and Biology Interest Inventory (BII). The BAT consisted of 24-item multiple choice objective questions. Data from the study was analyzed using means, standard deviations and ANCOVA. Result from the study indicated that the three (3) interaction patterns: co-operative, competitive and individualistic patterns enhanced students’ achievement and interest in biology.

Subsequent studies on the comparative effects of inquiry method and conventional (lecture) method on student achievement; Opara (2011) carried out a study on the Effects of Lecture and Inquiry Methods of Teaching on Students’ Achievement in Biology among SSI students in Ogba/Egbema/Ndoni L.G.A of Rivers State. The design for the study was quasi experimental, pre-test, post-test nonequivalent group with sample size of one hundred and twenty (120) students. One hundred and twenty (120) students randomly sampled from (4) four schools were selected through stratified random sampling techniques and were randomly assigned to two groups (Treatment and control groups). The treatment group was taught biology using inquiry teaching method while the control group was taught using the conventional lecture method. Data for the study was collected using Biology Achievement Test developed by the researcher. The data were analyzed using mean and standard deviations. Findings from the study revealed that the group taught with inquiry teaching method performed significantly better than the control group indicating that the inquiry teaching method has a significant effect
on facilitating students’ achievement in Biology more than the conventional lecture method.

From the foregoing, the reviewed studies indicated that the innovative teaching methods and activity oriented teaching methods such as constructivism, co-operative learning and inquiry teaching methods etc have positive effects on students’ academic achievement and interest, promote science process skill acquisition, improve the performance of low achievers in Biology and generally improve on students’ understandings of Biological concepts more than the conventional teaching methods such as lecture and demonstration methods respectively. From the reviewed studies there is also a clear indication that there is limited or no significant studies on the effects of guided and unguided inquiry teaching methods on students’ achievement and interest in Biology. In view of this, the researcher considered it necessary to investigate the effects of guided and unguided inquiry method of teaching on students’ achievement and interest in Biology.

Interest is one of the variables in this study because of its’ co-relational effect on students’ achievement hence this study also investigated related studies on students’ interest and achievement in Biology.

**Studies on Achievement and Interest in Science (Biology)**

Previous study by Obiekwe (2008) investigated the effect of constructivist instructional approaches on students’ achievement and interest in Basic Ecological concepts in Biology as earlier reviewed. Results from the study on Interest
inventory on Basic Ecological Concepts indicated that constructivist instructional approach was more effective in facilitating student’s interest in Ecological concepts more than the conventional (lecture) method.

In a related study, Yong (2009) carried out a study on students’ Motivational Orientations and their Association with Achievement in Biology in Brunei Darussalam. Population for the study included 296 grade 11 students from a government secondary schools (142 males and 154 females) randomly selected from science stream classes. Data for the study was collected using Students Motivational orientations in Learning Biology Questionnaire (SMOLQ) adapted from Sideridis (2002) which consisted of seven constructs namely: behavioural intention, behavioural beliefs, outcome evaluation, normative belief, motivation to comply and goal importance. Data collected from the study were analyzed using pearson’s product-moment correlation. The results obtained showed that behavioural intentions outcome evaluation and goal importance were significantly correlated with achievement. This indicate that high achievement score is associated with students’ interest.

In a similar study on the effect of student interest on achievement in biology; Okoro (2011) investigated the effects of interaction pattern on Students’ Achievement and Interest in Biology among secondary school students as earlier reviewed. Result from the study indicated that the three (3) interaction patterns: co-operative, competitive and individualistic patterns enhanced students’ achievement and interest in biology.
Subsequently Nasr (2011) carried out a study on Attitude towards Biology and its effects on Students’ Achievement among one hundred of eighty five 185 grade 12 students in Isfahan Azadi, Iran. Data for the study was collected through a questionnaire containing 30 Item based on Simpson-Troost Attitude Questionnaire-Revised (STAQ-R) developed by Owen et al (2008). Data collected from the study were analyzed with statistical software SPSS version 16.00 to determine the correlation coefficient between motivating Biology class and students’ biology achievement. Result obtained showed that there is no statically significant difference between attitude towards biology and students achievement but indicated that students’ attitude towards biology can be improved when biology courses and educational materials in biology make a fun and interesting atmosphere for students.

The reviewed literature on students’ interest and achievement indicated that any teaching methods that promote students’ interest in Biology will significantly enhance achievement in Biology. This is because the innovative teaching methods actively engage students in the teaching and learning process thereby increasing the attention and understanding of students. This study will therefore provide an answer to the question: what are the effects of different approaches of inquiry guided and unguided on students’ interest in biology?
Studies on influence of Gender on Students’ Achievement and Interest in science (Biology)

Gender differentiation is an old and long controversial issue in education. Different opinions and views abound on the issue of gender and its effect on student achievements especially in sciences. There are two strong arguments as regards to the effect of gender and achievement in science. The proposing argument and researchers; Obiekwe (2008) Yong (2009), Okoro (2011), Opara (2011) and Nasr and Asghar (2011) contend that there is a significant difference in the achievement and interest between male and female students in Biology, whereas the opposing argument and researchers Ibe (2004), Nwagbo and Chukelu (2011), Bello and Abimbola (2012) and Oludipe (2012) are of the view that there are no significant difference in the achievement and interest of male and female students in biology that both male and female students achieve equally in biology when exposed to the same treatment and given equal opportunity.

With regards to gender differentiation Obiekwe (2008) as earlier reviewed investigated the effects of constructivism instructional approach on students’ achievement and interest in Basic Ecological concepts in Biology. The study investigated the effects of gender as one of the variables. Findings from the study indicated that there was a significant difference between male and female students’ achievement and interest in favour of male students. Obiekwe reported that the male students achieved higher than female students and had higher interest in the use of constructivist approach in teaching basic ecological concepts in Biology.
Similarly, Yong (2009) previously reviewed also investigated students motivational orientation and their associations with achievement in Biology. Gender differences in motivational orientation, was one of the variables. Results obtained from the study indicated a significant difference in gender in favour of the females. Yong stated that although boys show positive attitude to sciences and achieve higher than girls in physics and other sciences like mathematics that girls show positive interest in Biology more than other science subjects.

In a similar view; Okoro (2011) also earlier reviewed, studied the effects of three interactive learning patterns on achievement and interest in Biology among secondary school students. The study equally investigated the effects of gender on achievement and interest in Biology. Findings from the study indicated that gender difference existed in achievement and interest of students in favour of the male students. The study indicated that male students achieved higher and had higher interest in Biology more than female students in when exposed to interactive learning strategy especially competitive and individualistic learning than cooperative learning.

In another study, Opara (2011) investigated the Effects of Inquiry Method and Lecture method of Teaching on Students’ Achievement in Biology, as previously reviewed. The study considered gender as one of the variables. Findings from the study on the issue of gender differentiation indicated that the mean scores of male students taught Biology using inquiry teaching method was significantly higher than those of their female counterparts. The study signifies that inquiry method influences male cognitive abilities more than females.
However the study did not investigate the effects of gender on students’ interest in Biology.

In a subsequent study Nasr and Asghar (2011) investigated the Attitude towards Biology and its effect on students’ achievement as previously reviewed; on the issue of the effects of gender, the findings indicated that there was no significant difference between females and males’ attitude toward biology although the females’ student had higher mean scores in achievement and attitude in biology when compared with their male counterparts. Nevertheless, in contrary to the research findings reviewed above on the issue of gender and students’ achievement, the following studies Ibe (2004); Nwagbo and Chukelu (2011); Bello and Abimbola (2012) and Oludipe (2012) reported that there is no differentiation in the influence of gender on achievement and interest among students in Biology.

Ibe (2004) as earlier reviewed, investigated the Effect of Guided Inquiry and Demonstration Methods on Science Process Skill Acquisition among secondary school biology students. Findings from the study indicated that there was no significant difference in the achievement of male and female students. The study indicates that inquiry method influences male and female students’ acquisition of process skill in biology equally the study did not include gender as one of its variables.

In a similar report Nwagbo and Chukelu (2011) investigated the Effects of Biology Practical Activities On Secondary School Students’ Process Skill Acquisition in Abuja Municipal Area Council, using a quasi-experimental design;
pre-test, post-test Non Equivalent control Group and a Sample of one hundred and eleven Senior Secondary One (SSI) biology students randomly drawn from two co-educational schools. Data was collected using researcher developed Science Process Skill Acquisition Test (SPAT). The data collected were analyzed using mean, standard deviation and Analysis of Covariance (ANCOVA). Results obtained from the study revealed that practical activity method was more effective in fostering students’ acquisition of science process skill than the lecture method, and on the issue of gender, the result indicated that there was no significant difference between the male and female students mean scores on science process skill acquisition test (SPAT). The study also investigated the interactive effects between methods and gender on students’ process skill acquisition and reported that there was no interactive effect between teaching methods and gender on students’ process skill acquisition in Biology but did not investigate the influence of gender on students’ interest in Biology.

In a related study on innovative teaching methods, Bello and Abimbola (2012) investigated Gender Influence on Biology Students’ Concept Mapping Ability and Achievement in Evolution. Design for the study was a case study. Sample for the study included eighty-seven (87) second year senior secondary (SSII) biology students. Data for the study was collected using a slightly modified form of Evolution Theory Test developed by Bello (1997). The data collected were analyzed using mean, standard deviations. Findings from the study indicated that there was no statistically significant difference of male and female high scoring, average scoring and low-scoring students’ respectively. The result
indicates generally that at all cognitive level, male and female students’ achieve equally in Biology. The study however did not investigate the influence of gender on concept mapping ability in Biology.

Similarly Oludipe (2012) investigated the influence of gender on Junior Secondary Students’ Academic Achievement in Basic Science Using Co-operative Teaching Strategy. The study employed a quasi- pre-test, post-test experimental design. Sample for the study consisted of One hundred and twenty (120) students drawn from intact classes of 3 selected Junior Secondary Schools in Ogun state. Data for the study was collected using lesson notes based on Jigsaw II cooperative learning strategy and Achievement Test for Basic Science Students (ATBSS). The data collected was analyzed using descriptive and independent samples T-test Statistical methods. Findings from the study revealed that there was no significant difference in the academic achievement of male and female students in the pre-test, post-test and delayed post-test levels respectively. However, this study did not investigate the influence of gender on interest in the use of cooperative learning teaching strategy in Biology.

From the studies reviewed on the issues of gender and students’ achievement and interest in Biology there are limited studies on the effects of gender on students’ interest and no consensus reached on the effects of gender differentiation on the achievement and interest of male and female student in Biology. In view of this, the present study intends to investigate and determine the effects on gender differentiation on male and female students’ achievement and interest using inquiry teaching methods (guided and unguided ) and also the
interactive effect of gender and the inquiry teaching methods (guided and unguided) on students’ achievement and interest in Biology.

**Summary of Literature Review**

Biological knowledge is an essential element for national and human development. Over the years use of ineffective teaching methods in teaching biology has contributed to the reduction in the number of students that could have opted for biological sciences and also in harnessing of the potentials in students of biology. In view of these shortcomings, researchers in Biology Education have continued to search for an effective teaching method that could facilitate teaching and learning of Biology to enhance students’ achievement and interest in Biology. The persistent search for an effective method of teaching Biology culminated to the identification of inquiry teaching method among other innovative teaching methods (student-centered approach). Inquiry is a teaching method that encourages students to construct meaningful knowledge through questioning and investigations into natural phenomenon using scientific skills.

Inquiry teaching methods are grounded in constructivism and grouped into different types; guided, unguided and coupled inquiry. The present study intends to determine the effects of two types of inquiry guided and unguided on students’ achievement and interest in biology, guided and unguided inquiry teaching methods emphasize different degrees of student-centeredness in the teaching and learning process and may have different effects on students’ achievement and interest in Biology. This study intends to determine the effects of independent
variable (Guided and Unguided Inquiry Teaching Method) on dependent variables (Achievement and Interest) as well as the effects of gender as a covariant on students’ achievement and interest in Biology.

