

**IMPACT OF AVAILABILITY, ADEQUACY AND UTILIZATION OF BIOLOGY
LABORATORY FACILITIES, EQUIPMENT AND MATERIALS ON STUDENTS'
ACADEMIC PERFORMANCE IN COLLEGES OF EDUCATION IN NORTH – WEST
GEOPOLITICAL ZONE NIGERIA**

BY

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**A THESIS SUBMITTED TO SCHOOL OF POSTGRADUATE STUDIES, AHMADU
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SEPTEMBER, 2018

DECLARATION

I hereby declare that this dissertation, Impact of Availability, Adequacy and Utilization of Biology Laboratory Facilities, Materials and Equipment in Colleges of Education in North-West Geopolitical, Zone Nigeria, has been carried out by me in the Department of Educational Foundations and Curriculum under the supervision of Dr. (Mrs) H.O. Yusuf, Dr. A. Guga and Dr. A. F. Mohammed. The information derived from literatures has been duly acknowledged in the text and a list of references provided. To the best of my knowledge, no part of this dissertation was previously presented for another degree at any university.

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CERTIFICATION

This dissertation entitled **IMPACT OF AVAILABILITY, ADEQUACY AND UTILIZATION OF BIOLOGY LABORATORY FACILITIES AND EQUIPMENT ON STUDENTS' ACADEMIC PERFORMANCE IN COLLEGES OF EDUCATION IN NORTH – WEST GEOPOLITICAL, ZONE NIGERIA** by **Ismaila Funtua ADO** meets the regulations governing the award of Doctor of Philosophy of Education Degree in Curriculum and Instruction of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to my late father, Alhaji Ado Na Iyaji, whose dream and wish was to see us through the best education possible. It is also dedicated to my mother, wife, children, brothers and sisters for their moral and kind support.

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All praise is to Allah, Lord of the world, for His help and courage to the successful completion of this work. With great delight, I sincerely appreciate the untiring contribution, help and mentorship of my supervisor, Dr. (Mrs) H.O. Yusuf from the beginning to the end of this work. Worthy of acknowledgement here are Dr. A. Guga and Dr. A. F. Mohammed for their wonderful guide and contributions in this research work. I must appreciate Professional advice, corrections and mentoring by Dr. A. A. Dada and all the esteemed lecturers in the department, for their untiring efforts in ensuring the completion of this work. In fact, my knowledge and skills in research has been improved to a great extent! This has been an invaluable experience which I must acknowledge with great delight; may God bless you all. I will not forget my Head of Department, Dr. H.I. Harbau, for his coordination and leadership in the department, this created a conducive atmosphere for us to learn and interact with staff as appropriate.

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ABSTRACT

The study was aimed at assessing the Impact of Availability, Adequacy and Utilization of Biology Laboratory Facilities, Materials and Equipment on Students' Academic Performance in Colleges of Education in North-West Geopolitical, Zone Five objectives, research questions and hypotheses were stated and tested on the basis of availability, adequacy and utilization of the biology laboratory facilities, materials and equipment as well as the impact of these on the conduct of biology practical. Some of the objectives are; to determine the availability, adequacy and utilization of biology laboratory facilities, equipment and materials in colleges of education in the North-West Geopolitical Zone, assess the adequacy (quantity) of biology laboratory facilities, equipment and materials in colleges of education in the North-West Geopolitical Zone. The study is a survey one, where a five Linkert scale questionnaire (consisting of parts A – D) was administered to 501 sampled research subjects. This was analysed to test all the hypotheses using simple descriptive statistics - frequency, percentages, mean, standard deviation and Chi-square and Kruskal Wallis H test. Frequency and percentages were used to analyse the demographic data, while mean and standard deviation were used to answer the research questions. Chi-square statistic was used to test hypotheses 1, 2 and 3, while Kruskal Wallis H test was used in testing hypotheses 4 and 5 respectively. The findings revealed that there was a significant difference among the respondents on the availability of Biology Laboratory facilities and equipment in Colleges of Education in the North-West Geographical Zone of Nigeria. The result showed there was a significant difference among the respondents on the adequacy of Biology Laboratory facilities and equipment in Colleges of Education in the North-West Geographical Zone of Nigeria. The conclusion from the research was that although colleges of education in Nigeria operates using same minimum standard, but the availability of biology laboratory facilities, materials and equipment varies from college to college, the same applies to their adequacy. Some of the recommendations made include the following: government should make available the

necessary biology laboratory facilities, material and equipment in all the colleges of education in the zone. Lecturers and other personnel concerned should effectively utilize the biology laboratory equipment and facilities in the colleges of education in the zone. Lecturers and students should ensure the impact of availability, adequacy and effective utilization of the biology laboratory facilities, materials and equipment be felt on the academic performance of students in biology practical exercise in colleges of education in the zone, and finally, suggestions for further studies were made.

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OPERATIONAL DEFINITION OF TERMS

The following terms were used in the discussion. They are defined operationally as follows:

Culture: Growing of organisms under controlled conditions such as temperature, light and nutrients in a laboratory setting

Curriculum Entire learning programme (experience) provided by the school which learners are expected to acquire over a period of time

Ecosystem: Place inhabited by living and non-living things

Equipment: machines or tools in the science laboratory which are used for experiment and or teaching and learning. It could be made of glass, metal, plastic, or wood.

Environment: Immediate surroundings, place around the living organism

Experiment: The conduct of test in order to discover new knowledge or verify already known phenomena

Facility: A building specifically designed, equipped and managed for a particular purpose

Laboratory: A laboratory is a facility that provides controlled conditions in which scientific or technological research and experiments can be performed.

Materials: Consumable substances, such as chemicals, reagents etc.

Organisms: Living things; plants and animals

LIST OF ABBREVIATIONS

BIO:	Biology
BLE:	Biology Laboratory Equipment
BLEQ:	Biology Laboratory Equipment Questionnaire
DFID:	Department for International Development
FGN:	Federal Government of Nigeria
LAB:	Laboratory
NECO	National Examination Council
NCCE:	National Commission for Colleges of Education
NCE:	Nigeria Certificate in Education
STAN:	Science Teachers Association of Nigeria
SSCE:	Senior Secondary Certificate Examination
UNESCO:	United Nations Educational Scientific and Cultural Organization
WAEC:	West African Examination Council

CHAPTER ONE INTRODUCTION

1.1 Background to the Study

Science being one of the subjects taught in secondary schools and colleges has to be taught in a way that will make its learning interactive and more meaningful. As a study of nature, science demands the use of experiments and investigations to study the universe, In this case, the use of laboratory facility and equipment for carrying out tests and experiments becomes necessary. Considering the objectives of science teaching which include the following, training the minds for research and investigation; discussion; objectivity and intellectual adventure, it is necessary to expose students to laboratory work which has been given a central and clear position in the teaching and learning of science.

Science has been defined differently in different ways. Some common definitions are: It is a systematic way of observation, a body of systematically organised knowledge concerning the world around us, and a way of investigating the world around us in order to discover that body of knowledge (Lawal 2014). In his opinion, Bello (2014) defined science as the attitude of enquiring, observing and reasoning with respect to the world. According to Michael (2016), science is the investigation of natural phenomena through observation, theoretical explanation and experimentation or the knowledge produced by such investigation. Science makes use of the scientific methods, which includes the careful observation of natural phenomena, the formulation of hypothesis, the conducting of one or more experiments to test the hypothesis and the drawing of a conclusion that confirms or modifies the hypothesis.

From these definitions the following can be deduced about science: science is a human activity; science is a systematised and verified body of knowledge that can be proven; science is a process of investigating and exploring the universe; science is acquired through actual practices of experimentation, observation and reasoning and that science is any branches of the natural or

physical sciences. Science therefore, can be seen as a body of knowledge and a process. The body of knowledge include the branches of science such as the natural science; (e.g. biology), the physical science; (e.g. physics and chemistry); the social sciences (e.g. psychology and sociology) and the applied sciences (e.g. engineering). The processes on the other hand are methods used by scientists to discover the body of knowledge and to solve problems of scientific nature. The processes include observation, hypothesis, measurement, classification, data collection, data analyses, reporting and interpreting data etc.

The place of science in the development and fulfilment of the needs of many countries is not in doubt. For instance; major advances in science and technology have helped nations to promote efficiency, self-reliance and overall well-being of humanity through inventions in telecommunications, transportation, health, agriculture among others (Agusiobi, 2010). The National Policy on Education (2008) stated clearly that the learner would be given opportunity to acquire basic practical skills for self-reliance and employment. For the effective acquisition of these practical skills and achievement of the objectives enshrined in the policy, adequate provision of essential laboratory equipment for the teaching and learning of science are inevitable.

Teaching and learning of science, technology and mathematics requires the intensive application of resources that would appeal all the senses of perception to improve the effectiveness of inspiration as well as maximize learning. Ige (2010) affirmed that science teaching can only be meaningful and effective if backed up with the necessary resources to enrich instruction. Other researchers have indicated that resources are potent tools, which could be used to effectively communicate science while enriching the learning experiences of the learners

Akano and Akpokiore (2011) have attributed the poor quality of education, low students' performance and poor skill acquisition in science to inadequacy of human and material

resources, such as qualified teachers, laboratory and equipment and many more. School facilities therefore, are potent factors to qualitative education. On this, Akande (2013) opined that learning can occur as result of one's interaction with the environment and other resources. Environment according to him refers to facilities that are available to facilitate students' learning through interacting with them. These include books, audio-visual, soft and hardware of educational technology, laboratories, and many others. Laboratory, therefore, is an essential facility for effective teaching and learning to take place.

The 21st century is characterized by advances in science and technology. For Nigeria to realize accelerated development in the 21st century, she needs qualitative science education in our schools especially in senior secondary schools. The role of colleges of education in this regard cannot be overemphasized. This is because, the colleges of education produces the personnel (teachers) for this level of education.

Over the last two decades, there have been repeated calls for reforms and innovations aimed at improving Education in Nigeria. This suggests that there are issues in education that needs to be improved upon; science inclusive, Daso (2013); Ogoyinka, Okeke and Adedoyin (2015). Many have argued that science cannot be meaningful to students without worthwhile practical experiences in the school laboratory. Unfortunately, the terms school laboratory or lab and practical have been used, too often without precise definition, to embrace a wide array of activities. Typically, the terms have meant experiences in school settings where students interact with materials to observe and understand the natural world. Some laboratory activities have been designed to engage students individually, while others have sought to engage students in small groups and in large-group demonstration settings. Teacher guidance and instructions have ranged from highly structured and teacher centred to open inquiry.

Laboratory practical have sometimes been used to include investigations or projects that are pursued for several weeks, sometimes outside the school, while on other occasions they have

referred to experiences lasting 20 minutes or less. Sometimes laboratory activities have incorporated a high level of instrumentation, and at other times the use of any instrumentation has been avoided.

In laboratory classes, learners spend a great deal of time handling real materials, but are required to discuss and interpret their findings and also to provide explanations of observed behaviour. For more than a century, laboratory experiences have been reported to promote central science education goals including the enhancement of students' understanding of concepts in science and its applications; scientific practical skills and problem solving abilities; scientific attitudes; understanding of how science and scientists work and more importantly, interest and motivation in the subject, Usman (2014). At the beginning of the 21st century it looks as if the issue regarding learning science in the laboratory is still relevant regarding research issues as well as developmental and implementation issues. Science cannot be meaningful to students without worthwhile practical experiences in the school laboratory. Unfortunately, the terms school laboratory or lab and practical have been used, too often without precise definition, to embrace a wide array of activities.

Many research studies have been conducted to investigate the educational effectiveness of laboratory work in science education in facilitating the attainment of the cognitive, affective, and practical goals (Eugenia 2012; Sa'ad 2015 and Aina 2013). Others are Hofstein and Lunetta in Harrison (2010); Blosser, 2013; Bryce and Robertson 2011; Hodson, 2011; Lazarowitz and Tamir 2014). All have affirmed that science laboratory has been given a distinctive role in science education. According to them, there has been little research to show simple relationships between experiences in the laboratory and student learning. Hodson (2011) has criticized laboratory work and claimed that it is unproductive, and confusing, since it is very often used without any clearly thought-out purpose, and he called for more emphasis on what students are actually doing in the laboratory. However, Galloway and Bretz (2015) opined that laboratory

activities appeal as a way to learn with understanding and, at the same time, engage in a process of constructing knowledge by doing science. They also emphasised that meaningful learning is possible in the laboratory if students are given opportunities to manipulate equipment and materials in order to be able to construct their knowledge of phenomena and related scientific concepts. According to them, it will be more interesting for science teaching to be related to real life situation. In other words, if science lessons are presented in relation to real life, students may see the relevance and may be more predisposed to learn. Example, interactions between organisms in an ecosystem; also effect of water pollution may be more meaningful to learners if they are given the opportunity to observe it practically and the consequences that this may have on the ecosystem.

Laboratory has been conceptualised as a room or building specially built for teaching through demonstration of theoretical phenomena into practical terms. Farombi (2008) argued that laboratory is essential to the teaching of science. According to him, the success of any science course is much dependent on the laboratory provision. This concurs with views of Shamsuddin (2013), that there is a general agreement by science educators of the necessity of a laboratory for a meaningful study in science. Biology, being one of the branches of science demands its teaching through the use of laboratory tests and experiments just like other fields of science.

The word biology is derived from the greek words; ‘bios’ means life and ‘logos’ means study. It is the science of life and living organisms. An organism is a living entity consisting of one cell e.g. bacteria, or several cells e.g. animals, plants and fungi Mogen (2012). Aspects of biological science range from the study of molecular mechanisms in cells, to the classification and behaviour of organisms, how species evolve and interaction between ecosystems.

Biology often overlaps with other sciences; for example, biochemistry and toxicology with biology, chemistry, and medicine; biophysics with biology and physics; stratigraphy with

biology and geography; astrobiology with biology and astronomy. Social sciences such as geography, philosophy, psychology and sociology can also interact with biology, for example, in administration of biological resources, developmental biology, biogeography, evolutionary psychology and ethics. The use of laboratory therefore, becomes necessary since organisms that may not be readily available in a particular season may be cultured in a laboratory setting. Considering the importance of laboratory facility in the teaching of science, Huxley in Eugenia (2012) asserted that science belongs to the laboratory as cooking belongs to the kitchen and gardening in the garden. It is in recognition of this that one of the conditions for establishing a science unit or department in a school is the provision of a laboratory facility and equipping it with the basic material and equipment for a meaningful study in science at all levels. Teachers recognize the value placed on laboratory work to familiarize students with the practical component; however, they feel that the lack of well-equipped laboratories, in most of their schools, is a great barrier for them to conduct laboratory work of any kind in their classes (Charles, 2012).

As a result of the immense importance attached to the role of colleges of education, which is charged with the responsibility for training and retraining of teachers; the Federal Government of Nigeria established a Commission whose role is to monitor the standards in colleges of education for quality assurance. Part of the terms of references of the commission is to monitor the availability, adequacy and utilization of the college facilities with a view to maintaining the standards. It is in line with this role that the commission set out minimum requirements for the running of all programme / courses in the colleges of education (in terms of students' admission requirements, personnel recruitment and promotion, offices and resources provision).

Biology as a course in the NCE programme under the school of sciences, like any other course, has its own minimum basic requirements for its running. In an attempt to ensure that

colleges of education adhere to the standards, a technical monitoring committee established by the commission is charged with the responsibility of ensuring their conformity with the minimum standard. This is done through accreditation visits after every five years. Colleges that could not meet up with the minimum standard are likely to have an interim accreditation or completely denied accreditation. Both federal and state colleges of education are struggling to get the minimum requirement and to maintain it. This explains the importance of the availability and adequacy of the facilities, equipment and materials in colleges of education.

The National Commission for Colleges of Education (NCCE) minimum standards for Biology (revised 2012) recommended the following facilities, equipment and materials that are basic in the establishment of a biology department in a college of education. These are as follows:

- a. A Laboratory space: At least three general laboratories for each level (of about 7.5m²), each large enough to accommodate not less than forty students.
- b. Other auxiliary facilities are Botanical garden (botanical and zoology), a museum, an aquarium and a herbarium.
- c. Others are a stock room and a preparation room that should be located adjacent to the laboratory.
- d. Minimum of three lecture halls each of which is large enough to accommodate sixty students should be provided. The large lecture halls to be equipped with public address system and an overhead projector.
- e. Staff offices: the following were recommended in the minimum standard: The office should be equipped with bulletin boards, book shelves, filing cabinet, and seats for at least three visitors and standard furniture. There should also be an office for support staff with relevant equipment.

Biology departments in colleges of education that met up this condition and others in the area of personnel and offices will be considered for a full accreditation by the NCCE. Colleges that may be deficient in these may have interim or a denied accreditation. This is in order to control the quality of biology teaching at the college level, so that lecturers can teach the subject in a manner that students will acquire the relevant knowledge and skills which will in turn have a positive impact on subsequent teaching and learning as they graduate or further studies. It is in view of this, that this study is conceived in order to ascertain what is available or not available, what is adequate or inadequate and what is utilized or not utilized in the teaching of biology in colleges of education and the impact on learning of biology.

1.2 Statement of the Problem

This study was conceived in recognition of the present biology laboratory conditions and the nature of practical exercises in them. Colleges of education, nowadays, experience a significant expansion in students' enrolment for some obvious reasons. Consequent upon of this, students are subjected to learning in difficult situations due to congestion in the laboratory rooms coupled with the inadequacies of the needed equipment, materials and facilities.

The NCCE minimum standard for biology laboratories (2012) was very clear on the number and size of the laboratory rooms, where it was stated that there should be at least three general laboratories for each level (of about 7.5m²), each large enough to accommodate not less than forty students. In addition, the following auxiliary facilities should also be provided: Biological garden (botanical and zoology); Museum; Aquarium; Herbarium, etc. Today, as a result of the rapid expansion in admission of students and the interest which they have on the study of science, these laboratories are congested and the little budget is grossly insufficient to build additional laboratories as well as equipping them with necessary materials. Where procurement of equipment and materials are made, these are packed in the laboratory store or preparation room due to the fear of their breakage and or damage by the high population of

students in the laboratories during practical lessons. In this kind of situation many students do not have the opportunity to handle or manipulate the materials and equipment during practical activities. Even in situations where alternative to practical exercises are done due to inadequacy of equipment and materials, many students do not have the opportunity to sit comfortably in the laboratory room. This undermines the objectives of practical activities in colleges of education (Crescentia and Amos 2012). The implication of this is that students will graduate without the necessary skills, employed as teachers and later encounter challenges for setting up biology laboratory practical especially during SSCE/WAEC/NECO examinations.

Nwachukwu in Hamid (2015) discovered in her survey of the resources for teaching and learning of Biology in some of the new secondary schools in Lagos. According to her, there was a general inadequacy of resources, that out of the 80 percent of the old schools with science laboratories none was well equipped and 40 percent of the schools had no laboratory at all, while the remaining 60 percent of the schools had some rooms labelled as laboratories, but without the essential equipment and materials. She therefore concluded that the teaching of Biology practical would be difficult and also students learning experiences will be limited.

Young in Joseph (2011) found that schools with well-equipped laboratories had better results in certificate science examinations than those schools that are ill-equipped. This agrees with findings of Gana in Roberts (2017) who explained that students taught through the use of laboratory methods had higher attitude scores but lower achievement scores than students taught through the traditional methods. Similarly, Yadar, (2011) opined that no course in science and mathematics can be considered complete without some practical work, which normally is to be conducted by individuals either in the laboratories or classes. This buttresses the fundamental importance of school science laboratories. Ajala (2011) discovered in his study that the very poor of resources for teaching and learning of biology affect students' learning outcomes. The state of biology laboratories according to him ranges from ill-equipped to total absence in some cases.

This concurs with the findings of Bello, (2014), that in many of the newly established schools there is one multipurpose science laboratory or none at all. Where laboratory is not available, a classroom is normally labelled as a science laboratory. This situation therefore calls for search on the condition of biology laboratories in colleges of education with a view to assessing the impact of the availability, adequacy and utilization of biology laboratory facilities, equipment and materials in colleges of education in the North – West Geopolitical zone.

1.3 Objectives of the Study

The objectives of this study are to:

1. determine the availability of biology laboratory facilities, materials and equipment in Colleges of Education in North - West Geopolitical zone;
2. assess the adequacy (in terms of quantity) of the available biology laboratory facilities, equipment and materials in Colleges of Education in North - West Geopolitical zone;
3. ascertain the level of utilization of biology laboratory facilities, equipment and materials in Colleges of Education in North - West Geopolitical zone;
4. assess the impact of the availability, adequacy and utilization of biology laboratory facilities, equipment and materials on the conduct of biology practical exercises in Colleges of Education in the North - West Geopolitical Zone; and
5. compare the level of availability, adequacy and utilization of biology laboratory facilities, materials and equipment between Federal, State and technical Colleges of Education in the North – West Geopolitical zone.

1.4 Research Questions

This study is designed to answer the following questions:

1. What are the available facilities, materials and equipment in biology laboratories in colleges of education in the North - West Geopolitical zone?
2. To what extent are facilities, materials and equipment adequate in biology laboratories in colleges of education in the North - West Geopolitical zone?

3. What is the level of utilization of the available facilities, materials and equipment in biology laboratories in colleges of education in the North - West Geopolitical zone?
4. What is the impact of the availability, adequacy (in terms of number) and utilization of biology laboratory facilities and equipment on the conduct of Biology practical exercises in colleges of education in the North – West Geopolitical zone?
5. How do Federal, State and Technical colleges of education in the North – West Geopolitical zone differ in the level of availability, adequacy and utilization of biology laboratory facilities, materials and equipment?

1.5 Hypotheses

The study is designed to answer the following null hypotheses:

- Ho₁: There is no significant difference on the availability of biology laboratory facilities, materials and equipment in colleges of education in the North – West Geopolitical zone.
- Ho₂: There is no significant difference regarding the adequacy (number) of biology laboratory facilities, materials and equipment in colleges of education in the North – West Geopolitical zone.
- Ho₃: There is no significant difference regarding the level of utilization of biology laboratory facilities, materials and equipment in colleges of education in the North – West Geopolitical zone.
- Ho₄: Availability, adequacy and utilization of biology laboratory facilities, materials and equipment have no significant impact on the conduct of biology practical exercises in colleges of education in the North – West Geopolitical zone.
- Ho₅: There is no significant difference in the level of availability, adequacy and utilization of biology laboratory facilities, equipment and material in Federal, State and Technical colleges of education

1.6 Basic Assumptions

This research assumes the following

1. The selected colleges of education have biology laboratories
2. The laboratories conform to the minimum standards set by the NCCE
3. Students do practical work in the biology laboratories
4. Students – equipment ratio is adequate
5. Laboratory Facilities, Materials and Equipment are well utilized by staff, students and laboratory technicians / attendants

1.7 Significance of the Study

For sometimes there has been public outcry especially by State Universal Basic Education Boards (SUBEB), Ministries of Education (MoE) and Local Education Authorities (LEAs) on the quality of teachers produced by colleges of education (science teachers in particular). The issue is on the student teachers who graduate, got employed as teachers without the necessary skills for managing science lessons. It is very common to see teachers panicking whenever instructions are provided by examination bodies (WAEC and NECO) to prepare for Biology practical examinations. The problem emanates from colleges of education who over admit students that the facilities in the colleges cannot contain. Since the colleges needed internally generated revenue, admissions are done in order to maximise revenue without consideration to their carrying capacities. In this way, teaching and learning in colleges (especially Biology) is not done the way it should be due high students- teacher ratio as well as equipment students' ratios in the laboratories.

This study aimed to find out the impact of availability, adequacy and utilization of Biology laboratory facilities, materials and equipment on students' academic achievements in colleges of education in North-West geopolitical zone. The findings of this study will be significant to biology lecturers and students in colleges of education, by providing information

on the status of availability, adequacy and level of utilization of the facilities, materials and equipment on students' academic performance in colleges of education. The findings will provide information to the NCCE, Federal and State Ministries of Education on the status of biology laboratories in conforming to the NCCE minimum standards and creating awareness on the justification for the demand of additional biology laboratory rooms in colleges of education and more supplies for equipment and materials in them. It will provide information to the education managers (Department of Higher Education of State Ministries of Education, Special Advisers on Education, Education Committees at the State and Federal Legislative Councils) about the conditions of biology laboratories and the way in which biology practical activities are conducted in colleges of education. The findings of the study may re-awaken biology teachers on the need to conduct biology laboratory activities / exercises in the laboratories for students to frequently utilize the available equipment and materials and to improvise where necessary. The findings of this study will prompt the college administrators to monitor or supervise more closely, biology activities / practical exercises in their colleges in order to ensure that biology lecturers conduct laboratory activities / exercises for students, utilizing the available biology laboratory facilities, equipment and materials. The findings will assist students and teachers to realise the importance of utilizing Biology Laboratory facilities, equipment and materials. It will motivate the college authorities / government, curriculum planners and developers, the academia and researchers, as well as publishers, the NGOs and science equipment manufacturers to provide more support in re-equipping of Biology Laboratories in colleges of education.

The study will not only serve as reference material for teachers of Biology, it will also assist teachers in other subject areas to realise the importance of having adequate facilities as well as their utilization. The findings of this study will pave way for further research in this area especially in exploring relationships or effects of the learning environment, school facilities and other variables on students' learning outcomes.

1.8 Scope of the Study

This study on the impact of availability, adequacy and utilization of Biology laboratory facilities, equipment and materials on students' academic performance in Colleges of education in the North – West geopolitical zone was conceived in recognition of the present day biology laboratory conditions and the way in which practical activities / exercises are conducted in them. As explained earlier, colleges of education, nowadays, experience a significant expansion in students' enrolment for some obvious reasons. Consequent upon this, students are subjected to learning in difficult situations due to congestion in the laboratory rooms coupled with the inadequacies of the needed equipment, materials and facilities.