Inquiry teaching method is based on the philosophical and epistemological ideas of some cognitive and constructivists’ theories of Dewey, Vygotsky, Brunner and Piaget among others. Although these theorists generally believed that learners should be the focus of every teaching and learning activities geared towards knowledge construction. Nevertheless, their ideas as to the degrees of involvement and participation of the learners in the teaching and learning process vary. While some of these theorists Dewey and Vygotsky advocate for guidance and assistance during instructional process, others Bruner and Piaget advocate that learner should not be guided or minimally guided during instructional process. The findings from this study are intended to support either of these arguments.

Reports from previous studies on the effects of inquiry method and some innovative teaching methods on students achievement in Biology indicated that inquiry teaching method and other innovative teaching methods like concept mapping, constructivism and cooperative learning methods enhanced students’ achievement and interest in Biology more than the traditional/conventional (teacher-centered) teaching methods lecture and demonstration etc. commonly used in most of our schools. However, no study was identified to have investigated into the effects of two inquiry methods (guided and unguided) on students’ achievement and interest in secondary school Biology – hence there is the need for this study. Secondly, on the issue of influence of gender on students’ achievement
and interest in Biology, studies reviewed indicated that there is no consensus reached as regards to the effect of gender and students’ achievement and interest in Biology. While some studies indicated that gender differentiation existed between male and female students’ achievement and interest in Biology, other studies indicated that there exist no gender differentiation between students’ achievement and interest in Biology. However, none of these studies investigated the effects of guided and unguided inquiry method of seeking on students’ achievement and interest in relation to gender; as well as the interactive effects of gender and teaching methods on achievement and interest in Biology.

In view of the limited studies on the effects of guided and unguided inquiry teaching methods on students achievement and interest in Biology and the inconclusive issue of the influence of gender on students’ achievement and interest in Biology, this study deemed it necessary to investigate the effects of Guided and Unguided Inquiry teaching methods on students achievement and interest in biology and also the influence of gender on students’ achievement and interest in Biology using guided and unguided methods of teaching respectively.
CHAPTER THREE

RESEARCH METHOD

This chapter describes the method that was used to carry out the study.

The chapter is broken down into the following sub-headings:

- Design of the study,
- Area of the study,
- Population of the study,
- Sampling and sampling techniques,
- Treatment procedure
- Instrument for data collection,
- Validation of Instrument,
- Reliability of instruments,
- Training of Biology teachers (Research assistants),
- Control of extraneous variables,
- Methods of Data collection,
- Method for Data Analysis,

Design of the study

The design for the study is quasi-experimental. Specifically the study applied pre-test, post-test Non-equivalent control group design. Quasi-experimental design is considered appropriate for the study because intact classes were used to avoid disruption of normal class lessons. The pre-test was used to
partial out initial difference in the two groups and also to control selection bias which is a threat to internal validity.

The study design is illustrated in the figure below

**Fig. I**

Group I $\rightarrow O_1 \quad X_1 \quad O_2$

Group II $\rightarrow O_1 \quad X_2 \quad O_2$

Where $O_1$ = Pre – test

$X_1$ = treatment for Exp. Group I

$X_2$ = treatment for Exp. group II

$O_2$ = post test

**Area of study**

The study was carried out in Nsukka Education Zone of Enugu State. The zone consists of three local Government Areas: Namely Igbo-Etiti, Nsukka and Uzo-Uwani. The study was delimited to Nsukka Local Area. The choice for this area is based on the fact that students’ achievement in Biology in the area is poor. Secondly, the researcher is familiar with the locations of all the schools within the area, which gave the researcher the opportunity to monitor and supervise the experiment properly.
Population of the study

Population for the study included all senior secondary one (SSI) Biology students in Enugu state. However, a sample population of eighty (80) Senior Secondary one (SSI) Biology students from two co-education secondary schools purposely selected in Nsukka education zone from two intact classes of forty (40) students each was used for the study.

Sample and sampling technique

Out of twenty-three co-education secondary schools in Nsukka Local Government Area, two schools were purposely selected. The choice of co-education schools was because gender was one of the variables under studied. One intact class of 40 Biology students of SSI was randomly selected from each of the schools sampled making a total of two intact classes of 80 SSI Biology students from the two co-education schools.

Treatment procedure

Out of the two intact classes of 80 students from two co-educational secondary schools in Nsukka L.G.A, one of the intact class consisting of 40 students from one of the sampled schools was assigned to group I and was treated using guided inquiry teaching method while the other intact class from a different sampled school was assigned to group II and was treated using unguided inquiry teaching method respectively.
Instrument for data collection

Two instruments; Biology Achievement Test (BAT) and Biology Interest Inventory Scale (BIIS) were developed by the researcher and were used to collect data for the study.

The Biology Achievement Test

BAT consisted of 30 multiple choice objective questions developed by the researcher. The multiple choice question items were developed using West African Senior School Certificate Examination (WASSCE) question papers and Biology text books based on the content that was taught in the lesson. Questions number 4, 6, 12, 27 and 30 were extracted from past (WASSCE) questions while other questions were developed by the researcher from Biology text books. The questions were dichotomously and positively scored.

Biology Interest Inventory Scale

The BIIS consisted of 30 positive interest statements measured on a four-point Likert type interest rating scale developed by the researcher. The four point Likert type rating scale was used to enable students indicate their level of interest as follows:

SA = Strongly Agreed (4)
A = Agreed (3)
D = Disagreed (2)
SD = strongly disagreed (1)
The interest inventory scores were polychotomously and positively scored. Both the BAT and BIIS were used for pre-test and post-test treatments respectively. The BAT question numbers were reshuffled before it was administered for the post-test treatment.

Validation of the Instrument

The research instrument (Biology Achievement Test and Biology Interest Inventory Scale) along with the purpose of the study, research questions, research hypothesis, lesson notes, test blue print and marking guide were face validated by three experts in the faculty of Education Nsukka, one in measurement and evaluation and the other two from Science Education Department respectively. After the face validation 30 out of 40 multiple choice objective questions of BAT and 30 out of 33 BIIS statements survived the face validation.

These experts validated the items in terms of

1. clarity of instrument,
2. clarity of language,
3. appropriateness and adequacy of the items in measuring what they supposed to measure.

The advice of the experts helped to, modify and select the set of test items used for data collection.
Content Validity

Content validity was done using Table of Specification/Test Blue Print. The questions were based on low order cognitive domain (knowledge, comprehension and application) and high order cognitive domain (analysis, synthesis and evaluation). Majority of the questions were low order questions because of the academic level of the students Senior Secondary One (SSI). See table 1page 108.

Trial Testing/ Pilot Study

The instruments were subjected to trial testing. The trial testing was carried out at Model Secondary School Nsukka which is within the study area. The school was excluded during sampling of population. The trial testing enabled the researcher to determine the clarity of the test items, its readability, appropriateness and adequacy and as well helped to determine the actual time. The time duration for the test was estimated using the average time taken by the first and last subject to complete the test. The data obtained from the responses of students in the trial testing were used to estimate the reliability of the instrument.

Reliability of the instrument

Scores of the Biology Achievement test that were obtained from trial testing was used to estimate the reliability co-efficient of the instruments using Kuder Richardson formula (k-R-20) and yielded a reliability index of 0.780. Kuder Richardson (K-R-20) was used because the test items consisted of multiple choice objective questions that were dichotomously scored. The reliability of the BIIS
items was estimated using Cronbach alpha formula which gave a reliability index of 0.812. Cronbach alpha was used because the BIIS involved a likert-scale that was polychotomously scored.

**Training of Biology teachers (Research Assistants)**

One week Training programme was organized for the Biology teachers in the sampled schools to assist in the study. These biology teachers were educated on the necessary techniques required for teaching students through guided and unguided inquiry methods respectively. For the Experiment group I, the Biology teacher was trained on how to teach using guided inquiry method while the Biology teacher in Experiment group II was trained on how to teach using unguided inquiry teaching respectively.

The Biology teachers in each group were allowed to teach for 30 minutes each to test their competence on the different inquiry techniques, before carrying out the treatment on the subjects.

**Control of Extraneous Variables**

The control of extraneous variables in this study was done through the following procedures:

**Teacher variables:** to control the error that might arise as a result of teacher difference on the students’ achievement and interest in Biology. The regular biology teachers in the sampled schools were trained and used for the study.
**Instructional situation variable:** The researcher issued out instructional guides to the regular biology teachers (research assistants) in sampled schools for both experimental group I and II in order to ensure that the instructional situation was the same for the two schools selected for the study. Teaching and testing were conducted in all the biology classes of SS1 in the various schools selected for the study and not just in the intact classes drawn. This was done to avoid Hawthorne effect (a situation in which research subjects’ behaviour is affected not by the treatment per se but by their knowledge of participation in the study) and Novelty effect (increased interest, motivation or participation on the part of the subject simply because they did something different).

**Inter group variables:** to eliminate the error of non-randomization of the subjects, data from the study will be analyzed using the Analysis of Covariance (ANCOVA).

**Subject Interaction:** the researcher will make sure that the experimental groups will be drawn from different schools because of any possible interaction that may arise (inter-class discussion) between the two experimental groups.

**Method of Data collection**

Data for the study will be collected through pre and post tests using the BAT and BIIS. The pre-test will be administered to the subjects before the treatment to measure the students’ group equivalence and to provide the researcher with baseline data about the subjects while post-test will be administered to the
students one week after the treatment. Data collected from the two tests (pre and post) after treatment will be used for data analysis.

**Method of Data analysis**

The scores obtained from the pre and post-test will be analyzed using mean and standard deviation and ANCOVA. Mean and standard deviation will be used to answer the research questions while Analysis of Covariance (ANCOVA) will be used to test the hypotheses at 0.5 % level of significance. ANCOVA will be used to test the hypotheses because the design for the study is quasi-experiment pre-test post-test, two experimental Non-equivalent intact groups and two dependent variables (achievement and interest).
CHAPTER FOUR

PRESENTATION OF RESULT

This chapter deals with analyses of data and presentation of results based on the research questions and hypotheses that guided the study. The research questions were answered using mean and standard deviations while Analysis of Covariance (ANCOVA) was used to test the hypotheses. All the hypotheses were tested at the P<0.05 level of significance.

Research Question I

What are the relative effects of guided and unguided inquiry methods of teaching on students’ achievement in Biology?

Table 2: Mean achievement scores of experimental groups I and II

<table>
<thead>
<tr>
<th>Groups</th>
<th>Method</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Gain score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>( \bar{x} )</td>
<td>SD</td>
<td>( \bar{x} )</td>
</tr>
<tr>
<td>I</td>
<td>Guided</td>
<td>7.7750</td>
<td>2.24736</td>
<td>17.2000</td>
</tr>
<tr>
<td>II</td>
<td>Unguided</td>
<td>7.1500</td>
<td>2.33754</td>
<td>12.4000</td>
</tr>
<tr>
<td>Mean difference</td>
<td></td>
<td>0.625</td>
<td></td>
<td>4.80</td>
</tr>
</tbody>
</table>

Result in table 2 indicated that the pre-test mean achievement scores for experimental groups I and II were 7.7750 and 7.1500 with standard deviation of 2.247 and 2.33754 respectively and mean difference of 0.625 at pre-test. This indicated that both Experimental groups I and II were relatively at the same cognitive level before treatment. However, the post-test achievement mean scores for Experimental groups I and II were 17.200 and 12.400 respectively with standard deviation of 2.61357 for Experimental groups I and 3.14439 for experimental group II and mean difference of 4.80. The achievement gain score
for Experimental group I was (9.425) over that of experimental group II (5.250). The higher achievement gain score of experimental group I (9.425) over experimental group I (5.250) indicated that guided inquiry method has relative effect on students’ achievement in Biology more than unguided inquiry method.

**Research question 2**

What are the relative effects of guided and unguided inquiry methods of teaching on students’ interest in Biology?

**Table 3: Mean interest scores of experimental groups I and II**

<table>
<thead>
<tr>
<th>Groups</th>
<th>Method</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Gain score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>¯x</td>
<td>SD</td>
<td>¯x</td>
</tr>
<tr>
<td>I</td>
<td>Guided</td>
<td>40</td>
<td>2.6237</td>
<td>3.6886</td>
</tr>
<tr>
<td>II</td>
<td>Unguided</td>
<td>40</td>
<td>2.7527</td>
<td>3.6271</td>
</tr>
<tr>
<td>Mean Difference</td>
<td>-0.129</td>
<td>0.0615</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3 indicates that the pre-test interest mean scores for experimental groups I and II were 2.6237 and 2.7527 with standard deviation .8977 and .9202 respectively and mean difference of -0.1290 indicating that both of the experimental groups have relatively equal interest in Biology before treatment. However, in the post-test interest mean scores, Experimental groups I and II mean interest scores were 3.6886 and 3.6271 respectively with standard deviation of .35531 and .37674 and mean difference of 0.0615. The interest gain score for groups I was 0.0649 while that for group II was 0.8744, indicating that both
guided and unguided inquiry methods have equal effects on students’ interest in Biology.

**Research Question 3**
What is the influence of gender on the mean achievement scores of students taught Biology using guided and unguided inquiry methods respectively?

**Table 4: Mean achievement scores of male and female student in experimental groups I and II.**

<table>
<thead>
<tr>
<th>Group</th>
<th>Method</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Gain score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sex  No</td>
<td>$\bar{x}$</td>
<td>SD</td>
</tr>
<tr>
<td>I</td>
<td>Guided</td>
<td>M 18</td>
<td>8.3889</td>
<td>2.22655</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F 22</td>
<td>7.2727</td>
<td>2.18614</td>
</tr>
<tr>
<td>II</td>
<td>Unguided</td>
<td>M 20</td>
<td>7.7000</td>
<td>1.78001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F 20</td>
<td>6.6000</td>
<td>2.72223</td>
</tr>
</tbody>
</table>

Table 4 shows that the pre-test achievement mean scores for Experimental group I male and female were 8.3889 and 7.2727 with standard deviation of 2.22635 and 2.18614 respectively; indicating that both male and female students in the Experimental group I were at the same cognitive level before treatment. On the other hand the post-test achievement mean scores for Experiment I group male was 16.6111 and females 17.6818 with standard deviation of 2.37979 and 2.74966 respectively with gain score of 8.2222 for male and 10.4091 for female students.
respectively indicating that guided inquiry enhances female students’ achievement in Biology more than the male students.

On the other hand in the experimental group II the male and female students’ pre-test mean scores were 7.7000 and 6.6000 respectively with standard of 1.78001 for males and 2.72223 for females, indicating that male students performed better than the female students before treatment. However, the post-test scores for the experimental group II male and females were 11.9000 and 12.9000 with standard deviation of 2.22190 and 3.851118 respectively and achievement gain score of 4.2000 for male and 6.3000 for females indicating also that unguided inquiry methods has relative effect on female students’ achievement more than male students in Biology.
Research Question 4

What is the influence of gender on the mean interest scores of students taught Biology using guided and unguided inquiry methods respectively?

Table 5: Mean interest score of male and female students in experimental groups I and II

<table>
<thead>
<tr>
<th>Group</th>
<th>Method</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Gain score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sex</td>
<td>No</td>
<td>x</td>
<td>SD</td>
</tr>
<tr>
<td>I</td>
<td>Guided M</td>
<td>18</td>
<td>2.8581</td>
<td>.8324</td>
</tr>
<tr>
<td>F</td>
<td>22</td>
<td>2.6473</td>
<td>1.1142</td>
<td>3.7614</td>
</tr>
<tr>
<td>II</td>
<td>Unguided M</td>
<td>20</td>
<td>2.6952</td>
<td>.9006</td>
</tr>
<tr>
<td>F</td>
<td>20</td>
<td>2.5599</td>
<td>.9063</td>
<td>3.6686</td>
</tr>
</tbody>
</table>

Table 5 shows that the pre-test mean scores and standard deviation of male and female students in Experimental I group were 2.8581, 2.6473 and .8324;1.1142 respectively and post-test mean interest scores of 3.5857 and 3.7641 with standard deviation of .3788 and .3987 respectively. The interest gain score for experimental group 1 male and female are 0.7276 and 1.1141 respectively, indicating that guided inquiry promote female students’ interest more than the male students in Biology.

Similarly the pre-test mean interest scores and standard deviation for Experimental group II male were 2.6952 and .9006 respectively and post-test mean interest scores of 3.6157 with standard deviation of .2938 and interest gain
score of 0.9205. However for the experimental group II female the pre-test mean interest scores were 2.5599 with standard deviation of .9063 and post-test mean interest scores of 3.6686 with standard deviation of .3756 and interest gain score of 1.1087. The interest gain scores of female students in experimental groups I and II indicated that both guided and unguided inquiry methods promote female students’ interest in Biology more than that of male students.

**Hypothesis 1:** There is no significant difference in the mean achievement scores of students taught Biology with guided and unguided inquiry methods respectively.

**Table 6:** Analysis of Covariance (ANCOVA) for the effects of guided and unguided inquiry methods on students’ mean achievement scores in Biology.

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III sum of Squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected model</td>
<td>4.72726&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2</td>
<td>236.138</td>
<td>28.387</td>
<td>.000</td>
</tr>
<tr>
<td>Intercept</td>
<td>1736.664</td>
<td>1</td>
<td>1736.664</td>
<td>208.771</td>
<td>.000</td>
</tr>
<tr>
<td>Pre-test</td>
<td>11.476</td>
<td>1</td>
<td>11.676</td>
<td>1.380</td>
<td>.244</td>
</tr>
<tr>
<td>Method</td>
<td>472.099</td>
<td>1</td>
<td>472.099</td>
<td>56.753</td>
<td>.000</td>
</tr>
<tr>
<td>Error</td>
<td>640.524</td>
<td>77</td>
<td>8.318</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>18636.000</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>1112.800</td>
<td>79</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> R Squared = .424 (Adjusted R Squared = .409)

Result of data analysis in table 6 shows that the probability value associated with the calculated value of F (56.753) for the effect of method on the achievement of students is 0.000. Since this value (0.000) is less than the 0.05
level of significance, the null hypothesis is rejected. Hence there is a significant
difference in the mean achievement scores of students taught Biology using
guided inquiry method and those taught using unguided inquiry method
respectively in favour of the group taught using guided inquiry method. This result
indicates that guided inquiry method is superior to unguided inquiry method in
enhancing students’ achievement in Biology.

Hypothesis 2: There is no significant difference in the mean interest scores of
students taught Biology with guided and unguided inquiry methods
respectively.

Table 7: Analysis of Covariance (ANCOVA) for the effects of guided and
unguided inquiry methods on students mean interest scores.

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>.358&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2</td>
<td>.179</td>
<td>1.342</td>
<td>.265</td>
</tr>
<tr>
<td>Intercept</td>
<td>189.607</td>
<td>1</td>
<td>189.607</td>
<td>1.421E3</td>
<td>.000</td>
</tr>
<tr>
<td>Pre-test</td>
<td>.226</td>
<td>1</td>
<td>.226</td>
<td>1.694</td>
<td>.195</td>
</tr>
<tr>
<td>Group</td>
<td>.156</td>
<td>1</td>
<td>.156</td>
<td>1.171</td>
<td>.281</td>
</tr>
<tr>
<td>Error</td>
<td>18.278</td>
<td>137</td>
<td>.133</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1891.285</td>
<td>140</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>18.636</td>
<td>139</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The analysis in table 7 reveals that the probability value associated with the
calculated value of F (1.171) for the effect of method on the students’ interest is
.281. Since this value is more than the 0.05 level of significance, the null
hypothesis is accepted meaning that guided and unguided inquiry methods have no
significant different effects on students’ interest in Biology. The result indicates
that both guided and unguided inquiry methods promote students interest in Biology.

Hypotheses 3 and 5: There is no significant difference in the mean achievement scores of male and female students taught Biology with guided and unguided inquiry methods respectively; there is no significant difference in the interaction of gender and inquiry methods on students' achievement and interest in Biology.

Table 8: Analysis of Covariance (ANCOVA) for the influence of gender on student mean achievement scores and interaction effects of gender and inquiry teaching methods (guided and unguided) on students achievement and interest in Biology.

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>487.581</td>
<td>4</td>
<td>121.895</td>
<td>14.622</td>
<td>.000</td>
</tr>
<tr>
<td>Intercept</td>
<td>1552.061</td>
<td>1</td>
<td>1552.061</td>
<td>186.182</td>
<td>.000</td>
</tr>
<tr>
<td>Pre-test</td>
<td>5.432</td>
<td>1</td>
<td>5.432</td>
<td>.652</td>
<td>.422</td>
</tr>
<tr>
<td>Method</td>
<td>452.876</td>
<td>1</td>
<td>452.876</td>
<td>54.326</td>
<td>.000</td>
</tr>
<tr>
<td>Gender</td>
<td>15.288</td>
<td>1</td>
<td>15.288</td>
<td>1.834</td>
<td>.180</td>
</tr>
<tr>
<td>Method * Gender</td>
<td>.024</td>
<td>1</td>
<td>.024</td>
<td>.003</td>
<td>.958</td>
</tr>
<tr>
<td>Error</td>
<td>625.219</td>
<td>75</td>
<td>8.336</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>18636.000</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>1112.800</td>
<td>79</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. R Squared = .438 (Adjusted R Squared = .408)

The analysis in table 8 was done to test hypothesis 3 and 5. For hypothesis 3, the analysis shows that the probability value associated with the calculated value of F (1.834) for the effect of gender on students’ achievement is 0.180. Since this value is greater than 0.05 level of significance, the null hypothesis is accepted. Thus, gender has no significant effect on the students’ achievement in biology. For the hypothesis 5, the probability value associated with the calculated value of F (0.003) for the interaction effects of method and gender is 0.958. Since
the probability value is greater than 0.05 level of significance, the null hypothesis is accepted. Thus, there is no significant interaction effect between inquiry teaching methods (guided and unguided) and gender on students’ achievement and interest in biology.

**Hypothesis 4:** There is no significant difference in the mean interest scores of male and female students taught Biology with guided and unguided methods respectively.

**Table 9:** Analysis of covariance (ANCOVA) for the influence of gender on students’ mean interest scores in Biology.

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>.857^a</td>
<td>4</td>
<td>.214</td>
<td>1.627</td>
<td>.171</td>
</tr>
<tr>
<td>Intercept</td>
<td>187.782</td>
<td>1</td>
<td>187.782</td>
<td>1.426E3</td>
<td>.000</td>
</tr>
<tr>
<td>Pre-test</td>
<td>.233</td>
<td>1</td>
<td>.233</td>
<td>1.771</td>
<td>.186</td>
</tr>
<tr>
<td>Group</td>
<td>.157</td>
<td>1</td>
<td>.157</td>
<td>1.190</td>
<td>.277</td>
</tr>
<tr>
<td>Gender</td>
<td>.053</td>
<td>1</td>
<td>.053</td>
<td>.404</td>
<td>.526</td>
</tr>
<tr>
<td>group* gender</td>
<td>.445</td>
<td>1</td>
<td>.445</td>
<td>3.380</td>
<td>.068</td>
</tr>
<tr>
<td>Error</td>
<td>17.779</td>
<td>135</td>
<td>.132</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1891.825</td>
<td>140</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>18.636</td>
<td>139</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. R Squared = .046 (adjusted R Squared = .018)

Table 9 shows that gender has no significant effect on the student’s interest in Biology. This is so because the probability value (.526) associated with the
calculated value of $F (.404)$ for the influence of gender on students’ interest in Biology is more than the 0.05 level of significance.