This study covers twelve colleges of education in seven states of the North – West geopolitical zone. It is designed to assess the availability, adequacy and utilization of biology laboratory facilities, equipment and materials on students' academic performance in Colleges of Education. However, the scope is limited to only the three colleges of education in the North – West geopolitical zone; these are FCE Katsina, FCE (T) Gusau and Isa Kaita College of Education Dutsin-Ma. The study is also delimited to NCE III students in three selected colleges of education in. The choice of this group is due to the fact that they have been in the biology department for some years and therefore have been exposed to the use of Biology laboratory for quite sometimes than their counter parts in NCE I and II. The study concentrates on finding out the types of facilities, equipment and materials that are available in biology laboratories in colleges of education as it compares to the NCCE bench mark and whether the facilities, equipment and materials are adequate or not and their level of utilization by lecturers, laboratory technicians/attendants and students and the impact of their utilization in learning of biology.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.0

2.1 Introduction

The purpose of this review is to highlight the concept and impact of the Biology Laboratory generally as it relates to the availability, adequacy and utilization of the facilities, equipment and materials to and to examine relevant previous studies in this area. The review is organized under the following sub - headings: theoretical framework, conceptual framework, the concept of biology, biology laboratory facility, equipment and materials. The review also discussed the availability, adequacy and level utilization of facilities, materials and equipment in biology laboratories in colleges of education, bench mark for a standard biology laboratory, the qualifications of biology teachers, effective methods for teaching / learning of biology, impact of the availability, adequacy and utilization of facilities, materials and equipment in biology laboratories on students' performance. Lastly, empirical studies on impact of the availability, adequacy and utilization of laboratory facilities, equipment and materials on students' performance were discussed.

2.2 Conceptual Framework

This section explains the major concepts which the research is based upon. Concepts considered here are: science, biology education, objectives of biology education, laboratory experiment and laboratory facilities, materials and equipment. The broad concepts formed the framework in which Biology teaching and learning in schools and colleges operate. Student - teachers undergoing training at NCE level must understand the concepts in the course of their training. The concepts are discussed under the following sub-headings:

2.2.1 Science

The nature of science can be viewed from various dimensions. A static view of science explains science as a body of knowledge which explains the universe. A dynamic view regards science as a continuous human activity and thus, emphasises the process of science. Thus, science is the process of adding to man's knowledge of the universe in an intelligent and orderly manner. According to Monk (2008) science is an attempt by human beings to organize their experiences about nature into meaningful explanations. The history of science, its knowledge, has been a long story, which developed more than two thousand years ago. The sole basis of scientific knowledge is the fact that man is rational being and has the capacity for critical thinking. The roots of science lie in the primitive, unwritten past events of human social evolution. An example is the history of tool making and weapons through trial and error to reliance on past experience of the individuals and families and even larger communities. As time went on, man learned to leave behind deliberately the ideas going through his mind. He also indicated careful and precise observations and recording of what has happened around him in his natural environment. The ancient science was man's ability to observe the natural phenomena and speculated on their causes so as to find explanations for them in his primitive way. His method of getting knowledge was by common sense and a trial and error system. From pre historic to Greek times, man had always wanted to understand the wonders of nature, example; what is the sun, moon, the stars, sea, rocks, living and non-living things? What are things made of? The ancient scientists were pre-occupied with useful arts, such as smelting, healing (medicine) and building; these arts were later recorded in writing. The Greeks were usually taken as the original theoretical scientists. Their studies were regarded as the forerunner of pure science Adey in Martins (2010). The early development of scientific thoughts were centred mainly on pure sciences which considered how the universe works and how life have developed

into plants and animals found on the earth. The Greeks at that time had no laboratories. The only instrument which they have was their own brains, the power of reasoning.

Adey (2006) added that the founder of science has been the considered to be Thales of Miletos about 640 – 546 B.C. according to him, he made speculations about the universe and the materials composing it.

One outstanding contributions of the Greek was that their scientific ideas and methods gave rise to modern science, (the word science means knowledge in Greek). Much of their contributions to the development of scientific process of enquiry were largely through Aristotle (385 BC). He was the first man in recorded history to attempt to devise method for arriving at a reliably knowledge based on the results of observation. His writings were subsequently put together under the title ‘Organon’ meaning instrument. His major contributions to the development of science were the invention of logic as well as outline of the methods for acquiring knowledge of natural things. The Arabs, Romans, men of medieval Europe all expand on what the Greeks have done (Monk, 2008).

2.2.2 Biology Education

Biology deals with the study of many varieties of lives. It is a natural science concerned with the study of living organisms including their structure, function, growth, distribution and taxonomy (Magna, 2012). It is the study of the structure, function, heredity and evolution of all living things: micro-organism fungi, plants and animals. However, despite the broad scope of biology, there are certain general and unifying concepts within it that governs all the studies and researchers that consolidates it into a simple and coherent field. In general, biology recognizes the cell as the basic unit of life, genes as the basic unit of heredity, evolution as the engine that propels the synthesis and creation of new species. It is also understood today that all organisms survived by consuming and transforming energy and by regulating their internal environment to

maintain a stable and vital condition. Sub-disciplines of biology are defined by the scale at which organisms are studied, the kinds of organisms studied and the methods used to study them. For example Biochemistry examines the rudimentary chemistry of life, molecular biology that studies the complex interactions among biological molecules: - Botany the studies of the biology of plants: cellular biology which examines the basic building – block of all life cells. Others are Physiology which examines the physical and chemical functions of tissues, organ and systems of an organism. Evolutionary biology, examines the processes that produced the diversity of life: ecology examines how organisms interact in their environment: zoology, the study of animals: pathology the study of diseases of plants and animals and methods of controlling them. Entomology, the study of insects: Algology which is the study of algae, Parasitology, which is the study of parasites and Microbiology the study of micro-organisms. Biology Education, therefore, is education in biology which generally aims at training individuals to understand himself or herself, the parts of his or her body and how the body parts function. Hence, the application of principles of education in teaching and learning of biology is known as biology education. It is the art of teaching and training in order to inculcate or transfer the knowledge of biology to students (Okenyi, 2012), for this can afford them the opportunity of contributing meaningfully to the development of the society in one way or the other.

Biology education is system of training biologists for scientific research institutions and as instructors in biological disciplines. Knowledge of biology is provided in the training of specialists in medicine, agriculture, pedagogy and other fields requiring special natural science education. For this study, biology education is conceived as the training of instructors in biological disciplines as well as pedagogy.

2.2.3 Objectives of Biology Education

Biology as a discipline (course) is taught in colleges of education to prepare student – teachers that will assume the role of biology teachers with knowledge and skills for teaching of biology. The National Commission for Colleges of Education (2012) has stipulated the objectives for teaching Biology in Colleges of Education in Nigeria as follows:

- a) To produce knowledgeable, highly motivated, professional and effective teachers of biology who will be able to develop in students an appreciating and understanding of biological process and principles.
- b) To develop confidence in biology teachers and enhance their ability to adapt to the changing situation in science and the technologically oriented society.
- c) To view biology as a process of inquiry into the living world.
- d) To analyze the activities of living things in their environment.
- e) To demonstrate practical skills in handling scientific apparatus.
- f) To demonstrate excellence and professional competence in teaching secondary school biology.
- g) To inculcate positive scientific attitudes and values in the society and promote positive disposition towards biology, science and the scientific enterprise.
- h) To apply concepts and methods acquired in new area of study and in everyday situation.
- i) To make a successful career in biology teaching.
- j) To successfully undertake a B.Ed /B.Sc. (Ed) degree programme.

The objectives are formulated to equip teachers of biology with expertise for teaching the subject as well as to pursue a higher study in the subject. Similarly, achieving the objectives can equip learners with scientific attitudes that will help them live as functional members in the society,

2.2.4 Importance of Biology Education:

There are many facets that point to the importance of Biology. First and foremost, the science of Biology is mainly studying about life. Second, it provides an in depth scientific understanding of how all living and non-living organism interact with each other. Thirdly, it provides insights on how diverse life forms are. Moreover, biology encompasses other fields of research that are related to the sustainability of life including the environment, ecosystem, food quality, causes of illness, the development of medicines the study of the human body and many more. Biology has been of great importance worldwide for its role in socio-economic development as well as for technological advancement of the nations. Knowledge of Biology is therefore required in all countries for the simple reason that the study of Biology is one of the core subjects leading to the study of medical sciences, pharmacists, nurses, science teachers, scientists, and other related professions. Biology education helps to promote the individuals' understanding of the man's relationship with environment as well as knowledge of the interrelationship existing between living and non-living things that abound in the environment. The skills include the ability to observe, communicate, identify problems, ask questions, formulate hypothesis, analyze data, and make inferences and predictions. Others are carefulness, open mindedness and acceptances of warranted generalization. Study of biology helps to prepare the individual for vocational selection such as Pharmacy, Medicine, Teaching, Agriculture and many other professions related to Biology. It helps to increase the individual's interest and aesthetic appreciation of nature. It helps to stimulate the individual's interest in biologically-based hobbies such as growing flowers, collecting insects, etc. thereby encouraging leisure activities for individual enjoyment. It helps to impart factual knowledge and stimulate scientific reflective thinking so as to produce a better informed individual. Biology helps to inculcate in the individual scientific skills and attitudes in his approach to personal and social problems. Study of importance of plants in botany makes us understand

their role in human survival. They are the resources which provide many of the basic needs like food (for both humans and animals in the form of carbohydrates, proteins and fats), clothing (they are the largest supply of fibres as cotton required to make cloth), shelter (as they provide interior and exterior furniture), medicines (as they are greatest sources of medicine).

Considering the above, knowledge of biology cannot be over emphasized, as it is one of the foundation disciplines for further study in other professions like medicine, agriculture, pharmacology and so on. Knowledge of biology also provides information on the types of living forms in the biosphere and the kinds of interactions that exist between them. Thus, study of biology is fundamental as it affects the quality of life directly or indirectly and therefore should be given the necessary attention.

2.2.5 Laboratory experiment

Laboratory experimental method is a controlled environment and is the main method used natural sciences such as biology, Chemistry and Physics, which enables the scientist to measure precisely the effects of independent variables on dependent variables, thus establishing cause and effect relationship. This in turn enables them to make predictions about how the dependent variable will act in the future (Thompson, 2012). The teaching of science is more effective using the laboratory experiments due to the following advantages as identified by Thompson (2012): there is accuracy and precision of results, acquisition of science processes skills as well as development of desirable scientific attitudes.

Laboratory helps to provide a forum wherein the learner is given exercises to subject his beliefs, ideas, and theoretical propositions to some forms of experimental test (Owoeye and Yara, 2011). To maintain and arouse the interests of students in subject involving laboratory experiment, the teacher should be effectively involved in order to transfer knowledge and facts for better performance in any examinations. Adeleye (2012) indicated that material resources are used to ensure effective teaching and learning, such as classroom/Laboratory,

equipment/supplies, material/audiovisual aids. According to Abdullahi in Paul (2012), laboratories were not usually associated with science but had become a scheme subject before the invention of instruments designed especially for scientific purposes. Most of the scientific equipment in the laboratory before 1960 was borrowed from practical crafts and craftsmen, whose tools were much better than those that the scientist used during that period. Before laboratory work becomes a permanent feature in science teaching in high schools in the nineteenth century, there was a tradition whereby community scientists arranged demonstration lectures that usually attracts youngsters who were interested in learning science. Eminent pioneer scientist of the calibre of Lavoisier (1743-1794), Priestly (1776-1804), Cavendish (1731-1810), Dalton (1766-1844) and Berzelius 1776-1848) converted their homes into laboratories where regular demonstration lectures were held. In Nigeria today, most modern science curricular emphasize students' involvement in science teaching through practical works in the laboratories. Examples of Nigerian science projects which place much emphasis on laboratory work are Nigerian Integrated Science Projects (NISP) developed by the Science Teachers' Association of Nigeria (STAN) and the Nigerian Secondary School Science Project (NSSIP) developed by Comparative Education Study and Adaptation Centre (CESAC). Such emphasis is in keeping with the demand of science which requests certain skills to be developed in the students. Such derivable knowledge or skills according to Ekwuozor in Mary (2010) include:-

- a. ability to plan an experiment and analyzes the practical problem with its component parts;
- b. ability to perform experiment; and
- c. ability to interpret the results of the experiment as well as draw conclusions.

Acquisition of the above skills will no doubt equip one to be a useful member of the society in which he or she belongs to. The role of laboratory exercises and activities in this regard cannot

be over emphasised. The challenge now for teachers of biology is to think of how they can plan and engage students with activities that will facilitate their biology lessons.

2.2.6 Biology Laboratory Facility, Materials and Equipment

A Laboratory is a place specifically designed, equipped, organised and managed for the purpose of scientific investigation, this could be at the school or factory setting. In the school setting, a laboratory is a place specifically designed, equipped, organized and managed to help pupils / students learn what science is and how scientists investigates. It is a special facility where experiments are done and typically contains equipment, glass wares, burners and other tools necessary to complete experiment. It provides controlled conditions in which scientific experiments can take place (Ado, 2012).

Two types of Laboratory are recognised, these are indoor and outdoor the indoor laboratory (Nwakonobi and Igboabuchi 2010). According to them, the indoor laboratory is a room specifically designed for the purpose of experimentation. It contains additional rooms (office, store room), working benches, and storage shelves, services (water, electricity and gas points). Other auxiliary rooms are museum and herbarium. The outdoor laboratories, on the other hand are places where biological experiments and investigations can take place. These include botanical/zoological garden; school field, a nearby pond or farm and many of their types.

Facility refers to a selected structure, elements, arrangement or materials, such as a school building; a plan or layout of a building (Australian Council for Educational Research, 2008). In this context, it refers to a special place or material(s) that promote the learning of science through practical or investigative approach. A school facility consists of all types of buildings and other materials that are used for academic and non-academic purpose. These include equipment, classroom facilities, furniture, instructional materials, audiovisual aids, toilet, ICT, library and laboratory materials and others which play a vital role to smoothly run teaching and learning process.

As early as the nineteenth century, Laboratory work had been recognized by science teachers as well as researchers in science education as one of the most distinctive feature of science instruction. In fact, Griffin in Harrison (2013) explained that the Laboratory has won its place in school; its introduction has proved successful. It is designed to revolutionize science education; pupils will go out from our laboratories able to see and do. This explains the paramount importance of a laboratory facility and the need to provide essential equipment for the students to see and do; without which learning of science would be a mirage.

Dahar and Faize (2011) opined that science laboratories have made this world very advanced and scientific in its purposes. According to them, in a laboratory or field learning environment, students work individually or in small groups on a question, problem or hypothesis. They use the processes and materials of science to construct their own explanation of biological phenomena. Therefore, learning of science must combine a field work and use of laboratory facility. The distinction between laboratory or field learning and traditional classroom learning according to them is that activities are students-centred, with students actively engaged in hands-on, minds-on activities using laboratory or field materials and techniques. This has been known to enhance learning in science and improve the understanding level of students (Lunetta, 2007).

Buckley, Schneider and Shang in Tadesse and Maeregu (2014) explained that school facilities enable the teacher to accomplish his/her task as well as help the learner to learn and achieve effectively. They emphasized that the availability and proper use of school facilities can affect the interest of the teacher to teach effectively, this will in turn positively affects student's academic achievement. This means that facilities in the school need a proper attention as they have a great value in the support of teachers and students morale and motivation; moreover, plays a significant role to improve the quality of education.

All the basic needs of the society will call for acquisition of skills and understanding of modern technologies. To acquire skills in modern technologies, a thorough knowledge and understanding of related science is essential. In other words, schools would have to organize their science teaching at all levels of education in such a way that students 'Do' science instead of merely learning science. Doing science implies going into the science laboratories to carry out scientific investigation, in this regard biology Laboratory as a school facility has been observed to be a potent factor. Its availability and utilization is essential for effective teaching and learning and consequently, a good performance in students.

According to the Clinton-Gore Administration (2000) report on modernizing America's schools, good facilities were an important precondition for student learning, provided that other conditions were present that supported a strong academic program in the schools. Researchers have found that poor achievement was attributed to specific building features such as substandard science facilities, noisy external environments, air conditioning, classroom furniture, as well as locker conditions. Supporting this view was Akande (2013) where he asserted that learning can occur through one's environment – facilities that are available to support students' learning and mastering better basic concepts of biology when they can learn by doing. Appropriate facilities, equipment and adequate utilization of them are necessary if school science course is to be successful (Crescentia and Amos 2011).

Over the years, many studies have been carried out to assess the relative effectiveness of laboratory and demonstration approaches to science learning. According to Bates, in Kempa (2008), most of these studies failed to establish any superiority of the laboratory over any of the other conventional methods of teaching science when assessments were based on paper and pencil achievement tests. He added that some of the studies on the effectiveness of the science laboratory revealed that students who had regular laboratory sessions tended to develop a range

of manipulative skills than their counter parts that did not have the opportunity to access laboratory work.

In a study by Lawal (2016), he discovered that in biology laboratory, physical structures as well as equipments in the schools studied were inadequate and far below standard. More effective learning goes on when many senses are involved. The sense of hearing alone easily leads to forgetting. Akuezuilo (2010) maintained that true learning is the result of many sensations interacting and merging with one another. If one or more sensations are omitted during learning process, the final impression is weakened, not only by the absence of the missing sensations, but also the absence of their effect on each other. The actual impression is that all the senses are important, but there are some that are more important than others. Supporting this was Morah in Juliette (2015), that man learns through his five senses; sight, touch, taste, smell, and hearing. In Juliette's analysis of our degree of learning, she posited that 1% of our learning is acquired through sense of taste, 1.5% through touch, 3.5 % through smell, 11% through hearing and alarming, and 83% through our sense of sight. Therefore, a lesson in which lecture and demonstration with visual aids are effectively utilized will tend to be more relevant to our most pattern learning and be more likely to stimulate and sustain learner's interest and understanding and retention of the material learned than that which appeals to other senses. Similarly, different people prefer a particular learning style more than others, it is therefore, essential for teachers to be aware of this and vary their teaching styles in order to accommodate learners needs; biology laboratory activities help in achieving this.

Learning is essentially a social process and teaching is only an instrument of learning. It therefore, becomes necessary that a teacher should use all types of machinery in guiding students' learning. The machineries that can be used in guiding learning are called instructional or teaching materials/aids NERDC (2009). Teaching/ learning resources are many and varied covering a range of objects, facilities, processes, locations, and human, from which teachers /

learners can obtain information to meet their teaching/learning needs. For a biology teacher, these resources are indispensable tools in his/her possession for the achievement of the objectives of teaching. According to Nzewi and Nwosu (2009), resources in teaching process include anything or anybody to which or whom a teacher or a learner can turn for information or help. From this definition, the following are some examples of teaching and learning resources: teachers, doctors, nurses, material resources e.g. chalkboard/whiteboard, textbooks, magazines, books e.g. reference materials, textbooks, magazines, non- printed materials; e.g. Pictures, drawings, community resources, e.g. farms and hospitals. These resources are indispensable to good science (Biology), teaching and learning (NERDC, 2009).

The relevance of science in development of the nation cannot be over emphasized. Science is a major subject taught in schools all over Nigeria and any nation that hopes to develop must not neglect the teaching of science in its schools. One of such science subject is Biology, which remains one of the basic sciences whose teaching and learning is universally known to be efficient and successful if taught with adequate instructional materials and use of relevant method. Adeyemi (2011) reported that resources for Biology teaching and learning are either in shortfall or lacking in schools due to insufficient fund; this has led to low achievement of students in Biology. There is therefore the need for improvisation of instructional resources and equipment for effective Biology teaching and learning in schools where resources are either not available or inadequate.

Teaching materials on the other hand, are those equipment and materials that a teachers uses to illustrate, emphasize, and explain a lesson in order to make it clearer to the students (Ajagun 2010). These materials and equipment include sophisticated objects or simple familiar ones that can be locally obtained (Nzewi and Nwosu, 2009). Ahmed (2008) opined that teaching materials also referred to as instructional materials or teaching aids. It should be noted that instructional materials or teaching aids are not and cannot be substituted for the teaching process

itself. However, the value or importance of teaching materials/ resources cannot be over emphasized. For Nzewi and Nwosu (2009) the importance of resources for teaching and learning processes is to provide the teacher with the means of expanding the horizon of experience of students, thereby seeking to have a counterpart of first-hand experience. Teaching resources help to provide materials and opportunity for experiment. This ensures students participation in the lesson, which promotes effective learning (Nzewi and Nwosu, 2009). The NCCE minimum standard curriculum for Biology that is currently in use in Nigerian colleges of education is activity- based and emphasizes the acquisition of productive skills for life- long learning. This requires creativity on the part of the teacher in sourcing for and using appropriate instructional resources for teaching and learning where they are not available.

Godswill (2013) asserts the study of biology provide students with opportunities to develop an understanding of our living world. According to him, Biologists recognize that knowledge based upon experimental results and accurate observations is gained through a variety of experiences. Thus, the role of the laboratory and field learning becomes a key component in the understanding of biology. Laboratory field activities and inquiry provide students with opportunities to question, observe, sample, experience, and experiment with scientific phenomena in their quest for knowledge of living things. The presence of a laboratory in a school or college, therefore, is to help teachers develop in the students an appreciation and understanding of biological processes and principles.

Teaching and learning have a lot to do with resources. The more the resources, the better the chances of attaining higher quality education are achieved in schools. This is obvious with learning of biology especially where laboratory is involved. Supporting this was Wehmeier (2010) who explained resources as a supply of something that can be used to help achieve an aim. According to him, one of the most needed resources in teaching and learning of Biology are laboratory equipment. He added that in the laboratory, a scientist requires basic tools and that

knowing the functions of the different tools is a start to learning the processes. The value of laboratory work as a means of involving students in concrete experiences with objects and concepts has been suggested and emphasized. Akusoba, (2015) reviewed the laboratory practical strategies that were used from his work. According to him, a teacher could gain insight with a variety of outcomes from particular techniques. Umeoduagu (2016) classified resources into human and non-human. According to him, the two are working together. He explained that application of non-human resources in human enterprise dated back to the Stone Age period when man utilised objects like stone, pebbles, beads, sticks, cowries and so on for communication and learning. Advances in technology have brought about tremendous applications of technological products in improving the effectiveness of instruction in the classrooms.

In spite of the important role played by school science laboratory, some educators (mainly science educators) started to criticize laboratory work: for its considerable preparation time by the science teachers; for the huge financial outlay involved in setting up a standard science laboratory; for using a substantial amount of school space; for the hazards involved in carrying out laboratory activities (Mbajiorgu, 2013). Whatever the case, laboratories are necessary in the teaching and learning of science (especially biology) because it provide forum for investigations under controlled conditions. Where a standard laboratory cannot be provided, a classroom can be designated a science room, where this is not possible a corner in a classroom may be designated a science corner, and collected materials can be kept there for usage, especially in a secondary school or newly college of education, before constructing the standard laboratory. This is known as improvisation.

In a study by Ahmed (2014) on the educational effectiveness of laboratory work in science education in facilitating the attainment of the cognitive, affective, and practical goals, he discovered that science laboratory has been given a distinctive role in science education.

According to him, research has failed to show simple relationships between experiences in the laboratory and student learning. Hudson in Ahmed (2014) criticized laboratory work and claimed that it is unproductive and confusing, since it is very often used without any clearly thought-out purpose. Hudson advised that teachers should put more emphasis on what students are actually doing in the laboratory. However, these should not be reasons or excuse to avoid Biology practical activities in schools especially that accidents in the school science laboratories are very rare. Science educationists like Oluwale (2009) and Akuezulo (2010) objected the above assertions where they explained that laboratory activities appeal as a way to learn with understanding and, at the same time, engage in a process of constructing knowledge by doing science. According to them these should not be reasons for condemnation of laboratory work due to the invaluable benefits derived from it. Furthermore, in every laboratory there are rules and regulations that govern the laboratory activities which are normally read, understood and complied with by all users of the science laboratory. Although accidents may be inevitable, safety measures and first aid procedures are also available. Furthermore, meaningful learning is possible in the laboratory if students are given opportunities to manipulate equipment and materials in order to be able to construct their knowledge of phenomena and related scientific concepts. This concurs with Asubel (2009) ideas on meaningful learning and constructivist learning theories. Supporting this, is the Chinese proverb, which states that I hear, I forget, I see, I remember and I do, I understand better; thus psychological principle of learning by doing becomes desirable.

2.3 Theoretical Framework

The research is hinged on the following theories of learning:

- a. Bruner's theory of cognitive learning
- b. Piaget's developmental theory
- c. John Dewey's theory on experience, reflection and learning
- d. David Asubel's theory

2.3.1 Bruner's Theory

Bruner is a psychologist who emphasised discovery as a major instructional strategy particularly in the area of science. Discovery learning according to Bruner (2009) is all the forms or methods used for obtaining knowledge by an individual. Bruner recognised two forms of discovery learning:

- i. Assimilation: where the learner recognises a new situation or information that is similar to some existing knowledge; the learner then assimilates the new situation or information.
- ii. Accommodation: where the problem or new knowledge is incompatible to the existing knowledge, the learner reorganises his cognitive framework so that the new material can be accommodated. According to Bruner (2009), when a learner is confronted with difficulties and contradictions, he is motivated to find out and discover new information through the reorganisation and restructuring of his ideas so as to assimilate or accommodate the new material.

Bruner's theory states that 'to perceive is to categorise, to conceptualise, and to learn is to form categories; to make decisions is to categorize'. According to him, people interpret the world in terms of similarities and differences and suggested a coding system in which people have a hierarchical arrangement of related categories. Each successively higher level of categories becomes more specific. The major variable in this theory of learning is the coding system into which learners organizes this coding system. Bruner believes that the system facilitates transfer; enhance retention and increase problem solving and motivation. He also advocated the discovery oriented learning methods in schools which he believed helped students discover the relationships between categories.

The concept of spiral curriculum in science teaching was explained by Bruner. According to him, any knowledge can be taught to any student at any level of his mental development provided the teacher is honest. This is the basis for spiral curriculum, where the teachers starts

with a simple idea from the initial stage and progressively build on the same idea in the advancing years increasing the scope. In essence, Bruner is saying that learning should be structured from the simple to the complex. Example, the concept 'cell' can be initiated from JSS up to the university level increasing the scope.

Implications of Bruner's theory for teaching

Bruner's discovery oriented learning methods can be applied in the teaching of biology using experiments which involves activity oriented learning. As Bruner advocated, experimentation helps students' active transfer and aids application of knowledge, because in experimentation, students have the opportunity to handle apparatus, make observation, predict phenomena, design and carry out experiments to test their prediction. Therefore, the establishment of biology laboratory alone is not enough for students to learn biological concepts and skill; rather it should be well supplied with materials, equipment and other necessary facilities that will allow for the acquisition of desired skills. These objectives will be achieved if learners are allowed to learn science really like science.