**Summary of the results of research questions:**

1. There is relative difference in the effects of guided and unguided inquiry methods on students’ achievement in Biology in favour of guided inquiry.
2. There is no relative difference in the effects of guided and unguided inquiry methods on students’ interest in Biology.
3. There is relative difference on the effects of guided and unguided inquiry methods on students’ achievement in favour of female students.
4. There is relative difference in the effects of guided and unguided inquiry methods on students’ interest in favour of female students.

**Summary of results for research hypotheses**

1. There is significant difference on the effects of guided and unguided inquiry methods on students’ achievement in Biology in favour of guided inquiry teaching method.
2. There is no significant difference between the effects of guided and unguided inquiry method on students’ interest in Biology.
3. There is no significant influence of gender on student’s achievement in Biology using guided and unguided inquiry methods respectively.
4. There is no significant influence of gender on student’s interest in Biology using guided and unguided inquiry methods respectively.
5. There is no significant interactive effect between gender and teaching methods on students’ achievement and interest in Biology.
CHAPTER FIVE

DISCUSSION, CONCLUSION, RECOMMENDATION AND SUMMARY

This chapter consists of the following sub headings.

- Discussion of findings of the study,
- Conclusion of the findings
- Educational implication of the findings,
- Limitations of the study findings,
- Summary.

Discussion of the findings of the study

The data analyzed in chapter four were interpreted and discussed based on thematic issues from the four research questions and null hypotheses.

Effects of guided and unguided inquiry methods on students’ achievement in Biology

Findings from the study as shown in Tables 2 and 7 indicated that the guided inquiry method had relative effect on students’ achievement (9.425) more than the unguided inquiry method (4.800). Similarly the probability value associated with the calculated value of F (56.753) in table 6 is 0.000 which is less than the 0.05 level of significance, null hypothesis is rejected. This indicates that there is significant difference on the effects of guided and unguided inquiry method on students’ achievement in favour of the guided inquiry method. The superiority of guided inquiry over unguided inquiry is due to the guidance and assistance provided by the teacher or instructor which enabled the students to gain
some competence in knowledge construction during the treatment. This finding agrees with the views of Kulthau et al., (2007) who stated that students get competence and foster motivation by being guided through an inquiry process by a teacher. The finding also in agreement with the findings of Mayer (2004) and Kirshner (2006) who found that guided inquiry is superior to unguided inquiry in enhancing students’ achievement. The finding disagrees with the finding of Guisti (2008) who found that unguided inquiry enhances students’ achievement in Physics more than guided inquiry. The finding is also supported with the constructivist’s theory of Vygotsky who stated that instructional assistance and guidance enables a child to develop beyond the zone of proximal development. This indicated that the high in the achievement gain scores of the Experimental group taught with guided inquiry was due to the assistance and guidance given to them by the teacher or instructor.

Effects of guided and unguided inquiry on students’ interest in Biology:

Data in Table 3 revealed that the interest gain scores of students taught with guided inquiry method was 1.0649 while the interest gain scores for the unguided inquiry was 0.8744. This indicated that guided inquiry method had relative effect in promoting students’ interest more than unguided inquiry method. However the ANCOVA analysis indicated that the calculated value of F (1.171) in table 7 for the effects of methods on students’ interest is .281 which is greater than the 0.05 level of significance. This indicates that the null hypothesis was accepted. Hence, there is no significant difference between guided and unguided inquiry methods on
students’ interest in Biology. The insignificant difference in guided and unguided inquiry is because both methods are activity oriented, encourage high level of motivation and active engagement of students in the teaching and learning process and thus both methods promoted students interest. This finding agrees with (Educational Broadcasting Corporation, 2004; Obiekwe, 2006) and Okoro, 2011) who stated that activity oriented teaching methods helps students to build up interest and share ideas which enable problems solving in the classroom.

**The influence of gender on mean achievement scores of students taught with guided and unguided inquiry methods.**

Data in Table 4 indicated that the achievement gain scores for male and female students in experimental group I exposed to guided inquiry were 8.222 and 10.4091 respectively while those of male and female students in experimental group II exposed to unguided inquiry method were 4.200 and 6.300 respectively. The differences in achievement gain scores of male and female students in experimental groups I and II indicated that the achievement gain scores of the female students in experiment groups I and II (10.4091 and 6.300) were enhanced more than those of the male students in experimental groups I and II (8.222 and 4.200) respectively. However, the ANCOVA analysis in table 8 indicated that the calculated value of F (1.834) for the effect influence of gender on achievement using guided and unguided inquiry methods is 0.180. This indicated that although gender has relative influence on achievement of female students using guided and unguided inquiry methods, the influence is not significant. This is because inquiry
methods are activity oriented and encourages active participation of students in the teaching and learning process. The active participation of students in teaching and learning process generally enhance knowledge construction and achievement in students irrespective of gender. This finding agrees with Kulthau et al., (2007) who stated that inquiry methods engage all students in active knowledge construction and not just those who have already shown that they are academic inclined; and also with those of Ibe (2004), Okeke (2007), Nzewi (2010) and Oludipe (2012) who stated that there is no significant difference in male and female students’ academic achievement in Biology. However, the finding disagrees with the finding of Opara (2011) who stated that inquiry teaching methods favour male students’ achievement more than those of female students in Biology.

**The influence of gender on mean interest score of students taught with guided and unguided inquiry methods respectively.**

Data in Tables 5 and 9 indicated that gender is not a significant factor on students’ interest in Biology. Comparing the interest gain scores of male students in experimental groups I and II (0.7276 and 0.9205), and those of female students in experimental groups I and II (1.1141 and 1.1087). The mean interest scores of male and female students in experimental groups I and II indicated that guided and unguided inquiry methods promote female students’ interest in Biology more than those of male students. However, the ANCOVA analysis in table 9 indicated that the probability value (.526) associated with calculated value
of F (.404) at 0.05 level of significance indicated that gender has no significant influence on students’ interest in Biology. This is because inquiry methods (guided and unguided) are activity oriented teaching methods encourage active participation of students in classroom activities and as well foster higher interest on students irrespective of male or female in the teaching and learning process. This finding agrees with Kuhthau et al., (2007) who stated that inquiry teaching methods generally promote the interest of learners irrespective of gender or academic inclinations. However it disagrees with those of Obiekwe (2006) and Okoro (2011) who found that there was a significant difference between the interest of male and female students in favour of the male students in Biology. The variation in Obiekwe and Okoro’s findings and the present study may be due variations in approaches of the teaching methods with inquiry having more activity- oriented processes more than constructivists learning model and co – operative learning respectively. However the higher interest indicated in the mean interest scores of the female students may be as a result that females prefer group activities as indicated in the findings of okoro (2011) which inquiry methods employ.

The interactive effects of gender and teaching methods on students’ achievement and interest in Biology

The ANCOVA analysis in tables 9 indicated that there is no significant interactive effect of inquiry method and gender on students, achievement and interest because the probability value associated with the calculated value of F
(0.003) is 0.958 which is greater than 0.05 level of significance indicating that the null hypothesis is accepted. The insignificant interactive effect between gender and teaching methods may be due to the fact that inquiry methods (guided and unguided) as activity oriented methods enhance and promote male and female students’ achievement and interest respectively. This finding agrees with those of Ibe (2004) and Nwagbo and Chukelu (2011) who found that there is no interaction between teaching methods and gender on the acquisition of science process skills in Biology.

**Conclusion**

Based on the findings and discussion of this study, the following conclusions were made:

1. Guided inquiry method enhances students’ achievement in Biology more than unguided inquiry method.
2. Both guided and unguided inquiry method promote students’ interest in Biology
3. Gender has no significant influence on students’ achievement in Biology using guided and unguided inquiry methods.
4. Gender has no significant influence on students’ interest using guided and unguided inquiry methods.
5. Gender and inquiry methods (guided and unguided) have no significant interactive effects on students’ achievement and interest in Biology.
Educational Implications

The findings of this study have some educational implications for students, biology teachers and curriculum planners.

Findings from this study indicate that the use of guided inquiry methods in teaching of secondary school Biology will enhance students’ achievement and interest in Biology. The use of both guided and unguided inquiry methods will help to bridge the gender gap in students’ achievement and interest in Biology since the two inquiry methods enhanced and promoted all students’ achievement and interest in Biology.

The findings of this study encourages biology teachers to adopt the use of inquiry methods both guided and unguided in their teaching since both methods enhance students’ achievement, promotes their interest and reduces gender gap in students achievement and interest in biology.

From the findings of this study, the use of inquiry methods in teaching and learning of biology will help to achieve the national curriculum objectives which is designed to promote students inquiry spirit and construction of a life-long knowledge needed for national development.

Recommendation

Based on the implication of the study, the following recommendations are made

(1) Guided inquiry method should be used more with unguided inquiry in teaching biology lessons in the classroom. The use of guided inquiry in
teaching and learning biology will enable the students to develop inquiry skills needed for concept and knowledge construction which will help them to appreciate biology better and improve on their achievements and interest. While the use of unguided inquiry method on the other hand will help teachers to accommodate the interest and individual differences that may exist between male and female students in the classroom.

(2) Biology teachers should be trained and retrained on the job to adopt the use of inquiry teaching methods in the teaching and learning of biology in the classroom. Training of these teachers could be done by the Government or relevant professional bodies like Science Teachers Association of Nigeria (STAN) through seminars, workshops and conferences.

(3) The curriculum planners should plan the nation’s Biological Science Curriculum to accommodate an inquiry based science programme for the students and should allot more time to biology in the school time table to enable the application of inquiry methods (guided and unguided).

(4) Examination bodies such as WAEC and NECO should take inquiry approaches into consideration while setting the examination questions.

Limitations of the study

The limitations of this study include:

(1) The nature of the research design which is quasi-experiment, only two schools out of twenty four co-education schools in Nsukka education zone
were used. The study may have more generalized effect if more schools in the education zone were used.

(2) The topic used for the study (animal nutrition) was only one topic out of numerous topics in SSI Biology scheme of work.

(3) The major variables were only achievement and interest out of other academic variables such as retention and location of schools for study.

(4) Non randomization of sample due to school administration and few periods allocated to biology in the school time table constituted some limitations.

(5) Lack of experience of some Biology teachers in the use of guided and unguided inquiry teaching methods.

**Suggestions for further Research:**

Based on the findings of the study, the following suggestions are made for further research.

1. Replication of the same study can be done in other education zones within or outside the state,

2. Further study could be carried out to determine the effects of guided and unguided inquiry on students’ achievement and retention of biological concepts.

3. Similar study could be carried out using another topic in biology.

4. Researchers should be encouraged to carry out similar study with students at other academic levels in the educational zone.
Summary of the Study

The purpose of the study was to determine the effects of guided and unguided inquiry teaching methods on students’ achievement and interest in Biology. Four research questions and five null hypotheses guided the study. The hypotheses were tested at 0.05 level of significance and they include:

HO₁. There was no significant difference in the mean achievement scores of students taught Biology using guided inquiry method and those taught using unguided inquiry method.

HO₂. There was no significant difference in the mean interest scores of students taught Biology using guided inquiry method and those taught using unguided inquiry method.

HO₃. There was no significant difference in the mean achievement scores of male and female students taught Biology using guided inquiry method and those taught using unguided inquiry method.

HO₄. There was no significant difference in the mean interest scores of male and female students taught Biology using guided inquiry method and those taught using unguided inquiry method.

HO₅. There was no significant difference in the interactive effects of guided and unguided methods of teaching and gender on achievement and interest of students in biology.

Related literature was reviewed under three major headings: namely conceptual framework, theoretical framework and empirical studies. Design for the study was quasi Experimental pre-test, post-test Non-equivalent control
groups. A total of 80 senior secondary school one (SS1) students from two intact classes randomly sampled from the two co-education secondary schools purposely selected within Nsukka education zone of Enugu state. One intact class of 40 students from each of the purposely selected schools was assigned to experimental group I and the other intact class of 40 students was assigned to as Experimental group II. The two Experimental groups were exposed to pre and post-tests respectively. Instruments for the study consisted of researcher developed Biology Achievement Test (BAT) and Biology Interest Inventory Scale (BIIS). Research assistants who were also the biology teachers in the two selected schools who were trained and supervise by the researcher were used to do the teaching and the administration of the research instruments to the students. A pilot study was carried out in another school outside the selected schools and was used to determine the reliability co-efficient of the two research instruments: Biology Achievement Test and Biology Interest Inventory Scale respectively. Two lesson notes on guided and unguided inquiry methods were used for the teaching that lasted for two weeks were also developed and used as a guide for the study. The four research questions were analyzed using mean, and standard deviations while the five null hypotheses were analyzed using ANCOVA statistics tested at 0.05 level of significance.

Results of the study indicated that:

(1) Students exposed to guided inquiry method had higher achievement more that those exposed to unguided inquiry method.
(2) Guided and unguided inquiry had no different effects on students’ interest in Biology.

(3) Gender has no significant effect on students’ achievement using guided and unguided inquiry methods respectively.

(4) Gender has no significant effects on students’ interest in Biology using guided and unguided inquiry methods.

(5) There is no significant interaction effect between gender and guided and unguided inquiry methods on students’ achievement and interest in Biology.

The educational implications of the study were examined and it was recommended that inquiry methods both guided and unguided should be adopted by biology teachers to improve on students’ achievement and interest in Biology. Limitations of the study were highlighted and some suggestions were made for further research.
REFERENCES


Chang, Y. (2003). Gender Differences in Science Achievement, Science Self Concept and Science Values. *[On line] available @Yuan Christian University @tea.ntue.edu.tw: Pp1-6


West African Examination Council (2009). *Biology Chief Examiner’s report*.


## Appendix I

### Analysis of May/June 2005-2010 SSCE/WASSCE results of some co-education secondary schools in Nsukka L.G.A

<table>
<thead>
<tr>
<th>Name of schools</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total No of</td>
<td>No of</td>
<td>No of</td>
<td>No of</td>
<td>No of</td>
<td>No of</td>
</tr>
<tr>
<td></td>
<td>candidates</td>
<td>Distinction</td>
<td>Credit</td>
<td>Pass</td>
<td>Failure</td>
<td>Total no of candidates</td>
</tr>
<tr>
<td>CSS Alor Uno</td>
<td>58</td>
<td>-</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>CSS Ede-oballa</td>
<td>12</td>
<td>4</td>
<td>2</td>
<td>9</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>CSS Isi-Enu</td>
<td>51</td>
<td>-</td>
<td>8</td>
<td>1</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>CSS Nru</td>
<td>62</td>
<td>-</td>
<td>4</td>
<td>7</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Model SS Nsukka</td>
<td>90</td>
<td>-</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

Distinction = $A_1 - A_3$
Credit = $C_4 - C_6$
Pass = $D_7 - E_8$
Failure = $F_9$
ANALYSIS OF 2005-2010 MAY/JUNE SSCE/WASSCE RESULTS

Percentage of performances of the schools over six-year period (2005-2010)

<table>
<thead>
<tr>
<th>Name of School</th>
<th>Total No of candidate</th>
<th>DISTINCTION</th>
<th>CREDIT</th>
<th>PASS</th>
<th>FAILURE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No %age</td>
<td>No %age</td>
<td>No %age</td>
<td>No %age</td>
<td>No %age</td>
</tr>
<tr>
<td>1 C.S.S Alor-Uno</td>
<td>307</td>
<td>18 5.9%</td>
<td>157 51.1%</td>
<td>78 25.4%</td>
<td>54 17.6%</td>
</tr>
<tr>
<td>2 C.S.S Ede-Oballa</td>
<td>833</td>
<td>21 2.5%</td>
<td>527 63.3%</td>
<td>207 24.8%</td>
<td>78 9.4%</td>
</tr>
<tr>
<td>3 C.S.S Isi-Enu</td>
<td>396</td>
<td>9 2.3%</td>
<td>110 27.8%</td>
<td>127 32.0%</td>
<td>150 37.9%</td>
</tr>
<tr>
<td>4 C.S.S Nru</td>
<td>359</td>
<td>35 9.7%</td>
<td>197 54.9%</td>
<td>113 31.5%</td>
<td>14 3.9%</td>
</tr>
<tr>
<td>5 M.S.S Nsukka</td>
<td>415</td>
<td>10 2.4%</td>
<td>113 27.2%</td>
<td>109 26.3%</td>
<td>183 44.1%</td>
</tr>
</tbody>
</table>
Cumulative summary of students’ achievement in Biology from 2005-2010

May/June SSCE/WASSCE

<table>
<thead>
<tr>
<th>Distinction</th>
<th>Credit level</th>
<th>Pass</th>
<th>Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1%</td>
<td>51.1%</td>
<td>25.4%</td>
<td>17.6%</td>
</tr>
<tr>
<td>2.5%</td>
<td>63.3%</td>
<td>24.8%</td>
<td>9.4%</td>
</tr>
<tr>
<td>2.3%</td>
<td>27.8%</td>
<td>32.0%</td>
<td>37.9%</td>
</tr>
<tr>
<td>9.7%</td>
<td>54.9%</td>
<td>31.5%</td>
<td>3.9%</td>
</tr>
<tr>
<td>2.4%</td>
<td>27.2%</td>
<td>26.3%</td>
<td>11.4%</td>
</tr>
</tbody>
</table>

\[
\text{Cumulative} \frac{5.1}{5} = 4.56 \quad \frac{2.5}{5} = 44.86 \quad \frac{2.3}{5} = 27.8 \quad \frac{9.7}{5} = 27.2 \quad \frac{2.4}{5} = 27.2
\]

\[
\text{Cumulative} \% \text{ no of students with credit and distinctions} = 44.86 + 4.56 = 49.42\%
\]

\[
\text{Cumulative} \% \text{ no of students with ordinary pass and failures} = 28.00 + 22.58 = 50.58\%
\]
### Appendix II

**TABLE I: TABLE OF SPECIFICATION/TEST BLUE PRINT.**

<table>
<thead>
<tr>
<th>Duration in weeks</th>
<th>Content</th>
<th>Lower order questions (know, compr, and Application)</th>
<th>Higher order questions (Analysis, synthesis and evaluation)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nutrition in Animal</td>
<td>70%</td>
<td>30%</td>
<td>100%</td>
</tr>
<tr>
<td>Week 1</td>
<td></td>
<td>7 (2,3,4,5,6,7,8)</td>
<td>3 (1,9,10)</td>
<td>10</td>
</tr>
<tr>
<td>Period I</td>
<td>Food substances</td>
<td>30%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Period II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heterotrophic nutrition and</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>feeding mechanism in holozoic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>organisms (20%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 (11,12,15)</td>
<td>2 (13,14)</td>
<td>5</td>
</tr>
<tr>
<td>Week 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Period I</td>
<td>Dentition in mammals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 (16,17,18,19,20,21,25)</td>
<td>3 (22,23,24)</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Period II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Digestive enzymes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 (26,27,29)</td>
<td>2 (28,30)</td>
<td>5</td>
</tr>
<tr>
<td>2 weeks</td>
<td>Total</td>
<td>100%</td>
<td>10</td>
<td>30</td>
</tr>
</tbody>
</table>
Appendix II

Analysis of Reliability Index: Kuder-Richardson and Cronbach Alpha

Kuder-Richardson formula 20 (KR-20)

\[ R = \frac{K}{k-1} \left(1 - \frac{\sum pq}{s^2}\right) \]

Where,

- \( R \) = test reliability
- \( k \) = number of items on the test
- \( p \) = proportion of correct answers
- \( q \) = proportion of wrong answers
- \( s^2 \) = total variance of the test scores

\( K = 25, \)
\( \sum pq = 5.03, \)
\( s^2 = 19.09 \)

\[ R = \frac{25}{25 - 1} \left(1 - \frac{5.03}{19.09}\right) \]

\[ R = \frac{25}{24} \left(1 - .26\right) \]

\[ R = 1.04(.74) \]

\[ R = 0.77 \]

Reliability Statistics

<table>
<thead>
<tr>
<th>Cronbach’s Alpha</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.812</td>
<td>24</td>
</tr>
</tbody>
</table>
Appendix III

LESSON NOTES ON ANIMAL NUTRITION BASED ON GUIDED INQUIRY METHOD OF TEACHING:

Week I  Period I

Subject:  Biology
Class:  SSI
Class Average age:  15+
Topic:  Food substances
Duration of lesson:  1 hr 10 mins (double period)
Date:  2012

Instructional Objectives:

By the end of the lesson the students should be able to:

(i.) define food substances
(ii.) list 6 different types of food substances.
(iii.) state 2 sources of carbohydrates and protein.
(iv.) name 6 food constituent of a balanced diet, the importance and deficiency diseases
(v.) state 3 importance of a balanced diet
(vi.) carry out experiments on simple food tests,
(vii.) report an experiment on a simple food test e.g. test for starch.

Instructional Materials:

The following materials and teaching aids would be provided and used for the lesson. Different food substances such as: Garri, yam, rice, meat, butter, olive
oil, common salt, fish, prawn, pepper, cowpea, crabs and onions etc. Charts; showing different classes of food and constituents of a balanced diet.

Materials (Apparatus and reagents) for food tests: Fehling’s and Benedict’s solutions, dilute solution of sodium hydroxide (NaOH) dilute hydrochloric acid (HCl) Cupper II Sulphate solution (CuSO₄) e.t.c.

Apparatus: Test-tubes, test tube holders, filter paper, water, source of heat (Kerosene stove) chalk, chalk board and duster.

Entry behaviour

The students have knowledge of nutrition in the previous lessons on characteristics of living things. The students eat different food substances and see different food substance at homes, markets places e.t.c.

Test of entry behaviour

The students were asked to:

(i) define nutrition

(ii) name some food substances.

(iii) list 2 importance of food.

Instructional procedures

Step 1

Food Substances

Teacher’s activities: The teacher states instructional objectives on the board and provides the students with different food substances for identification and explanation.
Students’ activities: The students identify and explain food substances and the importance of food. From the explanations and importance of food the students were able to deduce the definition of food substances.

Step II

Six Classes of Food.

Teacher’s activity: The teacher divides students into 4 small groups of 10 students for each group and provides each of the groups with different food substances and asks the students to classify the food substances into six different classes of food.

Students’ activities: The students in each of the small groups try to classify the different food substances with the teacher’s supervision and assistance.

Step III

Sources of Food Substances:

Teacher’s activities: The teacher asked each of the groups to list the local sources of the food substances and importance of each type of food substance.

Students’ activities: Each of the groups tries to list the local sources of the food substances and their importance to man.

Step IV

Balanced Diet:

Teacher activity: The teacher re-grouped the students into small groups and showed each group of the students a chart illustrating a balanced diet and asked the students to deduce the definition of a balanced diet from the illustrations on the
chart, build up a balanced diet from the food substances provided and list the importance and some diseases caused by unbalanced diet.

**Students’ activities:** Each of the groups observes the chart and tries to define balanced diet from the illustrations on the chart. Each of the groups builds up a balanced diet from the food substances provided to them, lists the importance of balanced diet and some diseases caused by unbalanced diet.

**Step V**

**Simple Food Tests**

**Teachers’ activity:** The teacher divides the students into 4 small groups of 10 students in each group and provides each of the groups with some apparatus and reagents for food test, some food specimens (starch, simple sugar, protein and lipids), a manual guide stating the procedure for food test and asked the students to carry out experiments on simple food test (starch, simple sugar, protein and lipids).

**Students’ activities:** Each group of the students carry out the experiments following the procedures stated in the manual guide, observe and make inferences.