In discovery learning, teachers are expected to issue instructions to pupils by way of posing problems to them so as to stimulate them and initiate individual discovery. The students are to be presented with activities that stimulate mental processes; such as classifying, observing and inferring, etc. All these are activities that are inherent in the teaching of biology at any level of education. Teachers using discovery learning style need to note that it is time consuming and a lot is needed in terms of preparation and execution.

2.3.2 Piaget's Theory

Piaget in Vygotsky (2012) explained that developing children actively and adaptively build cognitive structures (schemes) for understanding and responding to physical experience within their environment. Through successive stages of intellectual development, children develop intellectual structures that enable them have greater understanding not only of the world, but also

of themselves. According to Vygotsky (2012), Piaget considered intellectual activity to be a biological function, where he described development and adaptation of mental operations or thoughts structures, e.g. counting, classification etc which progress through rich interactions with the world. In his opinion, Tony (2015) explained the four stages of intellectual development by Piaget as having a constant sequence in which the time of manifestation may vary with the individual and the culture in which he/she belong to. Some scholars like Monk (1994) argued that the sequence is not permanent, according to him the stage can manifest at any level depending on the environment and the environment which a child find him or herself. The stages are as follow

- i. sensory motor stage (birth – 2 years old),
- ii. pre-operational (2-7 years),
- iii. concrete operation (7-11 years), and
- iv. formal operations (11 years and above).

The sensory motor stage is a pre-verbal stage in which most children cannot talk during this period. Objects exist only when in view and most infant behaviour at this stage is a reflection. The pre-operational stage is the period in which the child begins to have an organised knowledge. Ego-centrism is a prominent factor at this stage of development. In this period, child does not view quantity as constant and unaffected by changes in shape and appearance of the containing vessel. The child also does not conserve and has no operational reversibility in thought and action.

At concrete operational stage conservation of volume starts to be evident. During this stage, a child can easily say one object is more or less than the other; the child's thinking is concrete rather than abstract, however the child can perform simple logical operations. The concept of reversibility also develops at this stage.

In formal operation, the power or ability of abstract reasoning develops. This is the ideal period in which Biology as a subject begins to be taught in schools. At this stage, the child can perform simple experiment, setting all factors equal, but one variable. In this stage logic is hypothetical system in which the form of logic can be independent of the particular content of the problem. Example, a student at this stage can tell that one kilogram of feathers is equal to one kilogram of stones or lead; however a child at the concrete stage will reason that a kilogram is a kilogram, but comparison between feathers and stone or lead can easily interfere with his / her reasoning.

Piaget in Paul (2015) explained four factors that contradict to intellectual development as follows:

- i. Nervous maturation – according to him this varies from one society to another due to socio-cultural differences
- ii. Encounter with experiences – that experiences of physical reality is the basic factor of intellectual development
- iii. Social transmission – this is a structure that stimulates a child to receive information, e.g. educational, cultural, linguistic, etc.
- iv. Auto regulation/equilibrium – this is a process of assimilation and accommodation when new knowledge is encountered.

Implications of Piaget's Theory for teaching

While Piaget has not mainly been concerned with schools, one can derive from the theory a number of general principles which may guide educational procedures. The first of this is that the child's language and thoughts are different from that of adults. Teachers must be aware of this and must attempt to observe children very closely in an attempt to discover their unique perspectives.

Secondly, teachers should know that children need to manipulate things in order to learn. Formal verbal instruction is generally ineffective especially for young students. Utilization of Biology laboratory facilities, materials and equipment will no doubt help to achieve this. At the formal operational level (a level at which NCE students are) the students are able to interpret reality by deductive comparison and also able to compare alternative models relating to independent variables to each other and formulate models. Centred educational curriculum should be emphasised; good pedagogy must involve presenting the students with a situation in which they can experiment, try things to see what happens, manipulating apparatus and providing solutions, etc. Piaget believed that intelligence grows through the processes of assimilation and accommodation and careful planning is needed for these to take place, the factors that contradict to intellectual development should be understood by teachers and see how these can be minimised when planning and developing lessons.

Piaget in Tony (2015) believed that all children must go through these stages from infancy to adolescence, but the rate at which children get to any particular stage depends on their experience with the environment. The stages materialise when the time comes. It is important to note that there is nothing teachers and parents can do to skip any of the stages, the best that can be done is to realise the limits of children's understanding at each of the stages of development and to plan teaching within those stages. In scientific problems solving, formal thinking enables adolescents to systematically manipulate variables and reason about unknown, such as algebraic variables. At this stage of intellectual development, biology is taught through the active participation of students because they are ready to experiment through the handling and manipulation of equipment and materials. Teachers should note that learners need to manipulate, experiment, question and search answers for themselves. To achieve these, biology laboratories must be well equipped; materials and equipment should be fully utilized by all laboratory users.

2.3.3 John Dewey's Theory

Michael (2012) explained the theory of Dewey, where he emphasized the experimental aspects of learning. According to him, learning results from our reflections on our experiences as one strive to make a sense of them. He added that the role of education is neither to cater completely to a learner's inclinations nor to attempt to force upon a child pre-ordained curriculum which takes no account of the learner. He saw children's minds as flexible, expansive and unformed. Educators should use Dewey's theory to structure learning environment that engage children in inquiries which will guide them towards broader knowledge.

Dewey believed that human beings learn through a hand on approach. This places his theory in educational philosophy of pragmatism. Pragmatists believed that reality must be experienced. This means that students must interact with environment in order to adapt and learn. The same idea was true for teachers and that teachers and students must learn together, that is equal voice among all participants in the learning experience. Dewey explained that in classrooms where students are allowed to explore the learning environment, the role of the teacher changes to that of a facilitator rather than an expositor of knowledge.

According to Dewey in Emel (2012), real education is achieved via experience; however, some experiences become so disjointed with one another that it becomes impossible to establish any link. Teachers have a great duty in ensuring that the experiences gained in laboratory experiments have the desired link with day to day experiences. To achieve this, supply of material resources as well as the use of effective strategy becomes desirable.

The learning theories of Jean Piaget, Jerome Brunner, Lev Vygotsky and John Dewey serve as the foundation of constructivist learning theory. Constructivists believe that all learners have the ability to construct knowledge in their own minds through a process of discovery and problem solving (Chowdhury, 2006). Constructivists views learning as a process in which the learning activity constructs or builds new ideas or concepts or experience (Nwagbo & Obiekwe,

2010). In other words, learning involves constructing one's own knowledge from one's own experiences. Constructivist learning therefore is a very personal endeavour, whereby internalized concepts, rules, and general principles may consequently be applied in a practical real- world context. Constructivism is a cognitive learning theory because of its focus on the mental process that constructs meaning. Bruner's theoretical framework is based on the theme that learner construct new ideas or concepts based upon existing knowledge (Bruner, 1960 in NCCE/TDP/DFID 2015). This theory emphasizes the significance of categorization in learning. Learning theories suggest that verbal presentation of ideas, concepts, generalization and facts otherwise known as teacher directed teaching behaviour, do not promote meaningful learning as it appeals only to the sense of hearing. For learning to be effective more senses should be stimulated. Biology laboratory activities provide this opportunity as users have the chances of using them where more senses are stimulated.

Implications of Dewey's theory to teaching and learning of Biology

Dewey believed that learners should be involved in the use of tools (such as microscope) and research techniques used by scientists. According to him, this can make learners' inquiries and investigations more powerful and engaging. Therefore, providing basic equipment and materials in the biology laboratories in colleges of education will go a long way in making a positive impact on students learning of biology.

This study is hinged on the theories of Dewey, Piaget, Bruner and constructivism. In these theories emphasis was laid on learner engagement in the lesson and interaction with materials, which Biology practical exercise is concerned with.

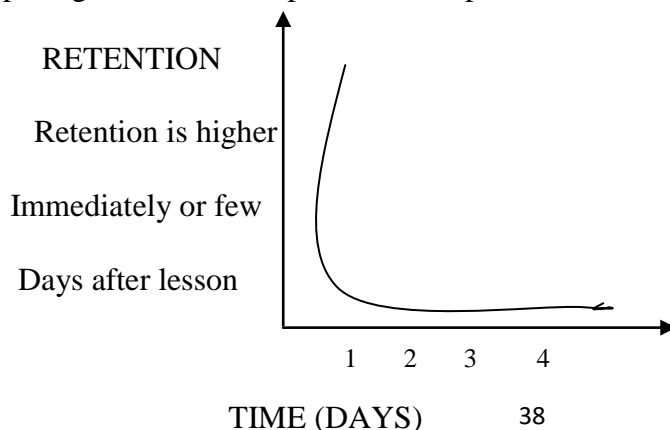
2.3.4 Asubel's Theory

Asubel criticizes Brunner's theory on the ground that it is inefficient, time consuming and allow students to be subjective and develop a tendency to jump to hasty conclusions. He suggested that science curriculum should be concerned with the systematic presentation of

organised body of knowledge as end in itself as well as a method of inquiry. Asubel also advocated for breadth after depth in the content of science. According to him, the introduction of depth gives the learner a taste of scholarship and a tool for research in inquiry. He provided a theory of learning which emphasises the dependence of new knowledge on old knowledge. According to him, teachers must consider cognitive functioning and psychological sets of the learner as new knowledge is internalised. That is teachers must distinguish between rote learning where new knowledge is arbitrarily incorporated into cognitive structure in contrast to meaningful learning, where new knowledge is assimilated into specifically relevant existing concept or proportions on cognitive structure.

Asubel explained the subsumer as the knowledge which the learner already acquired that can provide for association with different concepts of the new knowledge. He proposed a theory that distinguishes between rote learning and meaningful learning and how previous knowledge affects learning process in science. Based on Asubel’s theory, meaningful learning occurs when there is an interaction between the existing previous knowledge and the new information or knowledge to be acquired. However, where there is no previous knowledge or interaction, rote learning occurs.

Use of Biology laboratory facilities, materials and equipment are essential advance organisers that helps to promote meaningful learning. Babatunde (2013) explained that meaningful leaning is ensured immediately after a lesson as retention is higher, but this decreases with passage of time. He represented the phenomena with a forgetting curve, thus:



The forgetting curve shows that students forget in time. Most information is retained within the first few days after which the learners tend to forget at a very rapid rate. However, when learners are given the opportunity to interact with materials and equipment in Biology laboratories it helps to make learning more permanent, because of their utilization of them. This supports the Chinese proverb, that 'I hear, I forget, I see, I remember and I do I understand better'.

Implications of Asubel's theory to teaching and learning of Biology

The implications of this theory is that, teaching should be conducted in such a way that the ideas are stated in terms already familiar to the learner in which he can immediately relate the new learning. This method of interaction, Asubel called sub-sumption model. In short what this means is that new knowledge must be built to the existing knowledge so as to create a meaning. In situation where there are no relevant or related subsumers, Asubel suggested the use of advance organisers. That is alternative set of links to the new knowledge (teaching aids, stories, questions, examples). However, he emphasised on the use of subsumers, because according to him, most meaningful learning takes place via the use of subsumers. In lessons where subsumers and advance organiser are lacking, Asubel explained that rote learning will take place. Rote learning concerns memory work and students tend to forget things with passage of time.

Instruction in Biology teaching and science generally, should be concerned with broad and general organised statements that must include ideas which students are conversant with. Such instructions must be expository enough to bridge the existing knowledge and the new learnt material

This study hinged on the theories of Bruner's discovery learning, Dewey and Constructivists. In discovery learning, students are to be presented with activities that stimulate mental processes; such as classifying, observing and inferring, etc. These are activities that are inherent in the teaching of biology at any level of education. Teachers using discovery learning

approach engage students in making observations, predict phenomena, design and carry out experiments to test their prediction. The establishment of biology laboratory alone is not enough for students to learn biological concepts and skill unless the students are given opportunities to use them. It is for this reason that Biology laboratories should be well supplied with materials, equipment and other necessary facilities that will allow for the acquisition of desired skills. These objectives will be achieved if learners are allowed to learn science really like science.

Similarly Dewey believed that learners should be involved in the use of tools (such as microscope) and research techniques used by scientists. According to him, this can make learners' inquiries and investigations more powerful and engaging. Therefore, providing basic equipment and materials in the biology laboratories in colleges of education will go a long way in making a positive impact on students learning of biology.

This study is hinged on the theories of Dewey, Piaget, Bruner and constructivism. In these theories emphasis was laid on learner engagement in the lesson and interaction with materials, which Biology practical exercise is concerned with.

2.4 Availability of Facilities, Materials and Equipment in Biology Laboratories

Teaching resources, teachers' skill, and curriculum played a vital role in a child's education. Educators needed to be informed about the conditions of their school facilities as well as appreciate the differences that facilities could make in helping to educate their students. Resources according to Hornby (2008) are supplies of something that a country, organization or an individual has and can be used especially to increase wealth. Resources can be human, financial and material available in the institution or organization which is used as inputs in production. Biology laboratory resources can therefore be said to be supplies of teachers, learners, laboratory assistants/technologists, instructional materials and other necessary devices provided to the school to increase wealth of knowledge which gives help, support or comfort when the need is appropriately implemented.

Udo (2012) explained that a report of the National Science Board Commission on Pre-college Education, Mathematics, Science and Technology stressed that most states are failing to provide students with adequate tools, resources or facilities needed to excel in the 21st Century. Considering the aim of science laboratory and the need for adequacy of laboratory facilities in schools and colleges for effective teaching and learning to take place; teachers should ensure that adequate laboratory facilities are procured and students are allowed to access them.

Biology laboratory resources had been categorized into two namely: human and material resources. Human biology laboratory resources in colleges of education comprise all human beings or resourceful individuals who in one way or the other aid effective utilization of material resources in biology laboratories. These human resources include teachers, learners, resource persons, laboratory assistants and technologists together with other non-professional personnel (Okoli and Osuafor, 2010). They make up the workforce of biology departments in colleges of education that aid the effective management of biology laboratory material resources. Chimezie, Ike and Iwu (2002) pointed out that these are devices which present a complete body of information and largely self-supporting rather than supplementing in the teaching learning process. Educational material resources are those things which are manipulated, seen, heard, read or talked about plus instruments which facilitate such activity (Okafor, 2000). Such material resources according to Okafor are both tools for teaching and avenues for learning. They include textbooks, chalkboards, model/make -ups, television, radio and other projected as well as non-projected devices. Material resources whether they are real or representations, their main purpose is to improve the quality of teaching and learning.

In a study by Akpan (2010) he observed that chemistry practical was not conducted regularly in plateau State schools, except during the few months of WAEC examinations. According to him, if there were materials to work with, chemistry practical would have been conducted regularly throughout the year. This means that laboratory work is done only during

WAEC examinations due to high cost of materials and the growing students' population in schools. The situation is not only in Plateau state. Sa'adu (2015) reported that in many schools nowadays, there is only one general purpose science laboratory which is grossly inadequate for the teaching of sciences, a phenomenon that affects most of the newly established day secondary schools. For the older schools, the equipment and materials are either obsolete, damaged and / or that the number of students have outstretched the facilities and equipment available. Where this is so, no meaningful science learning would take place. This has agreed with the findings of Beskeni in Paul (2015) where he investigated the supply of equipment and material in chemistry laboratories in senior secondary schools in Plateau state using a survey method. The study covered 120 senior secondary schools randomly selected from the 17 Local Government Areas of the state. The study investigated the type of laboratories used for chemistry practical, those responsible for financing and purchasing the equipment and materials of chemistry laboratories. A checklist for chemistry practical inspection was used to find out the supply of equipment and materials in the laboratories and suggestions given by teachers for improving the supply of equipment and materials in senior secondary schools chemistry laboratories. The findings were: majority of the schools used general laboratory for teaching chemistry, because of this they cannot meet the laboratory conditions for chemistry laboratory. Those using chemistry laboratory were few and some do not have laboratory at all, other findings are; greatest focus of laboratory equipment is the government, all the schools sampled had the common materials except that they were not enough, some were functional and some damaged. In some schools the equipment and materials are there but not frequently used. In this study, the theories of reviewed Dewey, Asubel, Piaget and Bruner were reviewed; however, the theories of Dewey and Asubel formed the framework for the study.

2.5 Adequacy of Biology Laboratory Facilities, Equipment and Materials

The teaching and learning of Science is more effective through the activity – based approach; Biology being one of the branches of science is not left out in this regard. The teaching of Biology at the secondary and tertiary levels requires the availability of laboratory facilities, equipment and other materials necessary for teaching it, therefore, the argument in favour of adequate laboratory facilities, equipment and materials in the teaching and learning of the subject (Biology) are convincing in themselves. To think about learning of Biology without the necessary facilities, equipment and materials is like thinking of a motor mechanic without the workshop and necessary tools. According to Sa'adu (2015), observation on present decline in academic achievement as well as students' performance in Biology was found to have a link with the inadequacy of Biology laboratory facilities, equipment and materials. Oyedepo (2009) discovered that in schools where facilities are inadequate Biology is usually taught in abstract manner (theoretically); in which case, students are not given the opportunity to develop experimental and enquiry approach to the study of the subject and science generally. Goje (2014) reported that students perform poorly in science (Biology inclusive) for many reasons; among them are the non-availability and or inadequacy of resource materials.

Fundamental research among science educators and cognitive scientists focuses on how people learn science and how they apply this knowledge in their daily lives. Science education provides students with knowledge, training, and learning experience while stimulating their physical and mental growth. According to the National Science Board Commission on Pre-college Education, Mathematics, Science and Technology, in its report stressed that, most states are failing to provide its students with adequate tools, resources or facilities needed to excel in the 21st Century. It is necessary to provide students with a strong broad background in the area of science and mathematics education when laboratory facilities are adequate in schools,

students should be offered opportunities to enable them grow in their problem solving abilities, think critically and acquire scientific and technological literacy Neji (2014).

2.6 Utilization of Biology Laboratory Facility and Equipment

One major problem facing science teaching is the utilization of laboratory materials and equipment by staff, students and the laboratory technicians / attendants. Literature and researches on the extent of utilization of laboratory facilities and academic performance in Biology seem to be relatively limited and scanty. Utilization of laboratory facilities is the frequency with which the available laboratory facilities are used during laboratory experiments. Laboratory facilities can be available, adequate but not utilized during science teaching. The experiences gathered so far indicate that there is still much research to be done on the extent of utilization of laboratory facilities in secondary school science teaching and learning. This is why it becomes expedient to find out if lecturers, technicians and students are actually utilizing laboratory facilities during Biology teaching

It is common to visit biology laboratories in schools and colleges only to find that some of the equipment and materials are either kept in the store rooms looking new as at the point of purchase or have been used and later abandoned. This is because, either the equipment or materials are expensive and difficult to procure, lack of knowledge for their operation or sometimes they are obsolete/or completely damaged and out of working order. In some cases colleges may have the minimum required laboratory facility and equipment; however, their usage is limited due to some reasons. (Bajah, in Bello 2011). Similarly, Sa'adu (2015) observed that the utilization of laboratory facilities in chemistry teaching enables learners to develop problem solving skills and positive attitude, interest towards science learning. Igboabuchi (2010) reported that the use of Biology laboratory facilities had a significant relationship with the students' academic performance in Biology. Jatau (2008) analyzed the extent of utilization of laboratory facilities and students' academic performance in secondary schools in Pankshin. The

finding was that science teachers possessed adequate knowledge of the utilization of laboratory facilities for teaching science in secondary schools. Oriade (2008) in a separate study investigated the utilization of laboratory facilities in Biology. Results revealed that most laboratory facilities were not adequately utilized during Biology teaching and learning in secondary schools, while some of the facilities were seldom adequate in schools.

The objectives of utilizing biology laboratory resources in colleges of education as summarized by Chimezie, Ike and Iwu (2012) include:

- i. to encourage active participation of the learners.
- ii. to economize time.
- iii. to stimulate and sustain learners' interest
- iv. to control large group of learners at the same time.
- v. for easy assimilation of facts.
- vi. for easy understanding of lessons.
- vii. for easy recall of stored information.
- viii. to expose students to opportunities in the field of biology and its related courses.
- Viii to prepare students for varied future occupations.

Nwosu (2012) identified some factors that militate against the effective utilization of available resources in chemistry laboratory, these include in-competency of teachers; defective training given to chemistry teachers, huge class size, untrained laboratory staff; and inadequate funding. According to him this is not only limited to chemistry laboratory, but applies to biology and physics as well. This agrees with the views of Achimugu in Ismail (2014), who discovered that many schools that are rich in equipment are experiencing underutilization or non-utilization of the equipment. According to him, some of the apparatus are kept in the laboratory store room either forgotten or left to rust without usage for many years. Sometimes, there are cases of

misuse resulting to breakage and mutilation. Non-utilization of laboratory equipment was also reported in Biology laboratory by Cirfat and Zumyl (2008); and Agricultural science by Ajetumobi and Bashorun (2009). Although laboratory-based mode of presentation of concepts has been consistently found to be an important strategy in science teaching and learning in secondary schools, however, Oriade (2008) found that utilization of laboratory facilities in Biology laboratory were not adequate during Biology teaching and learning in secondary schools, he added that some of the facilities were seldom adequate in schools. Poor utilization of the laboratory apparatus and equipment is not unconnected with the lack of laboratory personnel to assist the Teachers in preparing for class demonstrations and practical in many schools, studies done in relation to resource utilization in education have revealed that essential facilities are not always utilized in schools. This non utilization of teaching resources has been of serious concern to educators. Neji (2015) reported academic performance in science for students who utilized laboratory facilities during science teaching and learning achieved higher than those who had no experience in laboratory activities in science. Similarly, Chukwuneka (2010) discovered laboratory facilities influenced students' academic performance in science.

Other factors that militate against effective provision and utilization of biology laboratory resources were identified. Oladipo (2008) stated that inadequate and inappropriate use of funds is major constraints in the provision and utilization of resources. According to him, funds are needed to provide the needed resources, maintain equipment and repair faulty ones.

He added that the situation is worsened by individuals who divert money meant for the purpose, thereby jeopardizing proper maintenance and effective utilization of the necessary materials for teaching. Sometimes political instability is inimical to purchase and supply of the needed equipment and materials; this normally is as a result of frequent change in government, resulting to the abandoning of many educational projects. Statistical deficiencies due to political data hinder effective planning and utilization of resources. Lack of training / technical knowhow is

also a problem, as such, that many teachers and students are ignorant of the operation of some of the biology laboratory equipment; this sometimes results to their vandalization and or destruction. Another problem is over enrolment, colleges with high population enrolment are prone to low resources since the procured quantity of the biology laboratory equipment and materials may not be commensurate with the number of users or utilizers.

Although the NPE (2008) clearly stated that “for effective participation of students in practical work, the teacher: student ratio shall be kept at 1:20”; however, in colleges of education, this ratio is unattainable. In this situation, conduct of biology practical becomes a problem, which according to Imogie (2010) results in poor or non-utilization of materials and equipment in Biology laboratories.

In most colleges of education, storage facilities, infrastructural facilities, care and safety of resources are not guaranteed. Additionally, documentary and logistics imbalances in biology laboratories are reported by Osondu (2009) as a factor to management problems in COE. According to him, most laboratory resources are lost, damaged without repair while unavailable ones are not replaced or improvised. Available laboratory resources are not effectively monitored, supervised and evaluated. These challenges have posed great threat to the provision and management functions since all biology laboratory users find it very difficult to adjust favourably to the poor conditions of biology laboratory human and material resources.

In a study by Okoli and Osuafor (2010), the finding was that 50% of the schools sampled do not have laboratory technicians/attendants. Oladipo (2010) found out that lack of technical expertise was a contributing factor to inadequate utilization of resources in schools. According to him, there is inadequate or outright lack of experts to handle and or repair the faulty equipment in most of the laboratories under study; hence failure to utilize them to the fear of their usage in a default condition which may be prone to hazards. Ukaegbu (2012) reported that the number of

science laboratories in the schools under his study were inadequate. According to him, many schools are overpopulated and most laboratory resource materials are lacking both human and material resources.

Lyons (2012), states that learning is a complex activity that involves interplay of students' motivation, physical facilities, teaching resources, skills of teaching and curriculum demands. The process of managing and organizing resources is called resource utilization. According to him, the utilization of resources in education brings about fruitful learning outcomes since resources stimulate students learning as well as motivating them.

As a result of the foregoing, the need for utilization of laboratory apparatus and equipment in the teaching of science, therefore, cannot be overemphasized. A paradigm shift from teachers over-dependence on excessive use of words to express or convey ideas in the teaching-learning process to the use of instructional materials such as laboratory apparatus, equipment, computer simulations and video clips that minimize the teacher's talking and at the same time make the message clearer, more interesting and easier for the learners to assimilate becomes necessary. Such materials also help in simplification and concretization of complex phenomena (Adeleye et al. 2012). However, in many instances the laboratories may not have adequate equipment and materials for use; in this case improvisation may be an option.

2.7 Improvisation

Biology practical work in ill – equipped laboratories is difficult, but not impossible if the teacher improvises. At the onset, a working definition of improvisation seems expedient; it embraced methods, materials, equipment, apparatus and teaching aids which teachers use for effective teaching and efficient learning process. Many scholars defined improvisation as the act of using alternative materials and resources to facilitative instruction whenever there is lack or shortage of some specific or first-hand teaching aids (Bichi 2011, Sabiru 2013 and Garba 2015). Improvisation and local production are related issues when

substitutes are being thought of for Biology equipment in the course of teaching and learning. For a teacher to be able to improvise, the teacher has to be creative and reflective in thinking so that the teacher can devise new procedures or structures in any given situation. Improvisation in Nigeria today is almost inevitable if meaningful learning is to take place. This makes students aware of the scientific principles applied to everyday things, not just associating it to only sophisticated apparatuses imported from abroad.

2.7.1 Types of Improvisation

Two forms of improvisation have been given by Bomide in Lawal (2015); these are as follows:

1. **Role substitution:** In this form of improvisation the original material is slightly modified in order to perform novel functions in an experimental setting; example, the use of kerosene stove as bunnies or a glass tumbler as a beaker are good illustrations.
2. **Role simulation:** In this case, actual construction of the apparatus is undertaken as an emergency measure either because the needed apparatus is too expensive or not available; example, the use of the local carpenter to construct test – tube holders.

The present day student's enrolment in colleges of education coupled with decline in the economy necessitates the act of improvisation of Biology equipment and materials. It is a known fact that majority of the items used in Biology laboratories are expensive; this makes their supply inadequate and therefore may not meet the student's demands. This necessitates the urge for maximum utilization of the locally available resources in place of the imported ones. Although it is relatively easy to device materials for primary and secondary schools based local science materials, at the same time it is much harder to generate among biology lecturers enthusiasm for and confidence in improvisation. In view of the above, teacher

educators (lecturers) should not see improvisation as a no go area. This was supported by Harrison (2010) where she explained advantages for improvisation as follows:

- i. It is cheaper so there is more apparatus available for individual or group experiments, in addition to teacher demonstrations.
- ii. Concern over loss, breakage and repairs, is reduced, therefore, equipment is more frequently used.
- iii. Students are made aware of the scientific principles applied to everyday things, not just special and sophisticated apparatus imported from abroad
- iv. Attention is drawn to the need to estimate accuracy.
- v. Students can see where inaccuracies arise and can see the need for more sophisticated design for many purposes.
- vi. A classroom can often be used if a laboratory is not available.
- vii. Simple equipment encourages students to make good use of local resources, and enhances self – reliance.
- viii. Simple experiment often demands an understanding of basic principles rather than following a set of complex experimental instructions.

In spite of the advantages given by Harrison (2010) on justification for improvisation, Ismail (2013) identified conditions that necessitate for improvisation in schools and colleges to include the following:

- i) Finance:- When a school budget is inadequate for the purchase of scientific equipment needed for instructional purposes some other provision has to be made. In these days galloping inflation and raising enrolment of students, most schools cannot provide enough money to meet the demands of the science department.
- ii) Shortage in the supply of equipment:- Even if money were to be available, it is possible to have a situation in which the apparatus / equipment are out of stock

- iii) Emergency: - it may happen that an equipment or material got damage in the course of its usage. A resourceful teacher will not abandon the experiment but rather think of improvising something in place of it.
- iv) Teaching strategy:- Many science teachers realize that equipment for introductory work in science need not be factory made, nor do they have to be of high precision in their utility.

Several pieces of apparatus are available locally that can be utilized for effective Biology teaching. However, before embarking on any form of improvisation it is necessary to assess the relative worth of the improvise material from the stand point of Biology teaching. Allsop in Harrison (2010) identified the following criteria for the assessment of the improvised materials:

- i) The device should seek to validly illustrate and provide answer to the specific problem or principle.
- ii) It should be simple, readily replicable and double
- iii) It should be produced at a relatively low cost
- iv) It should foster development of desirable skills and interest in the learner
- v) It should not differ significantly in quality and reliability from industrially produced types.

2.7.2 Construction of Improvisation

A meaningful attempt towards finding and using a substitute or alternative to a familiar (standard) science material is clearly an effort for cost reduction in Biology teaching and science generally. This view was supported by Ishola (2010) who described the role of improvisation as a way of minimizing cost of equipment and materials, an inexpensive method of widening the scope of inquiry, a challenge to curiosity and productive application of intellect, and a means of local replication of the universality of

science. Many scholars suggested a wide range of science teaching materials, few of which are highlighted here.

Adeniyi in Tadesse (2014) observed that a number of simple materials may be improvised to serve the purpose for which manufactured products are intended. He suggested the use of methylated spirit lamp for banners, malta bottles for storage of chemicals that require dark bottles, construction of gas generator (to serve as kipp's apparatus), extraction of flower pigment for use as indicator, use of polystyrene sheets for construction of calorimeter cases. Other examples are the use of ordinary drinking straw, or empty barrels of ball points such as Bic Biro as glass stubbing, water tumblers as beakers, a moderate size wide mouthed glass container as an aquarium, big locally manufactured plastic jerry cans and pots could be used for stocking solutions in place of standard reagent bottles and devices from assembly of separation funnels, the use of table / tea spoons as spatula, small transparent saucers or lids of many plastic containers as Petri dishes and watch glasses, ear and eye medicine droppers as dropping pipettes, soft drink bottles as wash bottles, molecular models can be improvised using local calabash and corn stalks, or broom sticks with plasticine or gum rolled into balls, dead electric bulbs as magnifying glasses.

In spite of the justification on the need for improvisation, it also has some shortcomings or limitations, these are:

- i) **Precision:** - The improvised material do not give a precise result as is expected of the standard materials, thus the interest here is to show the scientific principles involved.
- ii) **Effectiveness and durability:** - Most of the improvised materials lack durability. Thus, most of them are subjected to breakage.

- iii) **Some materials cannot be improvised at all**, whether the standard is available or not at all.

In support of the points on limitations for improvisation, Edet (2008) identified two major constraints to improvisation to be technical and human constraints. According to him, the technical constraints relate to the question of the degree of accuracy and precision that is possible with the improvised equipment as compared to the factory made. This problem can be overcome with proper planning; one way is to seek for assistance of local personnel, such as carpenters and blacksmiths on the construction of certain materials. In such a case, the teacher has to supervise the process of the construction to ensure conformity to the specifications. The human factor, on the other hand, relates to the teacher. That is to say in spite of the resources suggested, what matters most is the teacher's skills in developing the resources while providing appropriate learning experience to the learner. Thus, the teacher's professional commitment, creativity and imaginative ability are worth noting for an effective improvisation.

2.8 Qualifications of Biology Teachers and Teaching Delivery

Inadequate teaching has been advanced as one of the problems of science education in Nigerian secondary schools and colleges. Effective teaching occurs when students learn and achieve many scientific goals and not just being able to repeat scientific knowledge (Omoifo 2012). During effective learning, student learn how to learn, students develop conceptual understanding and thinking skills, thus helping students change their intuitive, everyday ways of explaining the world around them to incorporate scientific concepts and ways of thinking into their personal frameworks. Therefore students' ability to solve problems and perhaps enhanced learning occurs.

According to Okafor, (2008), quality teaching lies at the teacher's capacity to transform written knowledge into forms that are pedagogically powerful and yet adaptive to the students'

abilities and backgrounds. Ayodele (2010) identified the use of inappropriate non-effective teaching methodology as a major factor hindering students understanding and achievement in science. According to him, the teaching and learning of science do not require theoretical and lecture approaches, rather more engagements in demonstration, investigations and enquiries; thus, a continuous supply of equipment and materials in the science laboratories becomes necessary. Onose (2010) opined that many inexperienced teachers teach science in abstraction, thereby making science lessons boring and the students find it difficult to grasp some scientific concepts, skills and principles.

Abdullahi (2008) and Ogbeba (2010) observed that most teachers emphasise theory rather than practical aspects of science subjects and most of them lack adequate knowledge of subject matter and the competence to deliver. In addition, they stressed that the teaching of science has been reduced to a descriptive exercises through the use of lecture method and very little inquiry. Although, the National Policy on Education (2008) emphasised the activity based and child entered learning, still most science lessons are of the traditional approach in nature; even though, there are few classrooms with demonstrations and when in use it is often teacher demonstration which makes students passive. There are also few traditional hands- on (practical) classes. Our science lessons are yet to be structured, guided and students directed (Omoifo, 2012).

Academic qualification is a very important quality of a teacher. An academically qualified teacher has more authentic knowledge about the relevant subject than the academically less qualified teacher. Molnar in Bature (2009) reported some studies in which students taught by certified teachers consistently outscored those taught by uncertified teachers. He posited that a poorly trained teacher will likely produce a poor doctor, engineer, architect, fellow teacher and the like.

In colleges of education, the minimum teaching qualification is a degree from a recognised university, with a minimum of second class lower division. Possession of a teaching qualification is an added advantage; those without it are encouraged by colleges to obtain it, because for one to train a teacher, the person must also be a professional teacher. The NCCE minimum standard (2012) is very clear on this, where it states that a minimum number of ten (10) academic staff is required to adequately implement the NCE Biology programme. The minimum qualification for academic staff is second class lower for first degree, that is B. Sc, B. Ed, B. Sc (Ed). That holder of B. Sc degree must also possess either NCE or PDGE or Technical Teachers' Certificate (TTC) to be professionally qualified. Recently, Professional Diploma in Education (PDE) is recognised and accepted as a teaching qualification for B. Sc graduates.

2.9 Importance of Science Practical Work

Abdullahi (2008) explained the rationale for doing practical work. According to him, the subject matter of science is highly complex and abstract; students need to participate in inquiry based activities and that practical work is intrinsically interesting to students. Bruner, Gagne, and Shwab in Martins (2010) explained that the importance of practical work originated from the views of few American educationists in the early sixties and seventies that extolled the importance of laboratory work in science teaching following the launching of the sputnik by Russia. This motivated many countries to review their science curricula and science teaching in particular in order to make them more functional to their societies.

The Sa'ad (2015) explained the experimental teaching technique by STAN to involve observing, classifying, measuring, predicting, describing, hypothesising and inferring; according to him, all these have to do with activities that engage the learner in doing. Practical activities in biology, therefore, provide opportunities for students to actually do science which engage them in hands-on, mind – on activities using varieties of materials and equipment to drive the lesson home. As a result of the foregoing, Nwagbo and Chikelu (2011) asserted that the use of practical

activities in teaching of biological concepts should be a rule rather than an option to biology teachers, if the aim of biology teaching is to produce students that would be able to acquire the necessary knowledge, skills and competence to meet the scientific and technological demands of the nation.

Aminu (2014) identified the following as importance of experimentation in teaching of biology:

1. It enables students to have direct sensory experience of scientific knowledge, example, working with living organisms, providing opportunity not only to acquire knowledge but also appreciate life.
2. Foster opportunities for the acquisition of science processes skills, such as manipulation, measuring, classifying.
3. Helps in the retention of information as the students interact with the scientific process.
4. The use of experiments helps students to develop scientific attitudes such as enquiry, curiosity, carefulness, objectivity and honesty.
5. Experimental work helps to estimate and sustain students' interest in science.
6. It enhances students' problem solving skills and the thirst to arrive at conclusions
7. It helps to increase students' ability in critical thinking, reflection as well as better understanding of scientific knowledge.

In view of the importance of the acquisition of science process skills, which the use of laboratory facilities and equipment promotes, the Federal Government's National Goals for Education has the following as one of the objectives: education should aim at helping the child in the acquisition of appropriate skills, abilities and competencies, both mental and physical as instrument for the individual to live in and contribute to the development of the society (FGN: 2004)

Huxley in Aminu (2014) asserted that science belongs to the laboratory as gardening belongs to the garden and cooking to the kitchen. This explains the fundamental principle of learning by doing and the role of laboratory work in science teaching and learning. According to him, practical work in ill – equipped laboratory is not impossible; where the laboratory is not equipped the teacher has to improvise. Through improvisation, students will get a feel of what science is and how scientists work. This explains the paramount importance of the availability and utilization of laboratory facilities, equipment and materials.

Appendix IV provides Biology curriculum for NCE I, II and III. In all Biology students are expected to undergo five practical courses from NCE one to NCE. These are Bio 114, 124,216,224 and 325. Each course has a status of one credit.

2.10 NCCE Recommended Minimum Facilities, Equipment and Materials for the establishment of Biology laboratories in Colleges of Education in Nigeria

Considering the role of practical exercises in teaching and learning of biology in colleges of education, the NCCE (2012) provided minimum standard requirements as bench mark for the biology laboratories in colleges of education. Table 2.1 shows the list of materials and equipment that a standard biology laboratory should have according to the NCCE minimum standards.

Table 2.1 Recommended minimum facility, equipment and materials for NCE Biology**Facility**

Description	Quantity
Laboratory room	2
Botanic Garden	1
Laboratory workshop	1
Museum	1
Store	1

Description	Type	Quantity Required
Equipment/Materials	1. Modules and chart:	
	2. Skeletal system	1
	3. Muscular system	1
	4. Brain and Nervous system	1
	5. Circulatory system	1
	6. Digestive system	1
	7. Eye and vision	1
	8. Ear	1
	9. Skin and excretory organ	1
	10. Genetic models	4
	Equipment and Consumables:	
1. Hand lenses		40
2. Microscopes		20
3. Incubator / sterilizer		1
4. Autoclave (portable)		3
5. Balances		3
6. Hot plate		1
7. Refrigerator		1
8. Water filter		1
9. Hygrometer		1
10. Drying oven (30°C – 120°C)		1
11. Microtome/stage micrometer		1

12. Automatic tissue processor	1
13. Centrifuge	1
14. Herbarium cabinet	9
15. Herbarium Index Boxes	2
16. Air pumps	6
17. Photometer	2
18. Kymograph	10
19. Dissecting microscope	2
20. Insect Light traps	1
21. Insect box traps	1
22. Slide projector	1
23. Overhead projector	2
24. Steel frame aquarium	1
25. Oxygen meter	1
26. Binocular microscopes	4
27. Embedding bath	5
28. Glass distiller	1
29. Water bath	1
30. P ^H meter	2
31. Tissue grinder	4
32. Calorie meter	6
33. Auxanometer (electric)	4
34. Soil agar	2
35. Plant press	2
36. Soil training kit	1
37. Wooden quadrants	10
38. Measuring tape	5
39. Biological kits/dissecting set	10
40. Dissecting boards/plate	40
41. Bunsen burners	20
42. Giant gas cylinder	2
43. Prepared and plane microsc slides (assorted)	

- 44. Consumables: Glass wares,
stains, chemicals (assorted)
- 45. Test tube rack 10
- 46. Preserved plant and animal
specimens (assorted)
- 47. Desiccators 3
- 48. Gloves 40
- 49. Safety device (assorted)

Source: NCCE Nigeria Certificate in Education; minimum standards for sciences (2012)

Table 2.1 explains the minimum facilities, materials and equipment that standard college of education biology laboratory should have.

2.11 Impact of the Availability, Adequacy and Utilization of Laboratory Facilities and Equipment on Learning Biology

School facilities have been observed as a potent factor to qualitative education. The importance of the provision of adequate instructional facilities for education cannot be over-emphasised. The dictum that “teaching is inseparable from learning but learning is not separable from teaching” is that teachers do the teaching to make the students learn, but students can learn even without the teachers. According to Akande (2013) learning can occur through one’s interaction with environment. Environment here refers to the biology laboratory and other auxiliary service places (stores, museums and gardens) that are available in the college to facilitate students learning of biology. Others include books, audio-visual, software and hardware educational technology; size of classroom, sitting position and arrangement, availability of tables, chairs, chalkboards, shelves on which instruments for practical are arranged. Facilities constitute a strategic factor in organizational functioning; this is so because they determine to a very large extent the smooth functioning of any social organization or system including education. Their availability, adequacy and relevance influence efficiency and high

productivity. Supporting this, Finkelstein, Adams, Keller, Perkins and Wieman (2015) opined that the wealth of a nation or society could determine the quality of education in that land; emphasizing that a society that is wealthy will establish good schools with quality teachers, learning infrastructures; that with such, students may learn with ease thus bringing about good academic achievement. Explaining the role of facilities in teaching, Taale and Antwi (2012) stated that no effective science education programme can exist without equipment for teaching. This is because facilities enable the learner to develop problem-solving skills and scientific attitudes. In his contribution, Momoh (2010) stated that when facilities are provided to meet relative needs of a school system, students will not only have access to the reference materials mentioned by the teacher, but individual students will also learn at their own paces. The net effect of this is increased overall academic performance of the entire students; the facilities, materials and equipment have thus, impacted positively on the students learning.

Laboratory instruction plays an important part in the achievement of some science teaching goals, but not all the stated goals of science education, as many teachers have not incorporated laboratory goals into their instruction and evaluation systems. Thijs & Bosch in Momoh (2010) found that there was no significant differences in achievement between the laboratory and the demonstration methods and suggested that the extent to which laboratory instruction, experiments, and textbook are congruent with the expected objectives of teaching sciences should be investigated. This implies that laboratory work helps to simplify abstractness aspect of science thereby increasing the students' performance in academic environment. Also, it caters for individual differences, which encourages sharing of ideas and team work. This concurs with the views of Bello (2012) in his study on the Effects of availability and Utilization of Physics Laboratory Equipment on Students' Academic achievement in Senior Secondary schools. According to him, science laboratory with adequate equipment is a critical variable in determining the quality output from senior secondary school physics. In other words, there is

strong positive significant relationship between laboratory equipments and academic performance. Supporting this view is Olaniyonu in Ihuarulam, (2008) who said school facilities can be seen as a controlled environment, which facilitates the teaching and learning process while the facilities protect the well-being of the students. He added that in secondary schools, the modern teaching of sciences will necessitate the provisions of well-equipped laboratories. Ishola (2010) stated that one of the recurrent problems of teaching of science is large classes. According to him, one of the objectives of teaching science in schools is to communicate the spirit of science so that students acquire the processes skills of science. This cannot be effectively achieved unless students are exposed sufficiently to practical work and laboratory experimentation. He added that many secondary schools established over the years still remain without science laboratories while others have laboratories that are not sufficiently equipped.

Adeyemo (2012) found that adequate provision of laboratory facilities play a significant role in boosting students' achievement in physics. According to him, the relationship is high, positive and significant at 5% level of significance. This implies that laboratory facilities and equipment will impact positively on students' performance in science. In their findings, Ojediran, Oludipe and Ehindero (2014) reported that students given the opportunity to do practical activities performed significantly better than their counterparts who had lesser practical activity exposure. Meaningful learning is possible in the laboratory if the students are given opportunities to manipulate equipment and materials in an environment suitable for them to construct their knowledge of phenomena and related scientific concepts Uyota (2006). Learning, therefore, is more permanent when students are taught through the laboratory methods than when taught theoretically. In his opinion, Oluwale (2009) attributed the poor performance of students in chemistry to teachers' inability to meet the demand of WAEC practical. He stressed that chemistry lessons are not taught in the laboratory. Even in tertiary institutions, this poor foundation does affect the student's performance in chemistry. This agrees with Iloakasy in

Adesoji (2010) where he discovered that poor performance of students in NCE chemistry and related courses has had nothing to do with their past performance in WASC/GCE 'O' level chemistry in WASC, but is more related to the condition of teaching and learning at the NCE level especially the use of laboratory. Similarly, Adeleye (2015) attributed the poor performance of students in chemistry to lack of adequate exposure to practical work which according to him, is related to population explosion; thereby stretching existing facilities, laboratories, classroom space, workshops and so on. Therefore, School facilities can be seen as integral part of teaching and learning process, where facilities protect the well-being of the students. Olaniyonu in Sunday (2012) maintained that in secondary schools, the modern teaching of sciences will necessitate laboratories.

From the foregoing, one could see that the presence of laboratory facility, materials and equipment alone is not sufficient for the learning of science unless the facilities, materials and equipment are put into effective utilization. Poor utilization of the laboratory apparatus and equipment according to Adeleye (2012) may not be unconnected with the lack of laboratory personnel to assist the teachers in preparing for class demonstrations and practical in many of the schools. This necessitates for a paradigm shift from Teachers over-dependence on excessive use of words to express or convey ideas in the teaching-learning process to the use of qualified laboratory technologists who have the confidence to utilize the instructional materials such as laboratory apparatus, equipment, computer simulations and video clips that minimize the teacher's talking and at the same time make the message clearer, more interesting and easier for the learners to assimilate. Such materials also help in simplification and concretization of complex phenomena. This study therefore, targeted some colleges of education in the North West geographical zone of Nigeria to assess the impact of the availability, adequacy and utilization of Biology laboratory facilities and equipment on students' performance in colleges of education.

2.12 Usefulness of Laboratory Equipment in Teaching and Learning

Teaching is usually facilitated and is more effective through the active participation of the learners and utilization of appropriate resources. Active participation of the learner in science is facilitated by the availability and effective utilization of adequate instructional resources, personnel, facilities, equipment and supplies. It is worth to note that teachers' competency and available instructional facilities and equipment in a school determines the coverage of syllabus and curriculum of any subject including science. According to Ikioya (2008) the school science programmes require the availability and adequacy of facilities, equipment and supplies for the attainment of set goals. School resources have been observed as a potent factor to quantitative and qualitative education (Owoeye 2011). Teaching resources refers to a varieties of material used for teaching and learning purposes. Sa'adu (2015) asserted that they are collection of materials and equipment that can be used effectively for classroom interaction or communication. He added that they could as well be described as variety of products of educational technology and non-technology materials. They are collection of materials and equipment that can be used effectively for teaching and learning; they are resources that can be used to help achieve an aim, such equipment and supplies provides information for the teachers as students utilize them in teaching and learning process. The availability and adequacy of facilities, equipment and supplies as well as their utilization have a significant role in the learning process as they help the teacher to achieve the objectives of the programme more effectively.

The Biology curriculum for senior secondary schools in Nigeria prepared by CESAC in Philips (2011) recommended inquiry and guided discovery methods on the teaching and learning of Biology, this can best be achieved if laboratory equipment and materials are effectively utilized during science experiments and demonstrations. Onyemereikeya (2009) suggested some of the benefits derived in using laboratory facilities, equipment and materials as follows:

- a. the students are actively involved in the process of acquiring knowledge instead of being passive listeners;
- b. knowledge gained by students from a variety of examples, demonstrations, illustrations or experimentations are more meaningful, easily retained and transferred than that gained by rote learning of isolated facts;
- c. students are encouraged to develop critical thinking as well as intuition;
- d. science students manipulate equipment and materials in learning, this method helps in the acquisition of manipulative skills;
- e. activity method through the use of facilities, materials and equipment is versatile and can be used in a variety fully engage and motivate learners; and
- f. the method is naturally interesting to children who are normally very curious and inquisitive.

Onyemereikeya (2009) opined that the use of facilities, materials and equipment by learners enhance their skills, interest and attitudes through interaction with them. This enables the students to grow independently without restrictions to rigorous procedures in textbook and syllabuses. He added that it can promote student centred teaching, in which students are allowed to interact with each other, the materials and the teacher as well as to enquire, search, compare and generalize without undue intrusion or direction from the teacher fosters learning. In this case, the teacher will only introduce the lesson with the use of materials such as pictures, graphs and other visual aids, which stimulate them to investigate the phenomenon. Students on the other hand will be carrying out investigations while the teacher guides their search. This process leads to more discoveries. Nwakonobi and Igboabuchi (2010) contended that infrastructure promote intellectual growth and suggested the following guidelines for using materials in teaching and learning:

- a. any instructional material chosen must make direct contribution to the lessons or class work in progress;
- b. teaching material must be relevant to the specific objectives of the lesson;
- c. students must be adequately prepared for the materials to be used;
- d. teachers must make adequate arrangement for any excursion or field trip;
- e. teacher must endeavour to vary the media used and be prepared to assess the effect on the students using the media upon complete of the exercise;
- f. teacher must ensure that equipment to be used is in good working condition and will in no way hamper the exercise envisaged;
- g. a preview of all materials must be made by the teacher so as to ensure the technical quality as well as the suitability of materials for the age and educational level and experience of the students;
- h. all teaching materials must be such that pose no health or safety hazards to teacher or students;
- i. picture to be chosen for instruction must be authentic;
- j. considerations must be given to class size and space used; and
- k. enough time must be allowed to the ends of the presentation for class discussion or questions on or to practise the skills called for in the material just viewed;

The efficient use of the laboratory equipment depends on maintenance, improvisation and safety precautions taken. Maintenance is the act of keeping something in good condition by checking or repairing it regularly (Wehimener, 2003). Oyedeji (2011) sees school equipment maintenance as the keeping of the school equipment in as near their original state of utility as possible. Maintenance is the act of science of making necessary repairs to productive equipment as quickly and economically as possible and to anticipate thorough prevention. Mogbo (2007) pointed out that it is important that we keep a regular and proper maintenance of our equipment,

because without it, we experience break-down or the equipment will not function well. Where equipment is allowed to break down completely, due to poor maintenance, it will have to be repaired. Achimugu in Adeleye (2012) discovered that many schools that are rich in equipment, are experiencing non-utilization and underutilization. This non-utilization of laboratory equipment was also reported by Cirfat and Zumyl (2007), Ajetumobi and Bashorun (2009). Nwosu (2012) identified some factors that militate against effective utilization of available resources in laboratories to include; in-competency of teachers; defective training given to teachers, huge class size, untrained laboratory staff; and inadequate funding.

2.13 Instructional Methodology for Biology Teaching

This refers to the overall teaching – learning approaches which teachers use from time to time in the course of teaching. Effective biology teaching is achieved when students have the opportunity to interact with materials and objects. The NCCE minimum standard (2012) recommended the following as most suitable methods for biology teaching at college of education level; these are lecture, demonstration, problem solving, discovery, laboratory/practical, field trip, games and simulations, tutorial concept mapping and computer assisted instruction.

- a) **Demonstration:** involves showing a particular procedure to students who after careful teaching and learning interactions repeat and practice the processes shown to them. The strategy is generally used to motivate the students, teach certain techniques and skills and present problems for students to suggest explanation. According to Ogundare (2010), discussion method as an approach to teaching lead learners to express their opinion and ideas with the aim of identifying and solving problems collectively, while the teacher's role is that of moderating their ideas and asking leading questions to focus their thought on the objectives of the discussion. In consonance with this definition, is Ogundekun (2011) who explained discussion as an activity in which the class can be splitted into

small or large groups for effective management and sharing of ideas. According to him, the approach is less teachers centred, but student centred oriented approach which provide opportunity to acquire leadership skills in the process.

- b) Discovery: learning take place when an individual is involved in using his mental processes to discover some concepts, principles and processes by using mental activities and manipulating science equipment. This approach place mush emphasis on students' participation in learning. Yusuf (2012) is of the view that discussion as a process of teaching and learning provide learners with opportunities to discover new facts, methods and or techniques of solving problems. According to him, discovery learning is more effective if well planned and guided by the teacher, who ensures that no one dominate the process. In discovery approach, the teacher provides learners with opportunities to discover new facts, methods, and rules as well techniques of solving problems. Normally the teacher is not an initiator of the problem, but his role is that of providing continuous support to learners.