**Step VI**

**Reports on experiment on simple food test**

**Teacher’s activity:** The teacher asks each group to report the experiment

**Students’ activities:** Each of the groups reports the experiment and submits to the teacher.
Summary: The teacher briefly goes through the lesson topic and highlights important points.

Evaluation:

By the end of the lesson the students would be asked the following questions:

(i) define food substances?
(ii) list 6 different classes of food substances.
(iii) name 2 local sources of carbohydrate and fat and oil.
(iv) List 2 nutritional importance of carbohydrates.
(v) list 6 constituents of a balanced diet.
(vi) name a deficiency disease caused by lack of protein.
(vii) using a piece of yam, demonstrate test for starch.

Assignment

(i) Find out the differences in the element composition of carbohydrates, proteins and lipids.
(ii) List 3 types of carbohydrates and 2 types of proteins
(iii) In a tabular form, list types of vitamins, sources, importance and deficiency effects.

Week I

Period II

Subject: Biology
Class: SS I
Class Average: 15+
Topic: Heterotrophic Nutrition and feeding mechanism in holozoic organisms

Duration: 35 minutes (single period)

Date: 2012.

Instructional objectives

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

(i) define heterotrophic nutrition
(ii) list 3 types of heterotrophic nutrition
(iii) state 2 differences between heterotrophic and holozoic nutrition
(iv) carry out experiment to show the degradation of bread by Rhizopus/mould (saprophytic nutrition)
(v) explain feeding mechanisms in Housefly.

Instructional materials

Five loaves bread with fungal growth (Rhizopus), a bell jar, pieces of meat, Petri dishes, hand lenses, chalk, chalk board and duster.

Entry behaviour

The students have knowledge of food substances, types, sources and importance of food to organisms.

Test of Entry behaviour

The teacher asks the students to:

(i) state 2 differences between plants and animals nutrition?
(ii) Name any two classes of food substances, indicate their sources and importance.
Instructional procedure:

Step I

Heterotrophic Nutrition

Teacher’s activity: The teacher states the instructional objectives on the chalkboard and asks the students to explain 3 type of nutrition in animals.

Student’s activities: The students try to explain type of nutrition in animals and from the explanation they deduced the definition of heterotrophic nutrition with some assistance from the teacher.

Step II

Types of heterotrophic nutrition

Teacher’s activity: The teacher asks the students to list different ways by which different animals obtain food nutrients and listens to the students.

Students’ activities: The students list different ways different animals obtain food nutrients with the teacher’s assistance.

Step III

Differences between heterotrophic nutrition and holozoic nutrition

Teacher activity: The teacher asks the students to state 2 differences between nutrition in Tapeworm and nutrition in man. The teacher further asks the students to find out the differences between heterotrophic nutrition and holozoic nutrition with reference to their various definitions.

Students’ activities: The students define heterotrophic nutrition and holozoic nutrition and from the definition given, list out the differences between the heterotrophic and holozoic nutrition.
Step IV

Experiment to show degradation of bread by Rhizopus/mould:

Teacher’s activity: The teacher divides the students into small groups and provides each group with some stale wet loaves of bread with fungal growth (Rhizopus) and asked the students to observe the specimen with a hand lens.

Students’ activities: The students in small groups observe the bread with Rhizopus (fungal) growth; ask some questions to find out the type of heterotrophic nutrition.

Step V

Feeding mechanism in housefly

Teacher’s activity: The teacher divides the students into groups and provides each group with some exposed piece of meat with pestering houseflies in a Petri dish and asks them to observe and explain their observations.

Students’ activities: The students work in small groups, each group observes Houseflies perch on the meat, suck fluid with the proboscis and deposit eggs on the meat.

Summary: The teacher briefly goes through the lesson topic and highlights important points.
Evaluation

By the end of the lessons the students would be asked the following questions

(i) what is heterotrophic nutrition
(ii) list 3 types of heterotrophic nutrition
(iii) state 2 differences between heterotrophic nutrition and holozoic nutrition
(iv) name the nutrition in Rhizopus/fungi.
(v) explain briefly the feeding mechanism in Housefly and name the structure used for feeding.

Assignment

(i) List and explain 3 types of heterotrophic nutrition with examples.
(ii) Explain filter feeding, deposit feeding and fluid feeding mechanisms in animals.
(iii) State and explain 5 feeding processes in holozoic organisms.

Week 2  Periods I

Subject:  Biology
Class:  SS I
Class Average:  15+
Topic:  Dentition in mammals
Duration:  1 hr 10minutes (double period)
Date:  2012
Instructional Objectives

By the end of the lesson, the students should be able to

(i) define dentition in mammals

(ii) list 4 types of mammalian teeth.

(iii) write the dental formula of dog, goat and man

(iv) draw and label L/S of a mammalian tooth.

(v) list 5 ways to care for the teeth.

Instructional materials

Different types of teeth from the abattoir, preserved skulls of a cat and rat, chart illustrating the internal structure of a mammalian tooth, chalk, chalk board, duster.

Entry behaviour

Students have knowledge of heterotrophic nutrition and types of heterotrophic nutrition. The students also have knowledge of holozoic nutrition and different modes of holozoic nutrition. This was linked up with dentition in mammals and the relationship between dentition and modes of nutrition in holozoic organisms (mammals).

Test of entry behaviour

The teacher asks the students to:

(i) list 3 types of heterotrophic nutrition

(ii) explain differences between filter feeding and fluid feeding in holozoic organism,

(iii) list feeding processes in holozoic organisms.
Instructional Procedure

Step I

Dentition in Mammals

Teacher’s activity: The teacher states the instructional objectives on the board and then groups the students into 4 small groups of 10 each, shows each of the groups preserved skulls of a cat and rats to observe. The teacher shows the students the hand asks each group to explain their observations.

Students’ activities: The students in 4 small groups of 10 each observe the dental arrangement on the upper and lower jaws of the preserved skull of cat and rat and try to define dentition based on their observations. They also note the differences in the arrangement of teeth on the upper and lower jaws of cat and rat.

Step II

Types of mammalian teeth

Teacher’s activity: The teacher provides the students with different types of teeth from mammals collected from an abattoir and the biology laboratory and asked the students to observe, and differentiate between these teeth and the locations in the upper and lower jaws.

Students’ activities: The students in small groups of 10 each: observe the different types of teeth, classify the teeth and identify their different positions in the upper and lower jaws of a named mammal.
Step III

Dental formula of some mammals

Teacher’s activity: The teacher asks the students to state the observable differences between the dental arrangement in the jaw bones of cat and rat and suggest reasons for the differences in relation to the mode of nutrition. The teacher asks the students to find out what in dental formula and how it relates to mode of nutrition in mammals.

Students’ activities: The students in 4 small groups of 10 each observe critically the skulls of rat and cat. The students list observable differences in their dental arrangement and number (dental formula). The students suggest reasons for the variations in dental formula; relate the dental formula to different modes of nutrition in the animals.

Step IV

Longitudinal Section of a mammalian tooth:

Teacher’s activity: The teacher provides the each group of students with a chart illustrating the internal structure of a mammalian tooth and asks the student to identify each structure and state their functions. The teacher guides the students on how to identify each of the labelled structures.

Students’ activities: The students in 4 small groups of 10 each observe the chart, identify the labelled internal structures and find out their functions.
Step V

Care for the mammalian teeth (man)

Teacher’s activity: The teacher asks the students to list how to care for their teeth and ask them to find out other ways of caring for the teeth apart from the previously listed ways.

Students’ activities: The students list various ways to care for the teeth.

Summary: The teacher briefly goes through the lesson topic and highlights important points.

Evaluation

By the end of the lesson the students would be asked the following questions

(i) define dentition in mammals
(ii) list 4 different types of mammalian teeth
(iii) write the dental formula for dog and goat and give 2 reasons for the differences in the dental formula of the 2 animals.
(iv) draw and label the longitudinal section of a mammalian tooth showing the internal structures and functions.
(v) enumerate 5 ways which you can care for your teeth.

Assignment: The teacher asks the students to:

(i) visit an abattoir and collect different types of mammalian teeth.
(ii) find out the dental formula for an adult man, dog, sheep and rabbit, state the differences in relation to their different modes of nutrition.
**Instructional Objectives**

By the end of the lesson the student should be able:

(i) describe digestion in Amoeba, Earthworm, Cockroach and Birds.

(ii) dissect Cockroach and Bird to show the alimentary canals

(iii) state 2 differences and 3 similarities between the alimentary canal of cockroach and a bird.

(iv) define digestive enzymes

(v) list 4 types of digestive enzymes, 5 characteristics of enzymes and functions.

**Instructional materials**

Charts illustrating digestion in Amoeba, and Earthworm, freshly killed Cockroaches and Birds, saliva, test-tubes starch, Iodine solution, distilled water,
dissecting kits and guide, pins and dissecting boards, chalk, chalk board and duster.

Entry behaviour

The students have knowledge of the importance of dentition in nutrition and adaptation of different types of teeth to different modes of nutrition.

Test of entry behaviour

The students were asked to:

(i) list 4 types of teeth.
(ii) state 2 modifications in the dentition of goat in relation to the mode of nutrition of herbivores.

Instructional procedure

Step I

Digestion in Animals (Amoeba, Earthworm, Cockroach and Bird):

Teacher’s activity: The teacher hangs charts illustrating digestion in amoeba and digestive system in Earthworm; and asks the students to observe the 2 different charts and state their observations.

Students’ activities: The students observe the charts, describe their observations ask questions for further clarifications.

Step II

Experiment to show the Alimentary Tracts of Insects and Birds

Teacher’s activity: The teacher divides the students into small groups and provides each group with a dissecting kit, a freshly killed cockroach and bird,
dissecting board and a dissecting guide/manual then asks the students to dissect and observe the dissected alimentary canals.

**Students’ activities:** The students in the small groups among the group appoint a group demonstrator. Each of the group demonstrators with the dissecting guide and kit dissects Cockroach and the bird to expose the alimentary canal/canal members of each group observe the alimentary tracts/canal, note similarities and differences between the alimentary canal of Cockroach and a bird.

**Step III**

**Functions of Organs in the Alimentary Canal of Insects and Birds**

**Teacher’s activity:** The teacher asks the students to state out the functions of the different parts of the alimentary tract of a cockroach and a bird list out the modification in the alimentary canals of the cockroach and the bird; state differences and similarities between the alimentary canal of a cockroach and a bird.

**Students’ activities:** The students try to find out the functions of the dissected parts of the alimentary canal. Compare and contrast the alimentary canal of a Cockroach and that of a bird, state the modification in parts of the alimentary canal and relate it to their different feeding habits.

**Step IV**

**Definition of Enzyme**

**Teacher’s activity:** The teacher asks the students to deduce the definition of enzyme from the functions of the salivary glands on the digestive tract of a
Cockroach and the proventriculus in the digestive track of a bird. The teacher guides the students to define enzymes and relate the definition to nutrition and mode of nutrition and feeding habit in holozoic organisms

**Students’ activities:** The students deduce the definition of enzymes from the functions of digestive enzymes in the salivary glands of insects and proventriculus of a bird. State the functions of enzyme in food digestion.

**Step V**

**Types of Digestive Enzymes:**

**Teacher’s activity:** The teacher asks the students to list out 4 types of enzymes, the characteristics and functions of the listed enzymes.

**Students’ activities:** The students with the aid of their text books list out types of enzymes, state the characteristics and functions.

**Step VI**

**Experiments to show that saliva contains enzyme that digest starch**

**Teacher’s activity:** The teacher divides students into small groups and asks each group to carry out experiment to show that saliva contains ptyalin that acts on starch. The teacher asks the student to observe record and report the experiment following a given procedure.

**Students’ activities:** The students in small groups carry out the experiment make observation, record and report the observations and draw out conclusion.