To embrace the discovery method as advocated by the National Teachers' Institute Ojediran et al., (2014) said the most effective approach to science teaching is to support theoretical explanations with actual practices in the laboratory. Unfortunately, discovery is resource-based and so cannot be implemented without basic instructional materials such as laboratory.

- c) Experimentation: this involves the use of science material and equipment for experimentation in the laboratory to derive scientific knowledge. Moreover, it gives a firsthand experience to the students as they learn by doing. If used properly, this approach provides situation for discovery, skill development, inquiry and problem solving activity. According to Awaisu (2016), experimentation is an effective method of teaching biology,

however, the approach is too demanding in terms of teacher preparation and often challenging to new teachers.

- d. Laboratory approach: this is an approach that allows learners to learn in an environment different from a conventional classroom. In his opinion, Alake (2015) sees laboratory approach as an empirical learning, in which students are directly involved in the process, using apparatuses and materials in a functioning laboratory setting, having laid down procedures (instructions) with more support from the teacher, technician or both.

Allsop (1993) in Paul (2012), identified three steps when using the laboratory approach in biology teaching, these are:

- i. Introduction phase – this is the time for preparation to ensure all materials to be used are kept handy and ready sometime before the lesson begins. According to him, beginning teachers are advised to try out the experiment before students attempt it. In this way, the steps which can go wrong will reveal themselves.
- ii. Work period – in this phase each individual is actively engaged in experimenting, critical thinking, planning as well as searching for answers to problems.
- iii. Culminating activity – here students discuss their findings in groups or with the teacher; they should be guided to draw some conclusions from data they gathered.

2.14 Advantages of laboratory approach

The following were the advantages of teaching using the laboratory approach as explained by Ado (2005).

- i. It trains the students on a research oriented method
- ii. Students learn better and retain the experiences longer, since they are practically involved in the knowledge acquiring process
- iii. Students' interest is stimulated as they are actively involved during practical.

Considering the benefits of the laboratory approach, practical courses in the NCCE minimum standards have the status of one credit hour; however the actual conduct of the practical is three hours at a stretch. This is in order to provide learners with adequate time to be engaged in real experimentation with materials and equipment, as well as creating avenue for students to learn better and retain the experiences longer since they are practically involved in the knowledge acquiring process; supporting the Chinese proverb that ‘I hear I forget; I see, I remember and I do, I understand better.’

In spite of the advantages gained through the use of the laboratory approach, the approach also has some shortcomings. Sa’adu (2015) gave the following disadvantages for practical work in biology teaching: it is time consuming and requires a general supply of materials and equipment. It requires careful planning and a lot of time for preparation on the part of the teacher. According to Sa’adu, because of the high students’ population in NCE biology classes, coupled with the high cost of materials, government alone cannot satisfy the demands for biology laboratories in colleges of education as enshrined in the NCCE minimum standards, as such, a workshop or specific room is recommended for all biology laboratories where lecturers, laboratory technologist and students can produce low cost teaching materials through improvisation.

2.15 NCCE Biology Curriculum

The NCCE Biology curriculum is designed to produce knowledgeable, highly motivated, professionals and effective teachers of biology who will be able to develop in students an appreciation and understanding of biological processes and principles. The programme is also designed to develop confidence in biology teachers and enhance their ability to adapt to the changing situations in science and technologically oriented society. (Details about the NCCE biology curriculum are attached in appendix III).

To graduate from the NCE programme, a candidate must pass a minimum of 118 and maximum of 122 credit units, out of which biology courses constitute minimum of 32 and maximum of 34 credit units respectively. This will be within three years duration and five years as the maximum period for students with a drop or carryover courses.

Having gone through the NCE biology programme, the NCE biology teacher will be able to:

- i. view biology as a process of inquiry into the living world;
 - ii. critically analyse the activities of living things in their environment;
 - iii. demonstrate practical skills in handling scientific apparatus;
 - iv. demonstrate excellence and professional confidence in teaching biology;
 - v. include positive scientific attitudes and values in the society and promote positive disposition towards biological science and scientific enterprise;
 - vi. apply concepts and methods acquired in the course in new areas of study and in everyday situations;
 - vii. make a successful career in biology teaching;
 - viii. Successfully qualified to undertake a B.Ed / BSc (Ed) degree programmes.
- Source:** NCCE minimum standard (2012)

2.16 Empirical Studies

Studies done in relation to resource utilization in education have revealed that essential facilities are not always available in schools. This inadequacy of teaching resources has been a serious concern to educators. Lyons (2012) stated that learning is a complex activity that involves interplay of students' motivation, physical facilities, teaching resources, skills of teaching and curriculum demands. The process of managing and organizing resources is called resource utilization. The utilization of resources in education brings about fruitful learning outcomes since resources stimulate students learning as well as motivating them. Etiuben (2010) investigated the effect of utilization of Chemistry Laboratory facilities and academic

performance in Chemistry. The findings revealed that utilization of Chemistry laboratory facilities has no significant influence on students' academic performance in Chemistry. Benedict in (Bello (2014) reported that utilization of laboratory facilities has a significant relationship with students' academic performance in science.

A study was conducted by Okoli (2014) on the status of resources for teaching biology in colleges of education, in Anambra State. The design of the study was a descriptive survey which involves the Biology Department of the Federal College of Education (Technical) Umuze and Nwafor Orizu College of Education, Nsugbe. Specifically, the study was to find out the status of human resources for teaching biology in colleges of education in Anambra State, the availability of material resources for teaching biology in colleges of education in Anambra State and the extent of use of these material resources for teaching biology in colleges of education. The study revealed that the colleges lacked most required materials for teaching biology. This finding is in line with Akano and Akpokiere (2011) and Ifeakor (2008) who reported lack of material resources for teaching science in colleges and schools, that most of the available material resources are not always used during biology teaching. This is in consonance with Ifeakor (2008) who noted that some laboratories are open only during examinations. According to him, the number of equipment available in the colleges fell below the minimum standard of the NCC; this could indicate poor training of pre - service teachers, because inadequate material is linked to students' poor performance and acquisition of skills.

In a study on Students' Achievement in Biology and Adequacy of Laboratory Facilities in Some Selected Secondary Schools in Katsina state, the by Sa'adu (2015), the test of hypothesis indicated a p -value of 0.52. Thus, there was a significant relationship between students' academic achievement and the adequacy of working condition of laboratory equipment. According to him, inadequate laboratory facility in secondary schools is undoubtedly responsible for the fallen standard of students' performance in biology.

Asiyai (2008) in his study on adequacy of the physical resources available for teaching chemistry in secondary schools in Delta State, the study adopted the descriptive survey designs. The target population were principals and teachers of chemistry in 36 public secondary schools of 25 Local Government Area of Delta State in 2005. The proportional stratified random sampling technique was used to select 25 respondents for the study from 10 Local government areas. A checklist was provided for the respondents to indicate available and non-available in line with WAEC specification for correction. Questionnaire was also administered to respondents to answer the research questions. Data analysis was carried out using means and t-test statistic. The results obtained revealed that most secondary school, do not have the instructional resources for teaching chemistry.

Umeh and Okoye (2009), Utulu (1998); and Ochu (2010) in Emendu (2012) reported about series of inadequate equipment in the teaching and learning of chemistry in secondary schools. Asiyai (2006) result revealed that most secondary schools do not have the instructional resources for teaching chemistry. Consequently, non-availability of these resources has a link to students' poor performance in chemistry. This has agreed with the findings of Sa'adu (2015) where he asserted that lack of ideal resources for science teaching and learning in Nigerian schools has been a major issue of concern.

In a study by Beskeni (2008) where he investigated the supply of equipment and materials in chemistry laboratories in senior secondary schools in Plateau state using a survey method. The study covered 120 senior secondary schools randomly selected from the 17 Local Government Areas of the state with the aim of investigating the types of laboratories used for chemistry practical, those responsible for financing and purchasing the equipment and materials of chemistry laboratories. A checklist for chemistry practical inspection was used to find out the supply of equipment and materials in the laboratories and suggestions given by teachers for improving the supply of equipment and materials in senior secondary schools chemistry

laboratories. The following were the findings: The majority of the schools used general laboratory for teaching chemistry, because of this they cannot meet the laboratory conditions for chemistry laboratory. Those using chemistry laboratory were few and some do not have laboratory at all. The greatest focus of laboratory equipment is the government. Other findings are: all the schools sampled had the common materials except that they were not enough, some were functional and some damaged, and in some schools the equipment and materials are there but not frequently used.

Schneider (2009) noted that most of the school Educational leaders must support reform that helped to increase student performance. Educational leaders must understand the relationship that existed between learning and school facilities. Identifying specific factors that contributed to the learning and educational environment was significant in helping administrators, planners, lawmakers, and teachers prioritize what areas of the learning and the educational environment process led to a quality education for all students in the state of Texas. Schneider (2009) noted that most of the school buildings were about fifty years old. Faced with an aging building stock and growing, shifting student enrolments, states and communities were working hard to build and modernize K-12 facilities. In today's society, many of our schools faced many challenges of out-of-date design, deteriorating conditions, and changing utilization pressures (overcrowding and declining enrolments; Filardo, 2008). The challenges impaired the quality of teaching and learning that contributed to health and safety problems for staff and students. Building design had been associated with teacher motivation and student achievement (Filardo, 2008). The Chemistry Laboratory is a place where the teacher and students can do practical work. Unfortunately, forty percent of chemistry teachers indicated that the chemistry laboratory equipment were not available and not utilized. In general, equipment in chemistry laboratory was found to be non-available in schools. This result is supported by observation of earlier researchers. For instance, Achufusi, in Toyin (2013) observed that the quality of

education a student receives largely depends on the quality of teaching/learning resources provided. Teaching learning resources are all the things used by the teacher during teaching to aid understanding and make teaching successful and effective. They include modern textbooks, equipments, consumables like chemicals and reagents, models and charts. Others are physical learning environments which include the science classrooms and laboratories. One of the major objectives of science education is to teach students the scientific process. Students need some investigative skills such as observing, measuring, classifying recording experimenting, analyzing inferring, and so on. To achieve this, science classrooms, laboratories and the general learning environment must be adequate and conducive. Inquiry focused science teaching demands a lot of activities on the part of the learner that require scientific materials and equipment. Due to the fact that majority of schools lack the essential resources for imparting the knowledge of science concepts to students, many students learn little science, learning tends to be by rote and many students find science not interesting and boring (Ogunmade, in Omoifo 2012). The teacher - student interactions in many science classrooms are not healthy because of lack of adequate resources. In most of our schools, there are no facilities for the teachers to demonstrate phenomena, let alone allow the students to have opportunities for finding out things for themselves (Audu and Oghogho in Omoifo 2012). The situation in many science classrooms in Nigerian schools and colleges is nothing to write home about. In many schools there are no laboratories. Some schools merely have empty rooms labelled as laboratories. Students rarely have hands-on, minds-on experiences. Few days to science practical examinations, most schools acquire science equipments for teacher demonstration to students. This cannot make for effective learning and eventually results in poor achievement (Omoifo, 2012). To worsen the problem of lack of or inadequate resources, the few available ones are not properly maintained, protected and cared for. Joseph (2011) discovered that there is no significant difference between availability of facilities in rural and urban secondary school locations He added that rural and

urban secondary schools do not differ significantly in terms of availability of library facilities, textbooks and laboratory facilities. According to him, availability of facilities has been found to influence both efficiency and productivity, it has also been found to influence learning.

Adeleye and Danjuma (2015) examined the impact of the availability and effective utilization of instructional materials such as basic laboratory apparatus on the attitude of learners towards Physics and their sustained interest while offering the subject. Five students and one Teacher from each of the ten randomly selected senior secondary schools in Karu Local Government Area of Nasarawa State were used for the study. Data collected through the use of questionnaires from both the Teachers and the Students were analysed using percentages. The results show that the greatest hindrance to the effective teaching of Physics in these schools is not lack of the necessary laboratory apparatus and equipment but rather lack of their usage. It was also established that effective utilization of these materials have positive influence on the students' attitude towards Physics which could indirectly affect their academic achievement in the subject. A study conducted by Bello (2012) on the effect of availability and utilization of Physics laboratory equipment on Students' Academic Achievement in Senior Secondary School Physics showed that the use of appropriate teaching equipment and teaching method is critical to the successful teaching and learning of Physics. Taale and Antwi (2012) also discovered that inadequate exposure to science laboratory work at the secondary school level has been a major cause of first year University students' inability to comprehend and apply scientific knowledge and skills. A study by Ukaegbu (2012) revealed that, 88% of BLR are available in biology laboratories such as interactive white boards, prepared slides, chemicals, textbooks, beakers, flasks of different types, microscopes, first aid box, hand lens, maps, models, computers, dissecting kits, fire extinguishers, thermometers, insect nets, bell jars, incubator, water baths, freezers and lecturers as well as students. The study also revealed that biology laboratory resources are not adequately provided for in COE. Additionally, due to inadequacy in the

quantity and quality of BLR provided to COE, students and lecturers find it difficult to utilize BLR effectively. Different factors ranging from inadequate fund; over enrolment of students into COE; inadequacy in quantity and quality of human and material resources; lack of storage facilities; lack of supervision; lack of proper documentation and logistics together with ignorance on the proper usage of resources due to lack of training were found to militate against provision, utilization and management of BLR in COE.

Edet (2008) investigated the influence of utilization of laboratory facilities and students' academic performance in Biology. Using a sample of two hundred (200) Senior Secondary School one (SS I) students taught by utilizing laboratory facilities and the control group taught without utilizing laboratory facilities during Biology teaching. The results showed that students taught using laboratory facilities frequently achieved higher than those taught without utilizing laboratory facilities during Biology lessons. Opara (2008) examined the utilization of laboratory facilities and students' academic performance in Chemistry. The findings, using analysis of covariance (ANCOVA), revealed that the 26.4% of the laboratory facilities were utilized during Chemistry teaching and learning while 74% showed that laboratory facilities were never utilized during Chemistry teaching. The finding also revealed that laboratory facilities had a significant influence on the students' academic performance in Chemistry. Brewton (2000) analyzed the effect of utilization of laboratory facilities on students' academic performance, and discovered that the teaching of science concepts is more effective and meaningful when laboratory facilities are well utilized during science teaching. Brewton concluded that effective utilization of laboratory facilities during classroom interaction influenced students' academic performance in science. Studies by Filardo (2008), Schneider (2009) in Nwakonobi (2010) revealed that students in classrooms with large windows, natural lighting, and well-designed skylights performed 19 to 26% better than their peers in classrooms without these features. Hunter found that the environmental conditions in schools, which included the inoperative heating system, inadequate

ventilation, and poor lighting, affected the health and learning as well as the morale of students and the staff. Olson and Kellum (2003) found sustainable schools and the good qualities of lighting, site planning, indoor air quality, acoustics, healthy building materials, and the use of renewable energy benefited student achievement. Bullock (2008) found that students performed better in schools that were new or renovated recently than in older schools. The overall building condition, the age of the building, and the windows in the instructional areas were positively related to student achievement (Bullock, 2008). Lyons in (Chikelu 2011) contended that learning was a complex activity that supremely tested students' motivation and physical conditions. Teaching resources, teachers' skill, and curriculum played a vital role in a child's education; educators must realize that there were many elements that influenced the condition of the school facility. These elements could range from educational leadership to community involvement; educators need to be informed about the conditions of their school facilities as well as the difference in availability of such facilities could make in helping to educate their learners.

2.17 Summary of Literature Review

The review presented an analysis of studies related to this study. The review also explored works in different fields with a view to determining the gap which this study can bridge in terms of contributions to knowledge. From the literature reviewed so far, it has been evident that for biology teaching and learning to be effective, laboratory facility, equipment and materials must enrich instructions. However, these are either grossly inadequate or completely absent in many schools and colleges. Reasons for their inadequacy or non-availability are generally linked to low funding. Where the facilities, material and equipment are available, they are underutilized. This poor utilization of the laboratory apparatus and equipment is mostly not unconnected with the lack of laboratory personnel to assist the teachers in preparing for class demonstrations and practical in many of the schools. Finally, the need for utilization of laboratory apparatus and equipment in the teaching of science cannot be overemphasized.

Introductory biology can be among the most enjoyable educational experiences for students if only because there is so much hands-on activity in the laboratory. This necessitated the recent paradigm shift from teachers over-dependence on excessive use of words to express or convey ideas in the teaching-learning process to the use of instructional materials such as laboratory apparatus, equipment, computer simulations and video clips that minimize the teacher's talking and at the same time make the message clearer, more interesting and easier for the learners to assimilate. Such materials also help in simplification and concretization of complex phenomena (Adeleye and Danjuma 2015).

The review also indicated that facilities play a pivotal role in the actualization of the educational goals and objectives by satisfying the physical, emotional and cognitive needs of the staff and students. Abayomi and Olukayode (2010) states that resources in schools are important in education because learning takes place best through discovery, exploration, and interaction with the internal and external environments. As a result one of the main emphases in education today is the shift from a teacher centred approach to a more learner centred approach. This involves actually putting the learners' needs at the centre of activities. To achieve this goal teachers need to use a wide variety of resources, which can enrich the learning environment. The adequacy of physical resources and teaching materials as well as their effective utilization has been a matter of serious concern to educators. The utilization of resources in education brings about fruitful learning outcomes since it stimulates and motivates students" (Okorie, 2001).

The review further indicated concerns for the State and Federal Governments as well as all stakeholders to intervene in terms of provisions of biology laboratory materials and equipment in schools and colleges so as to complement the efforts of the government in this regard. However, it is surprising to note that from the review so far, that in schools and colleges where laboratory equipment and materials are available, they are not fully utilized by some of the users (teachers/lecturers, laboratory attendants / technicians and students). Biology teaching

and learning is more of practical oriented in nature and involves the use of laboratory facility, equipment and materials. When students are exposed to biology laboratory activities and experiments, they acquire, understand and retain the basic scientific principles and applications more. Where the biology laboratory facilities, equipment and materials are available and are well utilized by teachers and students the resultant effect is that the students achieved higher in biology practical examinations. This research concentrated on the availability, adequacy and utilization of biology laboratory facility, equipment and materials and their impact on students' performance in biology practical examinations.

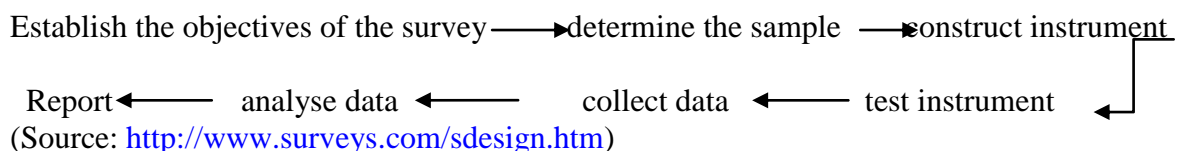
CHAPTER THREE RESEARCH METHODOLOGY

3.1 Introduction

This chapter is presented and discussed under the following headings. Research design, population for the study, sample and sampling techniques, instrumentation, method of data collection validity of the instrument, pilot study, reliability of the instrument, administration of the instrument and method of data analysis.

3.2 Research Design

The design of the study was a survey research. A survey research, according to Ponto (2015), is one in which a group of people or items is studied by collecting and analysing data from only a few people or items considered to be representative of the entire group. This design was considered appropriate and suitable for this study because it focused on obtaining information and analyzing data from a large group of biology Lecturers, Technicians and students considered to be representative of the entire population. Biology laboratories in colleges of education were assessed using a questionnaire produced by the researcher. Moreover, previous semester exam records of students' biology practical scores were obtained; these were compared with their performances in relation to availability, adequacy and utilization of the laboratory facilities and equipment in the colleges under study. The research design is therefore, a descriptive survey and the steps are illustrated as follows:



3.3 Population

The population of the study comprises of lecturers, laboratory attendants or technicians and students in biology departments in twelve colleges of education in the North-West geopolitical zone. The population consisted of 3047 members. Of this, 197 are biology lecturers, 26 biology technicians / attendants and 3,047 are students. The breakdown of the population is as shown in table 1.

S/No	College	No of Lab atte Techn 2	No of Biology Lecturers			No of NCE 3 Students		
			M	F	T	M	F	T
1	Isa Kaita CoE Dutsin-Ma	2	10	4	14	113	53	166
2	FCE Katsina	2	12	3	15	68	33	101
3	Sa'adatu Rimi CoE	2	09	06	15	211	75	286
4	FCE Kano	2	08	07	15	308	114	424
5	FCE(T) Bichi	2	08	04	12	187	36	223
6	COE Gumel	2	08	03	11	151	38	189
7	COE Maru	2	07	02	09	196	38	234
8	FCE(T) Gusau	2	04	06	10	-	234	234
9	Shehu Shagari COE Sokoto	3	06	04	14	133	211	344
10	COE Arugungu	2	05	06	11	107	85	192
11	COE Kafanchan	3	08	05	13	172	81	253
12	FCE Zaria	2	13	08	21	208	193	401

Source: Data units of the colleges (2016/17)

Table 1 indicates the population characteristics in terms of the number of laboratory technician / attendants, students and lecturers by gender in biology departments of the colleges of education in the North-West geopolitical zone.

3.4 Sample and Sampling Technique

The sample size for the study is only 501 from three colleges of education out of the twelve colleges of education in the North-West Geopolitical zone of Nigeria. All biology lecturers and laboratory attendants in the sampled colleges were selected; this is because they are few in number which the researcher can cope with. However not all NCE three biology students in the sampled colleges were present during data collection. Copies were left with their laboratory attendants for them to respond. At the time of collection not all were returned and all efforts to get them proved abortive.

The selection of the three colleges was purposive. According to Parlys (2008) a purposive sample is also known as judgemental, selective or subjective sampling. It is a deliberate effort to obtain representative samples by including presumably areas or groups in the sample. It is a type of non - probability sampling technique where the researcher select subjects based on certain characteristics that are of interest or due to convenience. In this case, the three colleges were selected based on proximity to the researcher as well as type and / or ownership. Two of the colleges are Federal owned, one is owned by state. Two of the colleges are conventional; meaning that they run courses for science, technical and vocational and also humanities; while the other college is a special college that run only science and technical course, moreover, it is specifically for women. In each of the college, all biology lectures, technicians / attendants and NCE three biology students were selected and participated in the study, this is because the number of biology lecturers and attendants are few in number. The choice of NCE three students was on the fact that they have spent considerable years in the college more than NCE one two and would have been in a better position to respond to the items in the questionnaire, since they might have known more about the departments in terms of what is available or not available, adequate or inadequate and whether it is utilized or not.

In all, a total of 501 subjects were studied, representing 33.5% of the population. According to Ali (2006) in Philip (2016), an appropriate size of a sample to use in a study should be about 30% of the population. Similarly, Roscoe in Hussain (2017) said for any given population that is more than 1000, a sample size of between 30 to 500 respondents may suffice. In this case, the sample size of 501 is considered adequate for this study. Table 2 indicates the sample size for the study.

Table 2: Sample of the study

S/N	College	No. of Biology Lab Tech/Attendant	Biology Lecturers	NCE 3 Students
1	Isa Kaita College of Education Dutsin-ma	2	12	166
2	FCE Katsina	2	15	101
3	FCE (T) Gusau	2	10	234
	Total	6	37	501

3.5 Instrumentation

The instrument used for this study tagged Biology Laboratory Assessment Questionnaire (BLAQ) is a Linkert scale instrument consisting of five parts: i.e. Strongly agreed (SA); agreed (A); undecided (UND); disagree (DA) and strongly disagreed (SDA). List of NCCE minimum requirements revised (2012) for setting up a standard Biology laboratory was transformed into a questionnaire; this was used for the data collection. The questionnaire is a closed ended type consisting of four parts (A-D). Part A required information on name of the college, sex of the respondents and their category; part B required information on the available materials in the biology laboratories with respect to the minimum standards for setting up a biology laboratory in colleges of education. Part 'C' and 'D' sort information on the adequacy and the extent of utilization of the materials in the biology laboratories. Parts B, C and D of the questionnaire consisted of five (5) items on facilities fifty eight (58) items for each of materials and equipment. Copy of the instrument is attached in Appendix I.

3.5.1 Validity of the Instrument

The instrument was given to expert in test and measurement, Curriculum in faculty of education as well as lecturers in the school of science and English department in colleges of education, who are not part of the research subjects for validation and scrutiny. This is done by looking at the clarity of the words to ensure that there was no ambiguity and or repetitions; that the content was based on the NNCE minimum standards (2012) for setting up Biology laboratories in colleges of education. The validation proved that the content reflected the NCCE guidelines for setting up a standard biology laboratory and that there were neither ambiguities nor duplication in the items. Validation also proved that the instructions are clear and timing for completion is appropriate.

3.5.2 Pilot study

A pilot study was conducted in College of Education Gumel to determine the reliability coefficient of the instrument, to check the instrument in terms of its difficulty in comprehending the content or language as well as in administration and retrieval of the instrument. Copies of the instruments were given to some students, lecturers and biology attendant / technician to respond. It was observed that the instrument was appropriate and that research subjects could easily respond without difficulty. The subjects for the pilot study are different from the actual research subjects; this is to ensure that the subjects did not have a first-hand experience on the instrument. The subjects used in the pilot study, however, have similar characteristics with the study population.

3.5.3 Reliability of the Instrument

The reliability of the Biology Laboratory Equipment Questionnaire (BLEQ) was determined by analysing the data generated from pilot study Cronbach Alpha Reliability method which determined the suitability of the instrument for the study. Cronbach Alpha Reliability method is commonly used where there are multiple Likert questions in a survey /

questionnaire that form a scale that one wish to determine if the scale is reliable. In this case the reliability yielded a coefficient value of 0.82. Brown in Omole (2014) indicated that reliability coefficient of 0.5 or more is considered reliable. Similarly, Andale (2016) explained that reliability coefficient vary between zero and one. According to him, an instrument is considered reliable if its reliability coefficient lies between 0 and 1. In a situation where the reliability is close to zero the less reliable the instrument; and the closer the reliability to one, the more reliable it is. In this case the reliability coefficient is 0.82 therefore the instrument is judged to be reliable.