**Summary:** The teacher goes briefly through the lesson topic and highlights important points.
Evaluation

By the end of the lesson the students would be asked the following questions

(i) briefly describe the digestion in Amoeba.

(ii) draw and label the digestive system of an Earthworm.

(iii) define an enzyme?

(iv) list 4 types of enzymes and name 4 different types of food each group of enzymes digests.

(v) state and explain 5 characteristics of an enzyme

(vi) name one digestive juice that secretes enzyme - ptyalin

Assignment

1. carry out and report an experiment to show that saliva contains an enzyme that digests carbohydrate (starch)

2. list types of digestive enzymes, and name the organs and sites of enzyme secretion.
Appendix IV

LESSON NOTES ON ANIMAL NUTRITION BASED ON UNGUIDED INQUIRY TEACHING METHOD

Week I Period I
Subject: Biology
Class: SSI
Class Average age: 15+
Topic: Food substances
Duration of lesson: 1 hr 10 mins (double period)
Date: 2012

Instructional Objectives:

By the end of the lesson the students should be able to:

(i) define food substances
(ii) list 6 different types of food substances.
(iii) state 2 sources of carbohydrates and proteins.
(iv) name 6 constituent of a balanced diet.
(v) State 3 importance of balanced diet.
(vi) carry out an experiments on simple food tests,
(vii) report experiment on a simple food test e.g. test for starch.

Instruction Materials:

The following materials and teaching aids would be provided and used for the lesson. Different food substances such as: Garri, yam, rice, meat, butter, olive
oil, common salt, fish, prawn, pepper, cowpea, crabs and onions etc. Charts showing different classes of food and constituents of a balanced diet.

**Materials (Apparatus and reagents) for food tests:** Fehling’s and Benedict’s solutions, dilute solution of sodium hydroxide (NaOH) dilute hydrochloric acid (HCl) Cupper II Sulphate solution (CuSO₄) e.t.c.

**Apparatus:** Test-tubes, test tube holders, filter paper, water, source of heat (Kerosene stove) chalk, chalk board and duster.

**Entry behaviour**

The students have knowledge of nutrition in the previous lessons on characteristics of living things. The students eat different food substances and see different food substance at homes, markets places e.t.c.

**Test of entry behaviour**

The students were asked to:

(i) define nutrition

(ii) name some food substances.

(iii) list 2 importance of food
Instructional procedures

Step I

Food Substances

Teacher’s activity: The teacher states the instructional objectives, divides the students into 4 small groups of 10 each and asks each group to carry out what were stated in the instructional objectives.

Students’ activities: Each group of the students collects different food substances and try to define food substances, making reference to previous knowledge about importance of food.

Step II

Six Classes of Food:

Students’ activities: The students work in small groups, each of the groups tries to classify the food substances into different classes.

Step III

Source of Food Substance:

Students’ activities: Each of the small groups tries to list local sources of each class of the food substances and state their importance to man.

Step IV

Balanced Diet

Students’ activity: The students look at the chart illustrating balanced diet and define balanced diet, each group tries to build up a balanced diet from the food
substances they have, list 4 importance of balanced diet and 3 diseases caused by unbalanced diet.

**Step V**

**Simple food test**

Teacher’s activities: The teacher divides the students into 4 small groups of 10 each and asks each group to carry out simple food tests. Provides each groups of the students with confirmatory tests for each food test.

**Students’ activities:** The students work in small groups; carry out experiments on food tests using reagents and apparatus provided to get the confirmatory results.

**Summary:** the teacher briefly goes through the topic and highlights the important points

**Evaluation:**

By the end of the lesson the students would be asked the following questions:

(i) define food substances?

(ii) list 6 different classes of food substances.

(iii) name 2 local sources of carbohydrates and fats and oil

(iv) list 2 importance of carbohydrates

(v) list 6 constituents of a balanced diet.

(vi) name a deficiency disease caused by lack of protein.

(vii) Using a piece of yam demonstrate test for starch
Assignment

(i) Find out the differences in the element composition of carbohydrates, proteins and lipids.

(ii) List 3 types of carbohydrates and 2 types of proteins

(iii) In a tabular form list types of vitamins, sources, importance and deficiency effects.

Week I       Period II
Subject:     Biology
Class:       SS I
Class Average:  15+
Topic:       Heterotrophic Nutrition and feeding mechanism in holozoic organisms
Duration:    35 minutes (single period)
Date:        2012.

Instructional Procedure

Step I

Heterotrophic Nutrition

Students’ activities: Students from the stated instructional objectives and test of entry behaviour try to define heterotrophic nutrition.

Step II

Types of heterotrophic nutrition

Students’ activity: The students’ list different heterotrophic nutrition with examples of organisms that carry out each of the named type.
Step III

Differences between heterotrophic and holozoic nutrition

Students’ activities: The students try to differentiate heterotrophic nutrition and holozoic nutrition from the definitions of heterotrophic and holozoic nutrition.

Step IV

Experiment to show Degradation of Bread by Rhizopus/mould:

Students’ activities: The students in 4 small groups of 10 each observe stale bread covered with a bell jar for 5 days with a hand lens. The students explain their observation and describe the mode of nutrition of the organism found on the stale bread.

Step V

Feeding mechanisms in holozoic organisms (e.g. fluid feeding in houseflies)

Students’ activities: The students from the definition of holozoic nutrition, list different types of holozoic nutrition. The students observe houseflies perch on pieces of meat in a slide and noted the type of feeding in housefly and also the structures used for feeding.

Summary:

The teacher briefly goes through the topic and highlights the important points
Evaluation

By the end of the lessons the students would be asked the following questions

(i) what is heterotrophic nutrition
(ii) list 3 types of heterotrophic nutrition
(iii) state 2 differences between heterotrophic nutrition and holozoic nutrition
(iv) name the nutrition in Rhizopus/fungi.
(v) explain briefly the feeding mechanism in Housefly and name the structure used for feeding.

Assignment

(i) List and explain 3 types of heterotrophic nutrition with examples.
(ii) Explain filter feeding, deposit feeding and fluid feeding mechanisms in animals.
(iii) State and explain 5 feeding processes in holozoic organisms.

Week 2

Periods I

Subject: Biology
Class: SS I
Class Average: 15+
Topic: Dentition in mammals
Duration: 1 hr 10minutes (double period)
Date: 2012
Instructional Objectives

By the end of the lesson, the students should be able to

(i) define dentition in mammals
(ii) list 4 types of mammalian teeth.
(iii) write the dental formula of dog, goat and man
(iv) draw and label L/S of a mammalian tooth.
(v) list 5 ways to care for the teeth.

Instructional materials

Different types of teeth from the abattoir, preserved skulls of a cat and rat, chart illustrating the internal structure of a mammalian tooth, chalk, chalk board, duster.

Entry behaviour

Students have knowledge of heterotrophic nutrition and types of heterotrophic nutrition. The students also have knowledge of holozoic nutrition and different modes of holozoic nutrition. This was linked up with dentition in mammals and the relationship between dentition and modes of nutrition in holozoic organisms (mammals).

Test of entry behaviour

The teacher asks the students to:

(i) list 3 types of heterotrophic nutrition
(ii) explain differences between filter feeding and fluid feeding in holozoic organism,
(iii) list feeding processes in holozoic organisms.
Instructional Procedure

Step I

Dentition in Mammals

Teacher’s activity: The teacher re-groups the students into 4 small groups of 10 each and asks each group to visit an abattoir and collect different types of teeth and also to go to the school Biology laboratory and collect some preserved skulls of small mammals (Cat and Rat).

Students’ activities: The students in 4 small groups of 10 each visit an abattoir and the biology laboratory; collect different types of teeth and skulls of small mammals. The students from the listed instructional objectives observe the different types of mammalian teeth and define dentition in mammals. The students in the small groups observe the position and arrangement of the different types of teeth in the upper and lower jaws of a rat.

Step II

Types of Mammalian Teeth

Students’ activities: The students in 4 small groups of 10 each gather the different types of teeth, for identification and classification. The students try to differentiate between each type of teeth, identify their positions in the upper and lower jaws and suggest functions of each of the types of teeth using their teeth as an example.

Step III

Dental formula of some Mammals

Students’ activities: The students observe the types and number of teeth in the upper and lower jaws of the skull of small mammals (cats and rats) and write them
Each of the groups writes down the dental formula from the arrangement of teeth observed on the skulls of cat and rat. The students relate the dental formula to the mode of nutrition of cats and rats and state reasons for differences in the dental formula.

**Step IV**

**Longitudinal Section of a mammalian tooth showing the internal structures**

**Students’ activities:** The students in 4 small groups of 10 each observe the chart illustrating the internal structure of a mammalian tooth, critically observe the chart, note the labelling and find out the functions of the labelled structures. The students make longitudinal sections into a tooth and make diagrams of the longitudinal section.

**Step V**

**Care for the mammalian teeth (man)**

**Students’ activities:** The students list 7 ways they can care for the teeth.

**Summary:** the teacher briefly goes through the topic and highlights the important points

**Evaluation**

By the end of the lesson the students would be asked the following questions

(i) define dentition in mammals

(ii) list 4 different types of mammalian teeth

(iii) write the dental formula for dog and goat and give 2 reasons for the differences in the dental formula of the 2 animals.
(iv) draw and label the longitudinal section of a mammalian tooth showing the internal structures and functions.

(v) enumerate 5 ways which you can care for your teeth.

Assignment: The teacher asks the students to:

(i) visit an abattoir and collect different types of mammalian teeth.

(ii) find out the dental formula for an adult man, dog, sheep and rabbit, state the differences in relation to their different modes of nutrition.

Week 2                                                                            Period 2
Subject:                       Biology
Class:                         SS I
Class Average:                15+
Topic:                        Digestion in Amoeba, Earth worm, Cockroach and bird and digestive enzymes
Duration:                    35 minutes (single period)
Date:                         2012

Instructional Objectives

By the end of the lesson the student should be able:

(i) describe digestion in Amoeba, Earthworm, Cockroach and Birds.

(ii) dissect Cockroach and Bird to show the alimentary canals

(iii) state 2 differences and 3 similarities between the alimentary canal of cockroach and a bird.

(iv) define digestive enzymes
(v) list 4 types of digestive enzymes, 5 characteristics of enzymes and functions.

**Instructional materials**

Charts illustrating digestion in Amoeba, and Earthworm, freshly killed Cockroaches and Birds, saliva, test-tubes starch, Iodine solution, distilled water, dissecting kits and guide, pins and dissecting boards, chalk, chalk board and duster.

**Entry behaviour**

The students have knowledge of the importance of dentition in nutrition and adaptation of different types of teeth to different modes of nutrition.

**Test of entry behaviour**

The students were asked to:

(i) list 4 types of teeth.

(ii) state 2 modifications in the dentition of goat in relation to the mode of nutrition of herbivores.

**Step I**

**Introduction and description of digestion in amoeba, Earthworm, Cockroach and Bird**

**Teacher’s activity:** The teacher hangs a charts illustrating digestion in Amoeba and Earthworm and provides the students freshly killed Cockroach and birds.

**Students’ activities:** The students’ works in 4 small groups of 10 each observe the charts illustrating digestion in Amoeba and Earthworm, and describe digestion in Amoeba and Earthworm
Step II

Experiment to show the Alimentary Tracts of Insects and Birds

Students’ activities: The students divided themselves into 4 small groups of 10 each; each group appoints a demonstrator/leader. Collect dissecting kit, pins and guide and dissect Cockroach and bird, members of each group observe the dissected alimentary canal, note the differences and similarities between the alimentary canal of a Cockroach and a bird.

Step III

Functions of the different parts of the alimentary canals of a Cockroach and a bird

Students’ activities: The students from the dissected alimentary canals of Cockroach and a bird, finds the functions of the alimentary canal, the modifications and the relationship between the alimentary canal and the feeding habits of cockroach and a bird.