3.6 Procedure for Data Collection

An Introductory letter was collected from the Department of Educational foundations and Curriculum, Faculty of Education Ahmadu Bello University, Zaria. This was used to introduce the researcher in each of the sampled colleges. 501 Copies of the instrument (questionnaire) were administered by the researcher to the Biology lecturers, Laboratory Technicians/Attendants and students in the colleges of education under study through direct contact. This was done with the assistance of other lecturers and laboratory attendants from chemistry and physics departments at one sitting. An orientation was provided for the research assistants in each of the colleges. The researcher and assistants went through the instruments for more understanding and familiarity. This was to equip them with more information for possible questions or demands for explanation from the respondents. In the case of lecturers and laboratory attendants, they were asked to go with it and to return the completed instrument to the laboratory attendants a day after. This was also applied to students that were not present on the days of the visits. However, only 423 were successfully filled and returned; as explained earlier all efforts made to retrieve them was in vain.

3.7 Data Analysis

The purpose of this study is to assess the availability, adequacy and utilization of biology laboratory facilities, equipment and materials in college of education. The data collected was analysed to test all the hypotheses using simple descriptive (frequency, percentages, mean and standard deviation) and inferential statistic (Chi-Square and Kruskal Wallis H test). Frequency and percentages were used to analyse the demographic data; frequency, percentages and mean were used to analyse the research questions; while Chi-Square was used to analyse hypotheses 1, 2, and 3 and Kruskal Wallis H test was used to analyse hypotheses 4 and 5 respectively.

CHAPTER FOUR RESULTS AND DISCUSSION

4.1 Introduction

This chapter deals with data presentation, interpretation and discussion of findings. The results of the study are organized around the items of the demographic data, research questions and hypotheses.

4.2 Demographic Data of Respondents

Table 3: Number of Respondents in the Sampled Colleges of Education

College	F	%
Federal College of Education Katsina	118	27.9
College of education (T) Gusau	115	27.2
Isa Kaita College of Education Dutsin-Ma	190	44.9
Total	423	100

Table 3 shows the frequency and percentage of three Colleges of Education sampled for the study. It can be seen from the table that 118 respondents representing 27.9 percent are from Federal College of Education Katsina, 115 respondents representing 27.2 percent are from Federal College of Education (T) Gusau and 190 respondents representing 44.9 percent are from Isa Kaita College of Education, Dutsinma.

Table 4: Gender of respondents

Sex	F	%
Male	362	85.6
Female	61	14.4
Total	423	100

Table 4 shows that 362 of the respondents, representing 85.6 percent are males while 61 respondents, representing 14.4 percent are females; this means that majority of the respondents were males.

Table 5: Category of Respondents

Respondents	<i>F</i>	%
Lecturers	38	9
Lab Attendants	6	1.4
Students	379	89.6
Total	423	100

Table 5 shows that 38 respondents, representing 9 percent are lecturers; 6 respondents representing 1.4 percent are laboratory attendants; while 379 respondents representing 89.6 percent are students. This indicates that majority of the respondents are students.

4.3 Descriptive Analysis

This was done by way analysing all the items for each of the category of the questionnaire on availability, adequacy and utilization; the responses are as follows:

Research Question One

What are the available facilities, equipment and materials in biology laboratories in colleges of education in the North - West Geopolitical Zone of Nigeria?

The aim here was to evaluate the extent of available facilities and equipment in biology laboratories in colleges of education in the North-West Geopolitical Zone of Nigeria. The responses of the respondents were assessed in line with the items that are available in the instrument administered. Table 6 indicates the frequencies and percentages expressed along the five point scale used in the instrument. The mean for each of the item was computed on the five point scale.

Table 6: Descriptive Statistics on Availability, of Facilities, Equipment and Materials in Biology Laboratories in Colleges of Education in North-West Geopolitical Zone of Nigeria.

N	Mean	SD
423	196.61	16.73

The result of the descriptive data analysis in table 6 shows that availability of facilities, equipment and materials in Biology laboratory in Colleges of Education in the North-West Geopolitical Zone of Nigeria has a mean of 196.61 and a standard deviation 16.73. This means that facilities, equipment and materials are available in Biology Laboratories in colleges of education in the in the North-West Geopolitical Zone.

Research Question Two

To what extent are the facilities, equipment and materials adequate in biology laboratories in colleges of education in the North - West Geopolitical Zone of Nigeria? The purpose here was to evaluate the extent of adequacy of facilities, equipment and materials in biology laboratories in colleges of education in the North-West Geopolitical Zone of Nigeria. The responses of the respondents were assessed with a number of items in the administered instrument. Table 7 indicates the frequencies and percentages expressed along the five point scale used in the instrument. The mean for each of the item was computed on the five point scale.

Table 7: Descriptive Statistics on Adequacy of Facilities, Equipment and Materials in Biology Laboratories in Colleges of Education in North-West Geopolitical Zone of Nigeria.

N	Mean	SD
423	189.00	3.85

The result of the analysis indicates that biology laboratory facilities and equipment in Colleges of Education in North-West Geopolitical Zone of Nigeria are adequate, having a mean of 189.00 and a standard deviation 3.85.

Research Question Three

What is the level of utilization of the facilities, equipment and materials that are available in biology laboratories in Colleges of Education in the North-West Geopolitical Zone of Nigeria? The aim here was to evaluate the level of utilization of facilities, equipment and materials in biology laboratories in colleges of education in the North-West Geopolitical Zone of Nigeria. The opinions of the respondents were assessed with a number of items listed in the questionnaire. Table 8 shows the frequencies and percentages expressed along the five point scale used in the instrument. The mean for each of the item was computed on the five point scale.

Table 8: Descriptive Statistic on Utilization of Facilities, Equipment and Materials in Biology Laboratories in Colleges of Education in North-West Geopolitical Zone of Nigeria.

N	Mean	SD
423	183.04	8.66

The result of the descriptive data analysis shows that level of utilization of facilities, materials and equipment in Biology laboratory in Colleges of Education in North-West Geopolitical Zone of Nigeria has a mean of 183.04 and a standard deviation 8.66; meaning that the facilities, materials and equipment were well utilized in the colleges of education.

Research Question Four

What is the impact of the availability, adequacy and utilization of biology laboratory facilities and equipment on the conduct of practical exercises in colleges of education in the North – West Geographical zone of Nigeria?

The purpose here was to find out the impact of availability, adequacy and utilization of biology laboratory facilities, materials and equipment on the conduct of practical exercises in

colleges of education in the North-West Geopolitical Zone of Nigeria. The responses of the respondents were assessed with a number of items listed in the questionnaire and results are computed in frequencies and percentages expressed along the five point scale used in the instrument; this is shown in table 9.

Table 9: Descriptive Analysis of the Impact of Availability, Adequacy and Utilization of Biology Laboratory Facilities, Equipment and Materials on the Conduct of Practical Exercises in Colleges of Education in the North – West Geographical Zone of Nigeria.

Variable	N	Mean	SD
Availability	423	196.0	16.73
Adequacy	423	189.00	3.85
Utilization	423	183.03	8.66
Total		568.63	29.24

The result of the descriptive data analysis in table 9 shows that availability has a mean score of 196.60, standard deviation of 16.73. Adequacy has a mean score of 189.00 and standard deviation of 3.85; while utilization has a mean score of 183.03 and standard deviation is 8.66. This means that the availability, adequacy and utilization of Biology Laboratory facilities, equipment, and materials have a positive impact on the conduct of Biology Practical in Colleges of Education in the North-West Geopolitical Zone of Nigeria.

Research Question Five

How do Federal, State, and Technical Colleges of Education differ in the level of availability, adequacy and utilization of biology laboratory facilities, equipment and materials?

The aim here was to evaluate if there is a difference in the level of availability, adequacy and utilization of biology laboratory facilities, equipment and materials in colleges of education in the North-West Geopolitical Zone of Nigeria. The responses of the respondents were assessed

with a number of items listed in the questionnaire. Table 10 indicates the frequencies and percentages expressed along the five point scale used in the instrument. The mean for each of the item was computed on the five point scale.

Table 10: Descriptive Analysis of Federal, State and Technical Colleges of Education on the Level of Availability, Adequacy and Utilization of Biology Laboratories Facilities, Equipment and Materials in the North-West Geopolitical Zone of Nigeria.

Institution	N	Mean	SD
Federal	118	300.94	15.48
State	190	300.80	15.40
Technical	115	300.76	15.39
Total	423	902.50	46.63

The result of the descriptive data analysis on the availability, adequacy and level of utilization of Biology laboratory facilities, equipment and materials among Federal, State and Technical colleges of education in the North-West Geopolitical Zone of Nigeria shows that Federal Colleges of Education has a mean of 300.94 and a standard deviation of 15.48, State Colleges of Education has a mean of 300.80 and a standard deviation of 15.40; while Technical Colleges of Education has a mean of 300.76 and a standard deviation of 15.39. This shows that there is no significant difference in the mean scores among Federal, State and Technical Colleges of Education in the North -West Geopolitical Zone of Nigeria.

4.4 Hypotheses Testing

Five hypotheses were formulated and tested for this study; the hypotheses were based on data collected on the terms related to the topic; which is Impact of Availability, Adequacy and Utilization of Biology Laboratory Facilities, Equipment and Materials in Colleges of Education in North-West Geopolitical Zone.

The testing of null hypotheses (Ho) focused mainly on the responses of the respondents on the availability, adequacy and utilization of Biology Laboratory Facilities, Equipment and

Materials in Colleges of Education. Chi-Square and Kruskal Wallis H test were employed in testing the null hypotheses. The level of significance set for the study is 0.05 ($P < 0.05$). This means that when the probability value is lower than the level of significance set for the study, the hypothesis is rejected; if on the other hand, the probability value is higher than the level of significance, the hypothesis is retained.

Null Hypothesis 1 (H_{01}): There is no significant difference in the responses of the respondents on the availability of biology laboratory facilities and equipment in colleges of education in the North – West Geopolitical zone of Nigeria. This hypothesis was tested by subjecting the expressed responses depicted with the observed frequencies on the five point scale by the respondents as indicated in table 11 to a Chi-Square Statistic. This is done in order to establish the significance expressed on the availability of biology laboratory facilities, equipment and materials in colleges of education. The summary of the Chi-Square Statistic is presented in table 11.

Table 11: Chi-Square on the Availability of Biology Laboratory Facilities, Equipment and Materials in Colleges of Education in the North West Geopolitical Zone

N	\bar{X}	SD	X^2_{cal}	Df	A	X^2_{crit}	P	Decision
423	196.61	167.3	39.75	2	0.05	5.991	0.00	Rejected

Significant at the 0.001 level (2-tailed $p < 0.005$) of significance

Table 11 indicates the result of chi-Square test carried out on the availability of biology laboratory facilities and equipment. The result was significant at the 0.001 level (2-tailed $p < 0.005$) of significance ($x^2 = 39.74$, $df = 2$). From the table, it can be seen that chi-square calculated is greater than the chi-square critical. This means that there is a significant difference in the opinions of respondents on the availability of biology laboratory facilities and equipment in Colleges of Education in the North-West geographical Zone of Nigeria. Therefore, the null hypothesis is rejected.

Null Hypothesis 2 (Ho₂): There is no significant difference in the on the adequacy of biology laboratory facilities, materials and equipment in colleges of education in the North – West Geopolitical zone of Nigeria. This hypothesis was tested by subjecting the expressed responses depicted with the observed frequencies on the five point scale by the respondents as indicated in table 12 to a Chi-Square Statistic to establish the significance expressed on the adequacy of biology laboratory facilities, materials and equipment in colleges of education. The summary of the Chi-Square Statistic is presented in table 12.

Table 12: Chi-Square on the Adequacy of Biology Laboratory Facilities, materials and Equipment in Colleges of Education in the North West Geographical Zone

N	X̄	SD	X ² cal	Df	A	X ² crit	P	Decision
423	189.00	3.85	29.15	2	0.05	5.991	0.00	Rejected

Significant at the 0.001 level (2-tailed p<0.0005) of significance

Table 12 shows a chi-Square test carried out on the adequacy of biology laboratory facilities, equipment and materials. The result shows that it is significant at the 0.001 level 2-tailed p<0.0005. ($x^2 = 29.14$, $df = 2$). Chi-square calculated is greater than the chi-square critical. This means that there is a significant difference in the responses of lecturers, students and laboratory attendants on the adequacy of biology laboratory facilities and equipment in Colleges of education in the North-West geographical zone of Nigeria; therefore, the null hypothesis is rejected.

Null Hypothesis 3 (Ho₃): There is no significant difference in the utilization of biology laboratory facilities, materials and equipment in colleges of education, in the North – West Geopolitical zone of Nigeria. This hypothesis was tested by subjecting the expressed opinions depicted with the observed frequencies on the five point scale by the respondents as indicated in table 13 to a Chi-Square Statistic. This is with a view to establish the significance expressed on

the utilization of biology laboratory facilities, material and equipment in colleges of education.

Table 13 shows the summary of the Chi-Square Statistic.

Table 13: Chi-Square on the Utilization of Biology Laboratory Facilities, Materials and Equipment in Colleges of Education in the North West Geopolitical Zone

N	\bar{X}	SD	X^2_{cal}	Df	A	X^2_{crit}	P	Decision
423	183.04	8.66	39.68	2	0.05	5.991	0.00	Rejected

Significant at the 0.001 level (2-tailed $p < 0.0005$) of significance

Table 13 shows a chi-Square test carried out on the utilization of biology laboratory facilities, materials and equipment. The result indicates that it is significant at 0.001 level 2-tailed $p < 0.0005$ of significance ($x^2 = 39.68$, $df = 2$). From the table it can be seen that chi-square calculated is greater than chi-square critical. This means there is a significant difference in the responses of lecturers, students and laboratory attendants on utilization of biology laboratory facilities, equipment and materials in colleges of education in the North-West geographical zone of Nigeria. The null hypothesis is therefore, rejected.

Null Hypothesis 4 (Ho₄): Availability, adequacy and utilization of biology laboratory facilities, equipment and materials have no significant impact on the conduct of biology practical exercises in colleges of education in the North – West Geopolitical zone of Nigeria. This hypothesis is tested using Kruskal Wallis H test in order to establish the significance expressed on impact of the availability, adequacy and utilization of biology laboratory facilities, equipment and materials on the conduct of biology practical exercises in colleges of education. Table 14 presents the summary of the Kruskal Wallis H.

Table 14: Kruskal Wallis Test on the Impact of Availability, adequacy and utilization of Biology Laboratory Facilities, Equipment and Materials on the Conduct of Biology Practical Exercises

Variable	N	\bar{X}	SD	X^2_{ca}	Df	α	X^2_{crit}	P	Decision
Available	423	196.61	16.73						
Adequacy	423	189.00	3.85	8.52	2	0.05	7.04	0.014	rejected
Utilization	423	183.04	8.66						

Significant at the 0.001 level (2-tailed $p < 0.0005$) of significance

The Kruskal Wallis H test in table 14 indicates a significant difference in biology practical scores between availability, adequacy and level of utilization in Colleges of education in the North-West Geopolitical zone of Nigeria; $X^2_{cal}(2) = 8.520$, $p = 0.014$, with a mean rank biology practical score of 196.61 for Availability, 189.00 for Adequacy and 183.04 for level of Utilization. Therefore, the null hypothesis is rejected; meaning that there is a significant difference in biology practical scores between availability, adequacy and level of utilization in colleges of education in the north-west geopolitical zone.

Null Hypothesis 5 (H_{05}): There is no significant difference in level of availability, adequacy and utilization of Biology Laboratory Facilities; Equipment and Materials in Federal and State Colleges of Education in the North-West Geopolitical Zone. This hypothesis was tested by subjecting the expressed opinions depicted with the observed frequencies on the five point scale by the respondents as indicated in table 15 to a Kruskal Wallis H test. This is in order to establish the significance expressed on the availability, adequacy and utilization of biology laboratory facilities, equipment and materials in Federal, State and Technical Colleges of Education in the North West Geographical Zone. Table 15 presents the summary of the Kruskal Wallis H test.

Table 15 Kruskal Wallis Test on the Availability, Adequacy and Utilization of Biology Laboratory Facilities, Equipment and Materials in Federal, State and Technical Colleges of Education

Variable	Institution	N	\bar{X}	SD	X^2_{cal}	df	α	X^2_{cri}	P	Decision
Availability	Federal	118	117.58	21.00	0.019	1	0.05	0.017	0.00	retained
	State	115	116.40	19.12						
Adequacy	Federal	118	116.51	19.22	0.014	1	0.05	0.002		retained
	State	115	117.50	22.31						
Utilization	Federal	118	116.90	18.73	0.001	1	0.05	0.002		retained
	State	115	117.10	16.88						

Not significant at the 0.001 level (2-tailed $p < 0.0005$) of significance

A Kruskal Wallis H test showed that there was no significant difference in the level of availability, adequacy and utilization of biology laboratory facilities, equipment and materials in Federal and State Colleges of Education; $H(1) = 0.019$, $p = 0.891$, with a mean rank biology practical score of 117.58 for FCE Katsina and a mean rank biology practical score of 116.40 for COE Dutsinma. Similarly, the Kruskal Wallis H test showed that there was no significant difference in the level of adequacy of biology laboratory facilities, equipment and materials in Federal and State Colleges of Education, $H(1) = 0.014$, $p = 0.907$, with a mean rank Biology Practical Score of 116.51 for FCE Katsina and a mean rank Biology Practical Score of 117.50 for college of education Dutsin-ma. Finally, the Kruskal Wallis H test showed that there was no significant difference in the level of utilization of biology laboratory facilities, equipment and materials in Federal and State Colleges of Education, $H(1) = 0.001$, $p = 0.9811$, with a mean rank Biology Practical Score of 116.90 for FCE Katsina and a mean rank biology practical score of 117.10 for COE Dutsinma. Therefore, the null H_0 is retained; meaning that there is no significant difference in the level of availability, adequacy and utilization of Biology Laboratory Equipment, Facilities and Materials in Federal and State Colleges of Education in the North West Geographical Zone of Nigeria.

4.5 Summary of Findings

The focus of this study was to examine impact of availability, adequacy and utilization of Biology Laboratory Facilities, materials and Equipment in Colleges of Education in North-West Zone of Nigeria. Factors such as availability of facilities, materials and equipment, adequacy of facilities, materials and equipment and level of utilization of the facilities, materials and equipment were investigated from the responses of biology lecturers, laboratory attendants and students. Based on the analyses carried out in this study, the following are the summary of the findings:

1. Biology laboratory facilities, materials and are available, but the level of availability varies from one college to another;
2. Laboratory facilities, materials and equipment are adequate in Colleges of Education in the North-West Geographical Zone of Nigeria, Some of the facilities, materials and equipment are adequate others not. The adequate ones are those that are inexpensive and easy to come by, while the more expensive ones are in adequate.
3. The result also showed that there was a significant difference on the level of utilization of Biology Laboratory facilities and equipment in Colleges of Education in the North-West Geopolitical Zone of Nigeria. In some colleges, both staff, laboratory attendants and students are utilising the laboratory facilities, materials and equipment, while in other colleges these are not utilised as expected, because they are either defective, no source of power or that the staff cannot operate them.
4. The outcome of the study also revealed that the availability, adequacy and utilization of Biology laboratory facilities and equipment had impact on students' Biology Practical Score in Colleges of Education in the North-West geopolitical zone.

5. Furthermore the result revealed that level of availability, adequacy and utilization of biology laboratory facilities, equipment and materials do not vary in Federal and State Colleges of Education in the North-West geopolitical zone.

4.6 Discussion of Findings

The first hypothesis stated that there is no significant difference among the respondents in their responses on the availability of biology laboratory facilities, materials and equipment in colleges of education in the North – West Geopolitical zone of Nigeria. This hypothesis was rejected by the result of the findings as it indicated a significant difference. The hypothesis was tested using chi-square statistic and the result of the analysis revealed $X^2 = 39.74$ $df = 2$; meaning that there was a significant difference among Lecturers, Laboratory Attendants and students' responses on the availability. This agrees with the findings of Umeh and Okoye (2009) and Ochu (2010) in Emendu (2012) where he reported that there were inadequate equipment for teaching and learning in chemistry in secondary schools. Further to this is also Asiyai (2008), whose findings revealed that most secondary schools do not have the instructional resources for teaching chemistry.

The second hypothesis which stated that there is no significant difference among the responses of the respondents on the adequacy of biology laboratory facilities, materials and equipment in colleges of education in the North-West Geopolitical Zone of Nigeria was rejected. The hypothesis was tested using chi-square statistic and the result of the analysis revealed $X^2 = 29.14$ $df = 2$; meaning that there was a significant difference among the respondents on the adequacy of the biology laboratory facilities, materials and equipment. This concurs with findings of Lawal (2016), Inyang (2012), Adesoji (2010); Akano and Akpolaere (2009) and Uyoata (2009) who discovered that in Biology laboratory, physical structures as well as equipment in the schools studied were inadequate and far below standard. Achufusi in Toyin (2013) observed that majority of schools under his study lack the essential resources for

imparting the knowledge of science concepts to students. He added that many students learn little science, because learning tends to be by rote and many students find it not interesting and boring. Ogunmade, in Omoifo (2012) explained that teacher - student interactions in many science classrooms are not healthy because of inadequate resources. According to him, in most of the schools, there are no facilities for the teachers to demonstrate phenomena, let alone allow the students to have opportunities for finding out things for themselves.

The third hypothesis stated that there is no significant difference in the respondents' opinions regarding the level of utilization of biology laboratory facilities and equipment in colleges of education in the North-West Geopolitical Zone, Nigeria. This hypothesis was rejected by the result of the findings as there was a significant difference. The hypothesis was tested using chi-square statistic and the result of the analysis revealed $X^2 = 39.68$ $df = 2$. This means that there was a significant difference in the biology lecturers, laboratory attendants and students' responses regarding the level of utilization of biology facilities, materials and equipment. This agrees with the findings of Filardo (2008), who reported that forty percent of chemistry teachers in his study indicated that the chemistry laboratory equipments are not utilized. Similarly, Adeleye (2015) reported that the greatest hindrance to the effective teaching of Physics in schools was not lack of the necessary laboratory apparatus and equipment but rather lack of their usage. He added that effective utilization of these materials have positive influence on the students' attitude towards Physics which could indirectly affect their academic achievement in the subject.

Hypothesis four stated that availability; adequacy and utilization of biology laboratory facilities and equipment have no significant impact on the conduct of biology practical work in colleges of education in the North – West Geopolitical zone of Nigeria. This hypothesis was rejected by the result of the findings as there was a significant correlation. The hypothesis was tested using Kruskal Wallis H test as shown in table 14, where it shows a significant difference

in biology practical scores between availability, adequacy and level of utilization in colleges of education in the North-West geopolitical zone of Nigeria; $H_{cal}(2) = 8.520$, $p = 0.014$, with a mean rank biology practical score of 196.61 for Availability, 189.00 for Adequacy and 183.04 for level of Utilization. Therefore, the null hypothesis is rejected; meaning that there is a significant difference in biology practical scores between availability, adequacy and level of utilization in colleges of education in the north-west Geopolitical zone. This concurs with findings of Sa'adu (2015) who reported a significant relationship between students' academic achievement and the adequacy of working condition of laboratory equipment. According to him, the laboratories of the sampled schools were inadequately equipped and not being utilized, consequence upon this, the biology SSCE results of the sampled schools for two years was very poor. Similarly, Audu and Oghogho in Omoifo (2012) said the performance of many students in many science classrooms in Nigerian schools and colleges is nothing to write home about. In many schools there are no laboratories. Some schools merely have empty rooms labelled as laboratories. Students rarely have hands-on, minds-on experiences. Few days to science practical examinations, most schools acquire science equipments for teacher demonstration to students. This cannot make for effective learning and eventually results in poor achievement. Taale and Antwi (2012) also discovered that inadequate exposure to science laboratory work at the secondary school level has been a major cause of first year University students' inability to comprehend and apply scientific knowledge. He added that poor utilization of the laboratory apparatus and equipment may not be unconnected with the lack of laboratory personnel to assist the teachers in preparing for class demonstrations and practical in many of the schools. Ihuarlam, (2008) and Ifeakor (2008) found that there is a dearth in science facilities in the laboratories and this contributes to students' poor academic performance in science at the secondary school level.

Lastly, the fifth hypothesis which stated that there is no significant difference among Federal and state colleges of education on the availability, adequacy, and utilization of biology

laboratory facilities and equipment in the North-West Geopolitical Zone of Nigeria was retained. The hypothesis was retained because the result of the findings shows that there was no significant difference. The hypothesis was tested using Kruskal Wallis H test and the result of the analysis revealed $H = 0.019$ $p = 0.891$. Findings from the study indicated that there was no significant difference among Federal and State Colleges of Education in the North-West Geopolitical Zone of Nigeria. This disagrees with the findings of Joseph (2011) who discovered that there is no significant difference between availability of laboratory facilities in rural and urban secondary school locations. He added that rural and urban secondary schools do not differ significantly in terms of availability of facilities like library, textbooks and laboratories. According to him, availability of facilities has been found to influence both efficiency and productivity; it has also been found to influence learning.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

In this chapter, summary, conclusion and recommendations based on the results obtained from the study were presented. The purpose of this research work was to examine the impact of availability, adequacy and utilization of Biology Laboratory Facilities, Equipment and Materials on Students' Academic Performance in Colleges of Education in the North-West Geopolitical Zone of Nigeria the research design used was survey, in which five research questions and five null hypotheses were formulated to guide the study. There are also literature reviews covering; conceptual, theoretical and empirical studies.

The sample of the study consisted of 37 Lecturers, 6 Laboratory Attendants and 380 students; making a total number of 423 respondents. One Federal College of Education, one State College of Education and a Technical College of Education in the North-West Geopolitical Zone of Nigeria were used in the survey.

5.2 Summary of the study

The objectives of this study are to:

1. determine the availability of biology laboratory facilities, materials and equipment in Colleges of Education in North - West Geopolitical zone;
2. assess the adequacy (in terms of quantity) of the available biology laboratory facilities, equipment and materials in Colleges of Education in North - West Geopolitical zone;
3. ascertain the level of utilization of biology laboratory facilities, equipment and materials in Colleges of Education in North - West Geopolitical zone;
4. assess the impact of the availability, adequacy and utilization of biology laboratory facilities, equipment and materials on the conduct of biology practical exercises in Colleges of Education in the North - West Geopolitical Zone; and

5. compare the level of availability, adequacy and utilization of biology laboratory facilities, materials and equipment between Federal, State and technical Colleges of Education in the North – West Geopolitical zone.

The different components of the study are contained in various chapters that constitute the main nucleus of the study. All the major issues discussed in the study are all embedded in these chapters. Chapter one explained the core fundamental issues that are considered very vital to the achievement of the objectives of the study. The problem statement, significance, objectives that guided the study, research questions, and basic hypotheses are all contained in this chapter.

Chapter two relevant literatures in various areas related to the study. All variables on which hypothetical statements were used as the anchor of the study were passed through the search light of literature reviewed. They were considered in the light of the work of others who have made valuable contributions to that effect.

Chapter three discussed the research design used in conducting the study, the population, sample size, the survey design, instrumentation process, data collection, and analysis. In data analysis, the normal electronic package for data analysis was also applied in the analytical process of this study.

Chapter four provided the actual analysis and interpretation of data. Tables were used to display the results of the data. Basic findings of the study are all contained in this chapter. Also, the summary of the findings were demonstrated in form of discussion and appropriate literatures used as back up for the findings. Hence, the findings in most cases agree with initial results while in some cases disagree with them. The present chapter that is chapter five contains summary, conclusion, and recommendations.

5.3 Conclusion

The study has been able to look at the Impact of Availability, Adequacy and Utilization of Biology Laboratory Facilities and Equipment in Colleges of Education in the North-West Geopolitical Zone of Nigeria. The various areas discussed include availability, adequacy, and level of utilization of biology laboratory facilities, equipment and materials in colleges of education in the North-West Geopolitical Zone of Nigeria.

The instrument used was a questionnaire developed by the researcher covering the five variables in the study. Chi-Square was used to analyse hypotheses 1, 2, and 3, while Kruskal Wallis H test was used to analyse hypotheses 4 and 5 respectively. The following conclusions were made:

Biology laboratory facilities, materials and equipment are available, but the level of availability varies from one college to another. All the sampled colleges have a biology laboratory, but the number is not adequate considering the population. Materials like reagents, chemicals and glassware are available; however these are seldom used by staff and students due to insufficient water supply or high student material to ratio. On equipment, high technology materials like refrigerators, autoclaves, desiccators and water bath that require electricity are available and adequate, but not utilized in teaching for two major reasons; poor electricity supply and the absence of Biology laboratory technologist who will operate and maintain them in the course of their usage. The adequate materials are those that are inexpensive and easy to come by, while the more expensive ones are in adequate. The result also showed that there was a significant difference on the level of utilization of Biology Laboratory facilities and equipment in Colleges of Education in the North-West Geopolitical Zone of Nigeria, in some colleges both staff, laboratory attendants and students are utilising the laboratory facilities, materials and equipment, while in other colleges these are not utilised as expected, because they are either defective, no source of power or that the staff cannot operate them. The outcome of the study

also revealed that the availability, adequacy and utilization of Biology laboratory facilities and equipment had impact on students' biology practical Scores in Colleges of Education in the North-West geopolitical zone. Furthermore the result revealed that level of availability, adequacy and utilization of biology laboratory facilities, equipment and material do not vary in Federal and State Colleges of Education in the North-West geopolitical zone.

5.4 Recommendations

Based on the outcome of this study, the following recommendations were made.

1. Governments (Federal, State and NCCE) should make available the necessary biology laboratory facilities, material and equipment in the colleges of education in the zone.
2. Government (Federal, State and NCCE) should ensure the biology laboratory facilities, materials and equipment are adequate in quantity in the colleges of education in the zone.
3. Lecturers and other personnel concerned should effectively utilize the biology laboratory equipment and facilities in the colleges of education in the zone and quality assurance units to monitor their utilization by the lecturers, laboratory attendant and students.
4. Lecturers and laboratory attendants should ensure that the impact of availability, adequacy and effective utilization of the biology laboratory facilities, materials and equipment be felt on the academic performance of students in biology practical exercise in colleges of education in the zone, and
5. Stakeholders especially donor agencies, development partners and philanthropists are to assist in providing biology laboratory facilities, materials and equipment in colleges of education in the North-West Geopolitical Zone and these should be effectively utilized to enhance academic performance in the colleges.

5.5 Suggestions for Further Study

The study has in no way exhausted the impact of availability, adequacy and utilization of biology laboratory facilities, materials and equipment in colleges of education in the North-West Zone Geopolitical zone of Nigeria. In the light of the findings of this study, the following areas are suggested for further research:

1. The study should be replicated in other northern parts of the country such as north-east, and north-central zones.
2. The study should be conducted in colleges of education across the six geopolitical zone of Nigeria so as to have a robust result.
3. A study should be conducted on the relationship among availability, adequacy and utilization on academic performance of biology students in colleges of education in the North-West Geopolitical Zone.

5.6 Contributions to Knowledge

The study has contributed to the body of existing knowledge in the following ways:

An instrument has been developed which could be used to assessment the impact of availability, adequacy and utilization of biology laboratory facilities, materials and equipment in colleges of education. This can be adapted and used to assess other subject areas in science, arts and humanities. The study also revealed that there were significant differences among the respondents on the availability of biology laboratory facilities and equipment in colleges of education in the North-West Geopolitical Zone of Nigeria, there was no significant difference among the respondents on the adequacy of biology laboratory facilities and equipment in colleges of education in the North-West Geopolitical Zone of Nigeria, furthermore, the study revealed that there was a significant difference among the respondents on the level of utilization of biology laboratory facilities and equipment in colleges of education in the North-West Geopolitical Zone of Nigeria.

On adequacy and utilization of biology laboratory facilities, materials and equipment, the study shows that these have a significant impact on students' biology practical exercise in colleges of education in the North-West Geopolitical Zone of Nigeria while availability has no significant impact on students' biology practical exercise in the zone. The result further revealed that there is no significant difference among federal, state and technical colleges of education on the level of availability, adequacy and utilization of biology laboratory facilities and equipment in the North-West Geopolitical Zone of Nigeria.

In the course of the study, the researcher developed scales measuring all the variables in the study which can be adopted or adapted for further use in studies of this nature. The study has provided information in form of literature which government, its agencies, and all stakeholders in education can access to have a better understanding of the impact of availability, adequacy and utilization of biology laboratory facilities, materials and equipment in colleges of education in the North-West Geopolitical Zone of Nigeria.

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APPENDIX I

Opinions of respondents on the Available Facilities and Equipment (Equipment and Materials) in Biology Laboratories in Colleges of Education in North-west of Nigeria

S/N	STATEMENT	SA		A		UND		DA		SDA		M
		F	%	F	%	F	%	F	%	F	%	
1	Laboratories are available your college	339	80.1	84	19.9	0	0	0	0	0	0	4.80
2	Botanical gardens available in your college	85	20.1	338	79.9	0	0	0	0	0	0	4.20
3	Laboratory workshops available in your college	254	60	84	19.9	0	0	85	20.1	0	0	4.19
4	Museums are available your college	0	0	0	0	84	19.9	170	40.2	169	40	1.79
5	Stores are available your college	0	0	169	40	84	19.9	85	20.1	85	20.1	2.79

Opinions of respondents on the availability of models/charts/equipment/materials

S/N	STATEMENT	SA		A		UND		DA		SDA		M
		F	%	F	%	F	%	F	%	F	%	
Models/Charts/Equipment/												
Materials												
1	Skeletal systems is available your college	170	40.2	84	19.9	0	0	84	19.9	85	20.1	3.40
2	Muscular system is available your college	85	20.1	168	39.7	170	40.2	0	0	0	0	3.79
3	Brain & nervous system available in your college	169	40	169	40	0	0	0	0	85	20.1	3.79

4	Circulatory system is available your colleges	170	40.2	169	40	85	19.8	0	0	0	0	4.20
5	Digestive system is available your college	170	40.2	84	19.9	85	20.1	0	0	84	19.9	3.60
6	Eye and vision is available your college	170	40.2	168	39.7	0	0	85	20.1	0	0	4.00
7	Ear is available in your college	254	60	84	19.9	0	0	85	20.1	0	0	4.19
8	Skin and excretory organ available in your college	85	20.1	84	19.9	170	40.2	84	19.9	0	0	3.40
9	Genetic models are available your college	0	0	84	19.9	253	59.8	85	20.1	0	0	3.00

Equipment and Consumables

10	Microscopes are available your college	170	40.2	84	19.9	0	0	85	20.1	84	19.9	3.39
11	Incubator/sterilizer is available your college	85	20.1	168	39.7	85	20.1	0	0	85	20.1	3.99
12	Autoclave(portable) is available your college	169	40	84	19.9	170	40.1	0	0	0	0	2.59
13	Balances are available your college	0	0	169	40	84	19.9	0	0	170	40.1	2.60
14	Hot plate is available your college	0	0	169	40	85	20.1	0	0	169	40	2.99
15	Hand lenses are available your college	0	0	168	39.7	170	40.2	0	0	85	20.1	3.59
16	Refrigerator is available your college	84	19.9	254	60	0	0	0	0	85	20.1	3.00

17	Water filter is available your college	0	0	85	20.1	253	59.8	85	20.1	0	0	3.59
18	Hydrometer is available your college	85	20.1	168	39.7	85	20.1	85	20.1	0	0	2.80
19	Drying oven is available your college	0	0	170	40.2	84	19.9	85	20.1	84	19.9	3.39
20	Microtome/stage micrometer is available in your college	169	40	0	0	85	20.1	169	40	0	0	3.39
21	Automatic tissue processor is available in your college	85	20.1	84	19.9	0	0	254	60	0	0	3.60
22	Centrifuge is available in your college	0	0	85	20	0	0	169	40	169	40	2.00
23	Herbarium cabinet is available in your college	84	19.9	85	20.1	0	0	169	40	85	20.1	2.79
24	Herbarium Index boxes are available in your college	0	0	85	20.1	169	40	84	19.9	85	20.1	2.60
25	Air pumps are available in your college	254	60	84	19.9	85	20.1	0	0	0	0	4.39
26	Photometer is available in your college	85	20.1	85	20.1	0		168	39.7	85	20.1	2.80
27	Kymograph is available in your college	85	20.1	169	40	0	0	84	19.9	85	20.1	3.20
28	Dissecting microscope is available your college	254	60	0	0	0	0	169	40	0	0	3.80

29	Insect light traps are available in your college	170	40.2	85	20.1	0	0	84	19.9	84	19.9	3.40
30	Insect box traps are available in your college	85	20.1	0	0	85	20.1	84	19.9	169	40	2.40
31	Slide projector is available in your college	170	40.2	84	19.9	84	19.9	0	0	85	20.1	3.60
32	Overhead projector is available in your college	169	40	169	40	0	0	0	0	85	20	3.79
33	Steel frame aquarium is available in your college	170	40.2	84	19.9	84	19.9	85	20.1	0	0	3.40
34	Oxygen meter is available in your college	0	0	0	0	338	79.9	85	20.1	0	0	2.79
35	Binocular microscopes are available in your college	169	40	254	60	0	0	0	0	0	0	3.39
36	Embedding bath is available in your college	0	0	84	19.9	0	0	254	60	85	20.1	3.00
37	Glass distiller is available in your college	85	20.1	168	39.7	85	20.1	0	0	85	20.1	3.19
38	Water bath is available in your college	0	0	254	60	0	0	85	20.1	84	19.9	3.40
39	PH meter is available in your college	0	0	254	60	84	19.9	0	0	85	20.1	3.99
40	Tissue grinder is available in your college	85	20.1	85	20.1	169	40	84	19.9	0	0	3.19

41	Caloric meter is available in your college	169	40	169	40	0	0	85	20	0	0	3.40
42	Auxanometer is available in your college	84	19.9	85	20.1	85	20.1	169	40	0	0	2.60
43	Soil agar is available in your college	0	0	85	20.1	85	20.1	253	59.8	0	0	2.79
44	Plant press is available in your college	0	0	169	40	0	0	253	60	0	0	2.20
45	Soil training kit is available in your college	85	20	0	0	0	0	169	40	169	40	3.39
46	Wooden quadrants are available in your college	85	20.1	169	40	84	19.9	0	0	85	20.1	4.39
47	Measuring tape is available in your college	254	60	84	19.9	0	0	0	0	85	20.1	3.19
48	Biological kits/ dissecting set are available in your college	84	19.9	170	40.2	0	0	84	19.9	85	20.1	2.79
49	Dissecting boards/plates are available in your college	0	0	253	59.8	0	0	0	0	170	40.2	3.20
50	Bunsen burners are available in your college	169	40	0	0	85	20.1	85	20.1	84	19.9	4.20
51	Giant gas cylinder is available in your colleges	254	60	0	0	0	0	169	40	0	0	5.00
52	Prepared and plane microscope slides are available in your college	254	60	84	19.9	0	0	85	20.1	0	0	4.19

53	Consumables such as glass wares, stains are available in your college	254	60	0	0	0	0	0	0	169	40	4.23
54	Test-tube racks are available in your college	85	20.1	84	19.9	169	40	85	20.1	0	0	3.39
55	Preserved plants and animals specimens are available in your college	254	60	169	40	0	0	0	0	0	0	4.60
56	Desiccators are available in your college	170	40.2	0	0	85	20.1	0	0	169	40	3.00
57	Gloves are available in your college	85	20.1	168	39.7	85	20.1	85	20.1	0	0	3.59
58	Safety devices (assorted) are available in your college	85	20.1	84	19.9	169	40	0	0	85	20.1	3.19

Opinions of respondents on the Adequacy of Facilities and Equipment (Equipment and Materials) in Biology Laboratories in Colleges of Education in North-west of Nigeria

S/N	STATEMENT	SA		A		UND		DA		SDA		M
		F	%	F	%	F	%	F	%	F	%	
1	Laboratories are adequately provided in your college	254	60	0	0	85	20.1	84	19.9	0	0	4.00
2	Botanical gardens are adequately provided in your college	0	0	169	40	254	60	0	0	0	0	3.39
3	Laboratory workshops are adequately provided in your college	0	0	84	19.9	85	20.1	169	40	85	20.1	2.39

4	Museums adequately provided in your college	85	20.1	0	0	85	20.1	169	40	84	19.9	2.60
5	Stores adequately provided in your college	0	0	169	40	85	20.1	84	19.9	85	20.1	2.79

Opinions of respondents on the Adequacy of Equipment and Materials in
Biology Laboratories in Colleges of Education in North-west of Nigeria

S/N	STATEMENT	SA		A		UND		DA		SDA		M
		F	%	F	%	F	%	F	%	F	%	
1	Skeletal systems are adequately provided in your college	170	40.2	84	19.9	85	20.1	84	19.9	0	0	3.80
2	Muscular system is adequately provided in your college	0	0	168	39.7	255	60.3	0	0	0	0	3.39
3	Brain nervous system provided in your college	85	19.9	85	19.9	0	0	170	40.2	85	20.1	2.79
4	Circulatory system is adequately provided in your college	170	40.2	84	19.9	0	0	85	20.1	84	19.9	3.40

5	Digestive system is adequately provided in your college	85	20.1	253	59.8	85	20.1	0	0	0	0	4.00
6	Eye and vision is adequately provided in your college	85	20.1	84	19.9	0	0	169	40	85	20.1	2.79
7	Model of Ear is adequately provided in your college	0	0	169	40	84	19.9	85	20.1	85	20.1	2.79
8	Skin and excretory organ is adequately provided in your college	84	19.9	84	19.9	170	40.2	85	20.1	0	0	3.39
9	Genetic models are adequately provided in your college	85	20.1	0	0	168	39.7	170	40.2	0	0	3.00
Equipment and Consumables												
10	Microscopes are adequately provided in your college	170	40.2	0	0	85	20.1	84	19.9	84	19.9	3.19
11	Incubator/sterilizer adequately provided in your college	0	0	253	59.8	85	20.1	0	0	85	20.1	1.79
12	Autoclave(portable) is adequately provided in your college	254	60	0	0	0	0	85	20.1	85	20.1	3.79

13	Balances are adequately provided in your college	84	19.9	84	19.9	170	40.2	0	0	85	20.1	3.80
14	Hot plate is adequately provided in your college	0	0	84	19.9	0	0	85	20.1	254	60	4.60
15	Hand lenses are adequately provided in your college	170	40.2	168	39.7	0	0	0	0	85	20.1	2.80
16	Refrigerator is adequately provided in your college	85	20.1	169	40	169	40	0	0	0	0	3.20
17	Water filter is adequately provided in your college	254	60	169	40	0	0	0	0	0	0	3.60
18	Hydrometer is adequately provided in your college	85	20.1	84	19.9	0	0	170	40.2	84	19.9	3.39
19	Drying oven is adequately provided in your college	170	40.2	84	19.9	0	0	0	0	169	40	3.19
20	Microtome/stage micrometer adequately provided in your college	170	40.2	84	19.9	84	19.9	0	0	85	20.1	4.20
21	Automatic tissue processor is adequately provided in your college	169	40	0	0	169	40	0	0	85	20	3.39
22	Centrifuge is adequately provided in your college	0	0	254	60	84	19.9	0	0	85	20.1	3.19
23	Herbarium cabinet is adequately provided in your college	254	60	85	20.1	0	0	84	19.9	0	0	4.20

24	Herbarium Index boxes are adequately provided in your college	0	0	85	20.1	0	0	338	79.9	0	0	2.40
25	Air pumps are adequately provided in your college	0	0	169	40	170	40.2	0	0	84	19.9	3.00
26	Photometer is adequately provided in your college	170	40.2	169	40	0	0	84	19.9	0	0	4.00
27	Kymograph is adequately provided in your college	85	20.1	85	20.1	84	19.9	169	40	0	0	3.20
28	Dissecting microscope is adequately provided in your college	84	19.9	85	20.1	85	20.1	84	19.1	85	20.1	2.99
29	Insect light traps are adequate provided in your college	84	19.9	85	20.1	0	0	84	19.9	170	40.2	2.59
30	Insect box traps are adequately provided in your college	0	0	85	20.1	0	0	253	59.8	85	20.1	2.20
31	Slide projector is adequately provided in your college	0	0	170	40.2	84	19.9	169	40	0	0	3.00
32	Overhead projector is adequately provided in your college	85	20.1	0	0	85	20.1	169	40	84	19.9	2.60
33	Steel frame aquarium is adequately provided in your college	169	40	84	19.9	85	20.1	85	20.1	0	0	3.79

34	Oxygen meter is adequately provided in your college	85	20.1	169	40	84	19.9	0	0	85	20.1	3.39
35	Binocular microscopes are adequately provided in your college	169	40	85	20	0	0	169	40	0	0	3.60
36	Embedding bath is adequately provided in your college	170	40.2	85	20.1	168	39.7	0	0	0	0	4.00
37	Glass distiller is adequately provided in your college	84	19.9	254	60	85	20.1	0	0	0	0	3.99
38	Water bath is adequately provided in your college	85	20.1	84	19.9	254	60	0	0	0	0	3.60
39	PH meter is adequately provided in your college	0	0	84	19.9	0	0	169	40	170	40.2	1.99
40	Tissue grinder is adequately provided in your college	0	0	84	19.9	169	40	170	40.2	0	0	2.79
41	Caloric meter is adequately provided in your college	0	0	85	20.1	0	0	253	59.8	85	20.1	2.20
42	Auxanometer is adequately provided in your college	85	20.1	0	0	84	19.9	169	40	85	20.1	2.60
43	Soil agar is adequately provided in your college	169	40	85	20	0	0	169	40	0	0	3.60
44	Plant press is adequately provided in your college	169	40	0	0	0	0	169	40	85	20	2.99

45	Soil training kit is adequately provided in your college	170	40.2	0	0	0	0	168	39.7	85	20.1	3.00
46	Wooden quadrants are adequately provided in your college	85	20.1	168	39.7	170	40.2	0	0	0	0	3.79
47	Measuring tape is adequately provided in your college	169	40	169	40	85	20	0	0	0	0	3.19
48	Biological kits/ dissecting set are adequately provided in your college	169	40	169	40	85	20	0	0	0	0	4.19
49	Dissecting boards/plates are adequately provided in your college	170	40.2	84	19.9	85	20.1	0	0	84	19.9	3.60
50	Bunsen burners are adequately provided in your college	85	20.1	84	19.9	85	20.1	84	19.9	85	20.1	3.00
51	Giant gas cylinder is adequately provided in your college	253	59.8	0	0	85	20.1	85	20.1	0	0	3.99
52	Prepared and plane microscope slides are adequately provided in your college	0	0	84	19.9	170	40.2	85	20.1	84	19.9	2.60
53	Consumables such as glass ware stains are adequately provided in your college	169	40	0	0	0	0	169	40	85	20	2.99

54	Test-tube racks are adequately provided in your college	85	20.1	0	0	84	19.9	84	19.9	170	40.2	2.39
55	Preserved plants and animals specimens are adequately provided in your college	170	40.2	169	40	0	0	84	19.9	0	0	4.00
56	Desiccators are adequately provided in your college	170	40.2	169	40	0	0	84	19.9	0	0	4.00
57	Gloves are adequately provided in your college	85	20.1	84	19.9	85	20.1	169	40	0	0	3.20
58	Safety devices (assorted) are adequately provided in your college	169	40	0	0	85	20	169	40	0	0	3.39

Opinions of respondents on the level of Utilization of Biology Laboratory Facilities in Colleges of Education in North-west of Nigeria

S/N	STATEMENT	SA		A		UND		DA		SDA		M
		F	%	F	%	F	%	F	%	F	%	
1	Laboratories are frequently utilized in your college	84	19.9	169	40	85	20.1	85	20.1	0	0	3.59
2	Botanical gardens are frequently utilized in your college	85	20.1	254	60	84	19.9	0	0	0	0	4.00
3	Laboratory workshops are frequently utilized in your college	0	0	84	19.9	84	19.9	170	40.2	85	20.1	2.39

4	Museums are frequently utilized in your college	85	20.1	0	0	84	19.9	85	20.1	169	40	2.40
5	Stores are frequently utilized in your college	0	0	84	19.9	169	40	85	20.1	85	20.1	2.59

Opinions of respondents on utilization of models/charts/equipment/materials

S/N	STATEMENT	SA		A		UND		DA		SDA		M
		F	%	F	%	F	%	F	%	F	%	
1	Skeletal systems are frequently utilized in your college	169	40	169	40	0	0	85	20	0	0	3.99
2	Muscular system are frequently utilized in your college	85	20.1	169	40	84	19.9	85	20.1	0	0	3.60
3	Brain & nervous system are frequently utilized in your college	85	20.1	168	39.7	85	20.1	85	20.1	0	0	3.59
4	Circulatory system is frequently utilized in your college	85	20.1	84	19.9	85	20.1	0	0	169	40	2.80
5	Digestive system is frequently utilized in your college	169	40	84	19.9	170	40.2	0	0	0	0	3.99
6	Eye and vision is frequently utilized in your college	169	40	84	19.9	0	0	0	0	170	40.2	3.40

7	Ear is frequently utilized in your college	170	40.2	84	19.9	0	0	84	19.9	85	20.1	4.00
8	Skin and excretory organ is frequently utilized in your college	85	20.1	254	60	84	19.9	0	0	0	0	3.19
9	Genetic models are frequently utilized in your college	0	0	84	19.9	84	19.9	255	60.3	0	0	4.12

Equipment and Consumable

10	Microscopes are frequently utilized in your college	170	40.2	168	39.7	0	0	85	20.1	0	0	4.00
11	Incubator/sterilizer is frequently utilized in your college	84	19.9	85	20.1	85	20.1	169	40	0	0	2.59
12	Autoclave(portable) is frequently utilized in your college	170	40.2	0	0	0	0	253	59.8	0	0	4.00
13	Balances are frequently utilized in your college	85	20.1	84	19.9	0	0	170	40.2	84	19.9	3.19
14	Hot plate is frequently utilized in your college	0	0	84	19.9	85	20.1	169	40	85	20.1	3.20
15	Hand lenses are frequently utilized in your college	0	0	84	19.9	85	20.1	169	40	85	20.1	2.80
16	Refrigerator is frequently utilized in your college	85	20.1	168	39.7	0	0	85	20.1	85	20.1	2.19

17	Water filter is frequently utilized in your college	0	0	168	39.7	170	40.2	85	20.1	0	0	3.29
18	Hydrometer is frequently utilized in your college	169	40	169	40	0	0	85	20	0	0	3.99
19	Drying oven is frequently utilized in your college	170	40.2	85	20	84	19.9	84	19.9	0	0	3.80
20	Microtome/stage micrometer is frequently utilized in your college	0	0	254	60	85	20.1	84	19.9	0	0	3.00
21	Automatic tissue processor is frequently utilized in your college	0	0	170	40.2	84	19.9	169	40	0	0	3.65
22	Centrifuge is frequently utilized in your college	0	0	85	20.1	0	0	254	60	84	19.9	4.40
23	Herbarium cabinet is frequently utilized in your college	85	20.1	169	40	85	20.1	84	19.9	0	0	3.80
24	Herbarium Index boxes are frequently utilized in your college	84	19.9	0	0	85	20.1	84	19.9	170	40.2	2.60
25	Air pumps are frequently utilized in your college	85	20.1	253	59.8	0	0	0	0	85	20.1	3.19
26	Photometer is frequently utilized in your college	170	40.2	0	0	0	0	168	39.7	85	20.1	2.40

27	Kymograph is frequently utilized in your college	84	20.1	85	20.1	0	0	84	19.9	169	40	3.40
28	Dissecting microscope is frequently utilized in your college	84	20.1	0	0	85	20.1	169	40	84	19.9	2.59
29	Insect light traps are frequently utilized in our college	31	80.1	0	0	0	0	84	19.9	0	0	2.60
30	Insect box traps are frequently utilized in our college	84	20.1	254	60	0	0	84	19.9	0	0	3.60
31	Slide projector is frequently utilized in your college	84	20.1	0	0	85	20.1	168	39.7	85	20.1	3.90
32	Overhead projector is frequently utilized in your college	84	19.9	0	0	255	60.3	84	19.9	0	0	2.76
33	Steel frame aquarium is frequently utilized in your college	84	20.1	0	0	85	20.1	84	19.9	169	40	3.00
34	Oxygen meter is frequently utilized in your college	84	20	169	40	0	0	169	40	0	0	3.60
35	Binocular microscopes are frequently utilized in your college	0	0	84	19.9	85	20.1	254	60	0	0	2.60
36	Embedding bath is frequently utilized in your college	84	20.1	0	0	84	19.9	169	40	85	20.1	2.80
37	Glass distiller is frequently utilized in your college	84	20.1	84	19.9	0	0	170	40.2	84	19.9	4.39

38	Water bath is frequently utilized in your college	84	20.1	169	40	84	19.9	85	20.1	0	0	3.60
39	PH meter is frequently utilized in your college	169	40	254	60	0	0	0	0	0	0	2.00
40	Tissue grinder is frequently utilized in your college	254	60	0	0	0	0	84	19.9	85	20.1	2.20
41	Caloric meter is frequently utilized in your college	84	20.1	0	0	169	40	169	40	0	0	2.41
42	Auxanometer is frequently utilized in your college	169	40.2	0	0	85	20.1	84	19.9	84	19.9	2.39
43	Soil agar is frequently utilized in your college	0	0	0	0	170	40.2	84	19.9	169	40	3.80
44	Plant press is frequently utilized in your college	0	0	0	0	170	40.2	168	39.7	85	20.1	2.79
45	Soil training kit is frequently utilized in your college	0	0	85	20.1	85	20.1	168	39.7	85	20.1	2.20
46	Wooden quadrants are frequently utilized in your college	84	19.9	0	0	0	0	254	60	85	20.1	2.79
47	Measuring tape is frequently utilized in your college	170	40.2	84	19.9	84	19.9	85	20.1	0	0	4.20
48	Biological kits/ dissecting set frequently utilized in your college	0	0	84	19.9	170	40.2	169	40	0	0	3.40

49	Dissecting boards/plates are frequently utilized in your college	85	20	0	0	0	0	169	40	169	40	3.60
50	Bunsen burners are frequently utilized in your college	0	0	84	19.9	84	19.9	170	40.2	85	20.1	3.00
51	Giant gas cylinder is frequently utilized in your college	169	40	0	0	0	0	85	20	169	40	3.70
52	Prepared and plane microscope slides are frequently utilized in your college	85	20.1	169	40	85	20.1	0	0	84	19.9	4.80
53	Consumables such as glass wares, stains are frequently utilized in your college	339	80.1	84	19.9	0	0	0	0	0	0	3.20
54	Test-tube racks are frequently utilized in your college	85	20.1	84	19.9	85	20.1	169	40	0	0	3.59
55	Preserved plants and animals specimens are frequently utilized in your college	84	19.9	85	20.1	254	60	0	0	0	0	3.40
56	Desiccators are frequently utilized in your college	85	20.1	0	0	338	79.9	0	0	0	0	3.00
57	Gloves are frequently utilized in your college	85	20.1	84	19.9	85	20.1	84	19.9	85	20.1	3.39
58	Safety devices (assorted) are frequently utilized in your college	169	40	0	0	85	20	169	40	0	0	4.20

APPENDIX II

QUESTIONNAIRES ON THE IMPACT OF AVAILABILITY, ADEQUACY AND UTILIZATION OF BIOLOGY LABORATORY FACILITIES AND EQUIPMENT IN COLLEGES OF EDUCATION IN NORTH-WEST GEOGRAPHICAL ZONE

Dear Sir/Ma,

I am a Postgraduate student of Ahmadu Bello University Zaria. The items in this questionnaire are designed to seek information on the Availability, Adequacy and Utilization of Biology Laboratory Equipment/Materials in colleges of education.