Step IV

Definition of enzymes

The students try to deduce the definition of enzymes from the functions of enzymes in the saliva of cockroach and proventriculus of a bird. The students define enzymes based on their different understandings. Students from the listed functions state the importance of enzymes in food digestion.
Step V

Types of Digestive Enzymes:

The students list out types of enzymes, characteristics and function with reference to their previous knowledge on food digestion.

Summary: the teacher briefly goes through the topic and highlights the important points

Evaluation

By the end of the lesson the students would be asked the following questions

(i) briefly describe the digestion in Amoeba.
(ii) draw and label the digestive system of an Earthworm.
(iii) define an enzyme?
(iv) list 4 types of enzymes and name 4 different types of food each group of enzymes digests.
(v) state and explain 5 characteristics of an enzyme
(vi) name one digestive juice that secretes enzyme - ptyalin

Assignment

(i) carry out and report an experiment to show that saliva contains an enzyme that digests carbohydrate (starch)
(ii) list types of digestive enzymes, and name the organs and sites of enzyme secretion.
Appendix V

BIOLOGY ACHIEVEMENT TEST (BAT)

Name of School

Sex:  Male  Female  Duration: 30 minutes

Tick (√) against the correct options

Instruction: Answer all the questions.

1. Which of the following food substances would be required by a farmer after a strenuous farming activity?
   A. unripened plantain porridge  B. Moi-moi
   C. Jollof rice  D. orange juices and salad

2. Which of the following food substances is not a major source of protein?
   A. Egg  B. Milk
   C. Cow pea  D. Guinea corn

3. Which of the following sugar is a monosaccharide?
   A. Cellulose  B. Fructose
   C. Starch  D. Sucrose

4. A growing child requires relatively high amount of proteins in the diet because proteins
   A. Maintains body weight
   B. Yield high amount of energy needed for work
   C. Promotes growth
   D. Promotes bones and teeth formation
5. Which of these processes describes the formation of complex sugar from two molecules of simple sugars?

A. Condensation  
B. Hydrolysis  
C. Photosynthesis  
D. Oxidation

6. A balanced meal for an adult man may consist of

A. 2 pieces of chicken, 4 balls of bean cake, 2 eggs and 2 cups of tea with milk  
B. 4 slices of bread, a bowl of pap, 2 oranges and 2 banana fruit  
C. 4 slices of yam with stew, 2 pieces of beef, a cup of tea with milk and 2 oranges.  
D. A plate of beans, 2 pieces of meat, 2 eggs, a cup of tea with milk and 2 oranges

7. Which of the following statements about a balanced diet is correct?

A. It promotes health growth and development of body  
B. It encourages under nutrition  
C. It is a form of malnutrition  
D. It gives energy only to the body

8. A urine sample of a patient tested with fehling’s solutions A$B gave an orange precipitate indicating the presence of

A. Glucose.  
B. Sucrose.  
C. Maltose.  
D. Amino-acid.

9. The enzyme invertase will hydrolyse sucrose to give

A. Mannose and galactose  
B. Glucose and fructose  
C. Maltose and galactose  
D. Glycerol and fatty acids
10. An individual whose diet consists mainly of cassava with melon soup, bread with butter and ground nut is likely to feel
   A. Tired on a cold weather               B. Thirsty on a cold weather
   C. Warm on a cold weather               D. Cold on a cool weather

11. Organisms that depend on manufactured food substances by other living organisms are called?
   A. Parasites                             B. Chemotrophs
   C. Autotrophs                            D. Heterotrophs

12. Parasitism can best be defined as association between two organisms which?
   A. Both organisms benefit from each other
   B. Both suffer same disadvantages
   C. One organism gains and other loses
   D. One organism gain and the other lose.

13. Which of these organisms is likely to be found at a refuse dump site?
   A. Amoeba                                B. Mucor
   C. Paramecium                            D. Chlamydomonas

14. A stale loaf of bread changed taste and colour due to degradation caused by
   A. Parasitic feeding by bacteria          B. Saprophytic feeding by Rhyzopus
   C. Symbiotic growth by lichen             D. Autotrophic feeding by spirogyra

15. Which of these structures is common to fluid feeders?
   A. Proboscis                             B. Mouth brushes
   C. Mandibles                            D. Mouth parts
16. The four common types of teeth in mammals are arranged in the following order

A. Incisors, canines, molars and premolars
B. Incisors, canines, premolars and molars
C. Canines, incisors, molars and premolars
D. Incisors, premolars, canines and molars.

17. The pulp cavity of the tooth contains which of the followings?

A. Blood vessel  B. Enamel
C. Cement  D. Bones

18. Diastema is a dental modification found in which of these organisms

A. Herbivores and omnivores  B. Carnivores only
C. Herbivores and carnivores  D. Omnivores only

19. Which of these parts of tooth will bleed when damaged?

A. Enamel  B. Crown
C. Dentine  D. Pulp cavity

20. Which of the followings can cause tooth decay in man?

A. Regular brushing of the teeth with fluoride paste
B. Intake of diet rich in calcium and phosphorus
C. High intake of pastries and sweeteners
D. Rinsing of the teeth with saline water before going to bed.

21. The hardest part of the teeth is called

A. Gum  B. Root
C. Enamel  D. Cement
22. Which of the followings represent the dental formula for a man whose upper incisors were lost in an accident?

A. \( i = \frac{2}{2} \quad c = \frac{1}{1} \quad p = \frac{2}{2} \quad m = \frac{3}{3} \)  
B. \( i = \frac{0}{2} \quad c = \frac{1}{1} \quad p = \frac{2}{2} \quad m = \frac{3}{3} \)  
C. \( i = \frac{0}{2} \quad c = \frac{0}{1} \quad p = \frac{2}{2} \quad m = \frac{3}{3} \)  
D. \( i = \frac{0}{0} \quad c = \frac{1}{0} \quad p = \frac{2}{2} \quad m = \frac{3}{3} \)

23. Herbivores lack canines because canines are used for?

A. Cutting and holding food
B. Tearing of food and removing flesh from bones
C. Chewing and grinding food
D. Masticating and holding food from falling off

24. Longitudinal section of a tooth shows these major parts

A. Enamel, dentine, pulp cavity, cement and blood vessels
B. Crown, neck, gum and root
C. Crown, neck, root and gum
D. Crown, neck, gum and cement

25. Children within the teething age are advised to take food substances rich in calcium and vitamin D because lack of calcium and vitamin D may result to

A. Tooth decay  
B. Malformation of the teeth and bones  
C. Bleeding of the gum  
D. Long teeth formation

26. Which of the following is not a characteristic of enzyme?

A. They are proteins which are activated by co-enzymes  
B. They are specific in action and can only act on a specific substrate  
C. They are organic catalysts  
D. Enzymic reactions are irreversible
27. Which of the following structures produces the greatest variety of digestive enzymes?
A. Salivary glands   B. Pancreas
C. Stomach           D. Colon

28. Which of this part of the alimentary canal of a bird when damaged can affect the digestion of grains?
A. Crop             B. Proventriculus
C. Gizzard           D. Beak

29. The optimum temperature range for enzymic reaction is
A. 20°C-25°C   B. 25°C – 40°C
C. 5°C – 10°C   D. 48°C – 45°C

30. If an enzyme works best in an acidic medium, in which of the following parts of the human gut is the pH best for enzymic activities?
A. Ileum pH 9.0   B. Stomach pH 2.0
C. Duodenum pH 7.0   D. Mouth cavity pH 8.0
Appendix VI

Marking/Scoring guide for the biology achievement test (one mark for each correct answer)

<p>| | | | |</p>
<table>
<thead>
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</tr>
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<td>B</td>
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<td>C</td>
</tr>
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<td>15</td>
<td>A</td>
<td>30</td>
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Appendix VII

Biology Interest Inventory

Name of School

Sex Male [ ] Female [ ]

This 4 point biology Interest inventory scale is designed to help students indicate the level of interest in biology, biology related activities and biological products.

You are expected to indicate the degree of your interest in the questions by ticking (√) against the option most appropriate to your level of interest.

Level of interest:

SA = Strongly agreed (4)
A = Agreed (3)
D = Disagreed (2)
SD = Strongly disagreed (1)
<table>
<thead>
<tr>
<th>S/N</th>
<th>Biological activities</th>
<th>SA</th>
<th>A</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I like the subject Biology.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2</td>
<td>I don’t like the subject biology.</td>
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<tr>
<td>3</td>
<td>I like enjoy reading biology text books at my leisure hours.</td>
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<td></td>
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<tr>
<td>4</td>
<td>I don’t enjoy reading biology text books at my leisure hours.</td>
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<tr>
<td>5</td>
<td>I prefer buying biology text books to other text books in other subjects.</td>
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<tr>
<td>6</td>
<td>I like biological illustration on charts and models.</td>
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<tr>
<td>7</td>
<td>I like doing assignments and carrying out projects in biology.</td>
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<tr>
<td>8</td>
<td>I enjoy identifying and observing features in biological specimens during practical classes.</td>
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<tr>
<td>9</td>
<td>I enjoy watching/listening to biology programmes on TV e.g. (world of animals and plants).</td>
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<tr>
<td>10</td>
<td>I like buying films and video tapes on biology programmes.</td>
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<tr>
<td>11</td>
<td>I like observing dissected animals.</td>
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<tr>
<td>12</td>
<td>I like dissecting animals by yourself.</td>
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<tr>
<td>13</td>
<td>I enjoy collecting specimens for biology practical.</td>
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<tr>
<td>14</td>
<td>I like to make charts and models in biology.</td>
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<tr>
<td>15</td>
<td>I enjoy watching animals in zoological gardens.</td>
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<td></td>
<td>I prefer visiting botanical gardens/orchards to zoological gardens.</td>
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<tr>
<td>17</td>
<td>I like visiting the school biology laboratory.</td>
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<td>18</td>
<td>I enjoy carrying out experiments in biology.</td>
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<td>19</td>
<td>I enjoy working in small groups during biology practical classes.</td>
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<td>20</td>
<td>I enjoy working alone during biology practical classes.</td>
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<tr>
<td>21</td>
<td>I like keeping pet animals like dogs/cats at homes.</td>
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<tr>
<td>22</td>
<td>I enjoy solving past questions in biology.</td>
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<tr>
<td>23</td>
<td>I enjoy discussing biological issues with others (sickle cell anaemia, HIV issues).</td>
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<tr>
<td>24</td>
<td>I like asking questions in biology.</td>
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<tr>
<td>25</td>
<td>I enjoy answering questions in biology.</td>
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<tr>
<td>26</td>
<td>I like reading biography of ancient biologists.</td>
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<tr>
<td>27</td>
<td>I like going for excursions and field trips for biological studies.</td>
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<td>28</td>
<td>I like reporting experiment in biology.</td>
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<tr>
<td>29</td>
<td>I like to take a career in biology-related discipline like (nursing, medicine, pharmacy, micro biology).</td>
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<tr>
<td>30</td>
<td>I like teaching biology to others.</td>
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</table>
Appendix VIII

LIST OF SENIOR CO-EDUCATION SCHOOLS IN NSUKKA L.G.A

1. Community Secondary School Agu-Umarbor Eha-Alumona
2. Community High School Umuarbor Eha-Alumona
3. Community Secondary School Alor-Uno
4. Community Secondary School Okpuje
5. Community Secondary School Obimo
6. Community Secondary School Opi-Agu
7. Community Secondary School Isienu Nsukka
8. Community Secondary School Nru Nsukka
9. Edem Community Secondary School Edem
10. Model Secondary School Nsukka
11. Community Secondary School Ede-Oballa
12. Community Secondary School Ehandiagu
13. Opi High School Opi
15. Community Secondary School Lejja
16. Community Secondary School Akpokoro Obimo
17. Okutu Community Secondary School Okutu
18. Lejja High School Lejja
19. Edem-Ani High School Edem-Ani
20. Community Secondary School Obukpa
22. Community Secondary School Breme