There are four parts in the questionnaire; part 'A' covers the personal data of the respondent, parts B, C & D covers the items based on availability, adequacy and utilization of biology laboratory facilities, equipment and materials in colleges of education. Kindly read each item carefully and complete the questionnaire by rating as honestly as you can. The information obtained will be used for research purpose only.

Thank you.

Ismail Funtua ADO

Research student

QUESTIONNAIRES ON THE IMPACT OF AVAILABILITY, ADEQUACY AND UTILIZATION OF BIOLOGY LABORATORY FACILITIES AND EQUIPMENT ON STUDENTS' ACADEMIC ACHEIVEMENTS IN COLLEGES OF EDUCATION IN NORTH-WEST GEOGRAPHICAL ZONE, NIGERIA

Instructions: Please complete the following by filling in the blank spaces on the questionnaire.

Part A demographic information, Part B requires your opinion on the availability of Biology Laboratory facilities, equipment and materials, Part C is on adequacy of the Biology Laboratory facilities, equipment and materials and Part D requires information on their utilization by staff, students and lab attendants

Part A: Name College.....

Sex: Male () Female ()

Respondents: Lecturers () Lab attendants () Students ()

Part B:

Please tick as appropriate by indicating your level of agreement with the availability of these items in your college

S/N	STATEMENT	SA	A	UND	DA	SDA
1	Laboratories are available in your college					
2	Botanical gardens are available in your college					
3	Laboratory workshops are available in your college					
4	Museums are available in your college					
5	Stores are available in your college					

S/N	STATEMENT	SA	A	UND	DA	SDA
	Models/Charts/Equipment/Materials					
1	Skeletal systems is available in your college					
2	Muscular system is available in your college					
3	Brain & nervous system is available in your college					
4	Circulatory system is available in your college					
5	Digestive system is available in your college					
6	Eye and vision is available in your college					
7	Ear is available in your college					
8	Skin and excretory organ is available in your college					
9	Genetic models are available in your college					

	Equipment and Consumables					
10	Microscopes are available in your college					
11	Incubator/sterilizer is available in your college					
12	Autoclave(portable) is available in your college					
13	Balances are available in your college					

14	Hot plate is available in your college					
15	Hand lenses are available in your college					
16	Refrigerator is available in your college					
17	Water filter is available in your college					
18	Hydrometer is available in your college					
19	Drying oven is available in your college					
20	Microtome/stage micrometer is available in your college					
21	Automatic tissue processor is available in your college					
22	Centrifuge is available in your college					
23	Herbarium cabinet is available in your college					
24	Herbarium Index boxes are available in your college					
25	Air pumps are available in your college					
26	Photometer is available in your college					
27	Kymograph is available in your college					
28	Dissecting microscope is available in your college					
29	Insect light traps are available in your college					
30	Insect box traps are available in your college					
31	Slide projector is available in your college					

32	Overhead projector is available in your college					
33	Steel frame aquarium is available in your college					
34	Oxygen meter is available in your college					
35	Binocular microscopes are available in your college					
36	Embedding bath is available in your college					
37	Glass distiller is available in your college					
38	Water bath is available in your college					
39	PH meter is available in your college					
40	Tissue grinder is available in your college					
41	Caloric meter is available in your college					
42	Auxanometer is available in your college					
43	Soil agar is available in your college					
44	Plant press is available in your college					
45	Soil training kit is available in your college					
46	Wooden quadrants are available in your college					
47	Measuring tape is available in your college					
48	Biological kits/ dissecting set are available in your college					

49	Dissecting boards/plates are available in your college					
50	Bunsen burners are available in your college					
51	Giant gas cylinder is available in your college					
52	Prepared and plane microscope slides are available in your college					
53	Consumables such as glass wares, stains are available in your college					
54	Test-tube racks are available in your college					
55	Preserved plants and animals specimens are available in your college					
56	Desiccators are available in your college					
57	Gloves are available in your college					
58	Safety devices (assorted) are available in your college					

Part C:

Please tick as appropriate by indicating your level of agreement with the adequacy of these items in your college

S/N	STATEMENT	SA	A	UND	DA	SDA
1	Laboratories are adequately provided in your college					
2	Botanical gardens are adequately provided in your college					
3	Laboratory workshops are adequately provided in your college					
4	Museums are adequately provided in your college					
5	Stores are adequately in your college					

S/N	STATEMENT	SA	A	UND	DA	SDA
	Models/Charts/Equipment/Materials					
1	Skeletal systems is adequately provided in your college					
2	Muscular system is adequately provided in your college					
3	Brain & nervous system is adequately provided in your college					
4	Circulatory system is adequately provided in your college					
5	Digestive system is adequately provided in your college					
6	Eye and vision is adequately provided in your college					
7	Ear is adequately provided in your college					
8	Skin and excretory organ is adequately provided in your college					
9	Genetic models are adequately provided in your college					

	Equipment and Consumables					
10	Microscopes are adequately provided in your college					
11	Incubator/sterilizer is adequately provided in your college					
12	Autoclave(portable) is adequately provided in your college					
13	Balances are adequately provided in your college					
14	Hot plate is adequately provided in your college					
15	Hand lenses are adequately provided in your college					
16	Refrigerator is adequately provided in your college					
17	Water filter is adequately provided in your college					
18	Hydrometer is adequately provided in your college					
19	Drying oven is adequately provided in your college					
20	Microtome/stage micrometer is adequately provided in your college					
21	Automatic tissue processor is adequately provided in your college					
22	Centrifuge is adequately provided in your college					
23	Herbarium cabinet is adequately provided in your college					
24	Herbarium Index boxes are adequately provided in your college					

25	Air pumps are adequately provided in your college					
26	Photometer is adequately provided in your college					
27	Kymograph is adequately provided in your college					
28	Dissecting microscope is adequately provided in your college					
29	Insect light traps are adequately provided in your college					
30	Insect box traps are adequately provided in your college					
31	Slide projector is adequately provided in your college					
32	Overhead projector is adequately provided in your college					
33	Steel frame aquarium is adequately provided in your college					
34	Oxygen meter is adequately provided in your college					
35	Binocular microscopes are adequately provided in your college					
36	Embedding bath is adequately provided in your college					
37	Glass distiller is adequately provided in your college					
38	Water bath is adequately provided in your college					
39	PH meter is adequately provided in your college					
40	Tissue grinder is adequately provided in your college					
41	Caloric meter is adequately provided in your college					
42	Auxanometer is adequately provided in your college					
43	Soil agar is adequately provided in your college					

44	Plant press is adequately provided in your college					
45	Soil training kit is adequately provided in your college					
46	Wooden quadrants are adequately provided in your college					
47	Measuring tape is adequately provided in your college					
48	Biological kits/ dissecting set are adequately provided in your college					
49	Dissecting boards/plates are adequately provided in your college					
50	Bunsen burners are adequately provided in your college					
51	Giant gas cylinder is adequately provided in your college					
52	Prepared and plane microscope slides are adequately provided in your college					
53	Consumables such as glass wares, stains are adequately provided in your college					
54	Test-tube racks are adequately provided in your college					
55	Preserved plants and animals specimens are adequately provided in your college					
56	Desiccators are adequately provided in your college					
57	Gloves are adequately provided in your college					
58	Safety devices (assorted) are adequately provided in your college					

Part D:

Please tick as appropriate by indicating your level of agreement with the frequency of utilization of these items in your college

S/N	STATEMENT	SA	A	UND	DA	SDA
1	Laboratories are adequately provided in your college					
2	Botanical gardens are adequately provided in your college					
3	Laboratory workshops are adequately provided in your college					
4	Museums are adequately provided in your college					
5	Stores are adequately in your college					

S/N	STATEMENT	SA	A	UND	DA	SDA
	Models/Charts/Equipment/Materials					
1	Skeletal systems is adequately provided in your college					
2	Muscular system is adequately provided in your college					
3	Brain & nervous system is adequately provided in your college					
4	Circulatory system is adequately provided in your college					
5	Digestive system is adequately provided in your college					
6	Eye and vision is adequately provided in your college					
7	Ear is adequately provided in your college					
8	Skin and excretory organ is adequately provided in your college					
9	Genetic models are adequately provided in your college					

	Equipment and Consumables					
10	Microscopes are adequately provided in your college					
11	Incubator/sterilizer is adequately provided in your college					
12	Autoclave(portable) is adequately provided in your college					
13	Balances are adequately provided in your college					
14	Hot plate is adequately provided in your college					
15	Hand lenses are adequately provided in your college					
16	Refrigerator is adequately provided in your college					
17	Water filter is adequately provided in your college					
18	Hydrometer is adequately provided in your college					
19	Drying oven is adequately provided in your college					
20	Microtome/stage micrometer is adequately provided in your college					
21	Automatic tissue processor is adequately provided in your college					
22	Centrifuge is adequately provided in your college					
23	Herbarium cabinet is adequately provided in your college					
24	Herbarium Index boxes are adequately provided in your college					
25	Air pumps are adequately provided in your college					
26	Photometer is adequately provided in your college					
27	Kymograph is adequately provided in your college					

28	Dissecting microscope is adequately provided in your college					
29	Insect light traps are adequately provided in your college					
30	Insect box traps are adequately provided in your college					
31	Slide projector is adequately provided in your college					
32	Overhead projector is adequately provided in your college					
33	Steel frame aquarium is adequately provided in your college					
34	Oxygen meter is adequately provided in your college					
35	Binocular microscopes are adequately provided in your college					
36	Embedding bath is adequately provided in your college					
37	Glass distiller is adequately provided in your college					
38	Water bath is adequately provided in your college					
39	PH meter is adequately provided in your college					
40	Tissue grinder is adequately provided in your college					
41	Caloric meter is adequately provided in your college					
42	Auxanometer is adequately provided in your college					
43	Soil agar is adequately provided in your college					
44	Plant press is adequately provided in your college					
45	Soil training kit is adequately provided in your college					

46	Wooden quadrants are adequately provided in your college					
47	Measuring tape is adequately provided in your college					
48	Biological kits/ dissecting set are adequately provided in your college					
49	Dissecting boards/plates are adequately provided in your college					
50	Bunsen burners are adequately provided in your college					
51	Giant gas cylinder is adequately provided in your college					
52	Prepared and plane microscope slides are adequately provided in your college					
53	Consumables such as glass wares, stains are adequately provided in your college					
54	Test-tube racks are adequately provided in your college					
55	Preserved plants and animals specimens are adequately provided in your college					
56	Desiccators are adequately provided in your college					
57	Gloves are adequately provided in your college					
58	Safety devices (assorted) are adequately provided in your college					

APPENDIX III

1 PHILOSOPHY OF THE NCE BIOLOGY CURRICULUM

The curriculum is designed to produce knowledgeable, highly motivated, professionals and effective teachers of biology who will be able to develop in students an appreciation and understanding of biological process and principles. The programme is also designed to develop confidence in the biology teacher and enhance his ability to adapt to the changing situations in science and the technologically oriented society.

2. OBJECTIVES At the end of the programme, the N.C.E. teacher will be able to: i) view biology as a process of inquiry into the living world; ii) critically analyse the activities of living things in their environment; iii) demonstrate practical skills in handling scientific apparatus; iv) demonstrate excellence and professional competence in teaching biology; v) include positive scientific attitudes and values in the society and promote positive disposition towards biological science and the scientific enterprise; vi) apply concepts and methods acquired in the course in new areas of study and in everyday situations; vii) make a successful career in biology teaching; viii) Successfully qualified to undertake a B.Ed/B.Sc (Ed) degree programmes.

3. GENERAL ADMISSION REQUIREMENTS

GENERAL ADMISSION REQUIREMENTS a) Senior Secondary School Certificate of WAEC or NECO or any other equivalent Certificate from recognized examination bodies with credit passes in four (4) subjects including English Language and Mathematics at not more than two sittings. Two of the credits must be in the subjects making up the combinations the candidates wish to offer. b) A Grade II Teacher's Certificate (TC II) with credit or merit in four (4) subjects, two of which must be relevant to the course the candidate wishes to offer. Credits/Merits in English Language and Mathematics are required for candidates wishing to study Biology. c) A pass in Pre-NCE Biology final examination or a pass in IJMB Biology final examination and a

pass in JAMB is required for admission. d) All candidates wishing to be considered for direct admission must enroll for and write the selected examination organized by an accredited body such as JAMB. e) It should be noted that some colleges may in addition to all the above, administer their own elimination tests and/or interviews for.

ADDITIONAL REQUIREMENT Pre-NCE candidates should have a minimum of D grade (2.0) before transiting to read Biology at NCE proper.

4. FACILITIES i) LABORATORY SPACE There should be at least three general laboratories for each level (of about 7.5m²), each large enough to accommodate not less than forty students. The following auxiliary facilities should also be provided:

- Biological garden (botanical and zoology);
- Museum;
- Aquarium;
- Herbarium; There should also be a stock room and preparation room adjacent to the laboratory.

ii) Lecture Hall: There should be at least three lecture halls each of which is large enough to accommodate sixty students. Public address system and an overhead projector should be provided in the large halls.

STAFF OFFICES The comfort of teaching staff must be taken into consideration. Ideally, there should be an office per lecturer. The office should be equipped with bulletin boards, book shelves, filing cabinet, seats for at least three visitors and standard furniture. There should also be an office for support staff with relevant equipment. a) Staff Common Room - There should be a big general office with adequate furniture to comfortably accommodate all the staff of the biology department.

b) HOD's Office - This should be fully furnished with adequate convenience and file cabinets.

iv. Books in the Library: There must be enough books to cover all the areas of the subject to the ratio of one student to ten books in the department and college library. In addition, there should be E-library at the departmental level.

APPENDIX IV

Appendix IV provides Biology curriculum for NCE I, II and III. In all Biology students are expected to undergo five practical courses from NCE one to NCE. These are Bio 114, 124,216,224 and 325. Each course has a status of one credit

COURSE DESCRIPTION NCE 1 FIRST SEMESTER COURSE CODE COURSE TITLE CREDIT UNIT AND STATUS

BIO 111 - BASIC PRINCIPLE OF BIOLOGY 1 Credit. Compulsory

Objectives:

At the end of the course, students should be able to:

i. Apply basis biology principles to everyday life.

ii. Explain steps involved in scientific method.

- Definition, brief history and

- Importance of science

- Scientific method: -

➤ Identifying and defining problem,

➤ Raising question, formulating

➤ Hypotheses, designing experiments to test hypothesis, collecting data,

➤ analyzing data, drawing inference and conclusion.

- Science processes/intellectual skills:

❖ Basic processes: observation,

❖ Classification, measurement etc

-Integrated processes:

❖ Experimentation, prediction, Hypothesis,

❖ Communicating, Theory formulation etc

- Science of biology and its subdivisions: Botany, Zoology, Biochemistry, Microbiology, Ecology, Entomology, Genetics, etc.
- The Relevance of Biology to man: Application in conservation, Agriculture, public health, medical sciences etc.
- Relation of Biology to other science subjects
- Principles of classification: Brief history of classification nomenclature, and systematic, The 5 kingdom system of classification.
- Living and non-living things: General characteristics of living things.
- Differences between plants and animals.

BIO 112 CELL BIOLOGY 1 Credit Compulsory

Objectives:

At the end of the course, students should be able:

- i. Describe the cell theory
- ii. List the cell constituents
- iii. Differentiate between mitosis and meiosis.
 - a) A brief history of the concept of cell and cell theory. The structure of a generalized plant cell and a generalized animal cell, and their comparison; protoplasm and its properties. Cytoplasmic Organelles: Definition and functions of nucleus, endoplasmic reticulum, cell membrane, mitochondria, ribosomes, golgi complex, plastids, lysosomes and other cell organelles.
 - b) Chemical constituents of cell – salts, carbohydrates, proteins, fats and oils, nucleic acid.
 - c) Physical processes of cell: particle size, molecules and ions, suspensions, colloids and true solutions, properties of aqueous system; diffusion, osmosis, plasmolysis, turgor, pinocytosis, phagocytosis.

d) Cell Division:

- Mitosis and meiosis
- Major stages of mitosis and meiosis
- Comparison of the two divisions
- Significance of mitosis and meiosis

BIO 113 VIRUSES, BACTERIA AND LOWER PLANTS. (2Credits) Compulsory

Objectives:

At the end of the course, students should be able:

i. Illustrate the diversity of lower organism

ii. Explain the economic importance of the organism.

i. Viruses - Classification, size, structure, kinds, replication; role in diseased human (e.g. STD, HIV –AIDS), plants and domestic animals e.g. (coccidiosis in poultry). Bacteriophages – structure and its biochemical activities

ii. Bacteria - General description: structure; classification based on shape, mode of nutrition, types of flagella, mode of respiration and staining mechanism; life history; nutrition, role in diseases. Fungi - General description, classification, and relationship with the environment.

Study of various representatives of the phycomycetes e.g. Mucor, Rhizopus and their economic importance.

iv. Algae - Classification, range of forms i.e. solitary, colonial, filamentous, etc. Reproduction and economic importance of a named example.

v. Lichens - An example of symbiotic relationship between fungi and algae.

General description, classification and importance.

vi. Bryophytes - Musci and Hepaticae. Treatment of each class using common examples in Nigeria – Perlia, Funaria generations, habits, problems of the terrestrial environment as encountered by bryophytes in transition from water to land.

vii. Pteridophytes - Classification, general description of various classes, alternation of generations. Structure, reproduction and habit of Lycopodium, Sellaginella Dryopteris. Types of stele. Transitional position of pteridophytes among vascular and non-vascular plants.

BIO 114 BIOLOGY PRACTICAL I 1 Credit Compulsory

Objectives:

At the end of the course, students should be able:

- i. Identify materials used in biological practical
- ii. Explain the rules guiding biological drawings
- iii. Explain the techniques in biology practicals.
- i) Requirements for practical classes in biology
- ii) Examining biological specimens using hand lens
- iii) Rules for making biological drawings.
- iv) The microscopes and their uses (including magnification)
- v) Data collection, analysis and presentation of results
- vi) Format for reporting observation in practical biology
- vii) Forms of practical examination in biology (observing and drawing specimens, performing or carrying out experiments, alternative to practical etc)
- viii) Sectioning and staining techniques
- ix) Slide preparation
- x) Principles and practice of sterilization
- xi) Culturing techniques for microscopic organisms such as bacteria and fungi
- xii) Study of plant and animal cells using onion leaf, Rheodiscolour or similar plants (for plant cell) and scraping of the inner lining of the cheek to isolate and study animal cells
- xiii) Practical study of mitosis and meiosis
- xiv) Experiments on plasmolysis, osmosis and diffusion

- xv) Preparation and observation of slides of Mucor and Rhizopus
- xvi) Observation, of slides of some pteridophytes
- xvii) Preparation and observation of slides of algae e.g. Spirogyra, Euglena, Chlamydomonas etc
- xviii) Preparation and observation of slides of lichens showing various types and forms
- xix) Collection of Bryophytes and observation under the microscope
- xx) Dissection techniques, practice on dissection of toad and lizard (Agama)
- xxi) Use of dichotomous key to identify organisms.

BIO 115 ECOLOGY 2 Credits Compulsory

Objectives;

At the end of the course, students should be able:

- i. Describe basis concept used in ecology
- ii. Explain plant succession and biotic interaction eg. Symbiosis, Commensalism, predation, parasitism, competition etc.

Ecological cycles (carbon, nitrogen, water and oxygen)

Basic terms and concepts of ecology - autecology, syneacology, environment, habitat, niche, ecosystem, adaptation. Ecological factors (their measurement and units in which the values are expressed). Soil studies – soil components, soil properties, beneficial role of soil organisms, soil fertility and its loss. Soil in relation to plant and animal life. Aquatic habitats, terrestrial habitats – their nature, distribution, classification, environmental features, ecological hazards to life and adaptations of plants and animals in these habitats. Microhabitants: cracks on rock surfaces, tree crowns, soil litter on the ground, tree barks savannah micro-habitats: termiteria.

Population Studies

- Terminology in population studies (species, population, community, population size, biotic potential, natality, mortality, immigration, emigration, carrying capacity, innate capacity, environmental resistance)
- Methods of assessing the size of population;

- Population growth and population growth curves
- Factors affecting size of populations. Reference should also be made to human population.

Plant Succession

Primary and Secondary succession

Processes involved in plant succession,

Plant succession in selected habitats. Consequences of population changes on the Ecosystem.

Biotic Interactions:

Symbiosis, commensalisms, Predation, parasitism, competition, saprophytism, epiphytism, phoresis. Energy and material relations of organisms. Concept of biological productivity, energy transfer, trophic interactions, methods of expressing trophic interactions.

NCE I SECOND SEMESTER

BIO 121 DIVERSITY OF INVERTEBRATES 1 Credit Compulsory

Objectives:

At the end of the course, students should be able:

- i. State the general characteristics of protozoa, porifera platyhelminthes, nematodes, mollusks and the echinoderms
- ii. Describe the life cycle of protozoa porifera coelenterate platyhelminthes, nematodes etc.

Protazoa

- General Characteristics
- Mode of life and life cycle of Sarcodina e.g. Amoeba sp
- Mode of life and life cycle of Mastigophora e.g. Euglena
- Mode of life and life cycle of Sporozoa e.g. Plasmodium
- Mode of life and life cycle of Ciliata, e.g. Paramecium

Porifera

- Characteristics and structure of sponges

Coelenterate

- General Characteristics of major classes
- Mode of life and life cycle of Hydra and Obelia

Platyhelminthes

- General Characteristics
- Mode of life and economic importance of

CLASS: Tubelaria e.g. Planaria

CLASS: Trematoda e.g. Fasciola

CLASS: Cestoda e.g. Taenia

CLASS: Aphasmidia e.g. Ascetidina

Nematoda

Ascaris- mode of life and economic importance

Annelida

General Characteristics, mention of mode of life, and economic importance

CLASS: Oligochaeta - e.g. Earthworms.

CLASS: Polychaeta e.g. Tubeworm/Sand/Lugworm.

CLASS: Hirudinea – e.g. leech.

Arthropoda

General characteristics of the phylum.

External features of an example of each class:

- Crustacea
- Insecta
- Arachnida
- Myriapoda
- Chilopoda
- Diplopoda

General features, mode of life and life history of the following orders of the class

Insecta: Diptera, Lepidoptera, Hemiptera, Hymenoptera.

Mollusca

General Characteristics.

Brief classification and examples of each class.

Echinodermata

General description. Link between invertebrates and chordata.

BIO 122 DIVERSITY, ANATOMY AND HISTOLOGY OF SPERMATOPHYTES

2 Credits Compulsory

Objectives:

At the end of the course, students should be able:

- i. Outline the general characteristics gymnosperms, conifer and angiosperm
- ii. Describe the morphology/physiology of angiosperm – stem, leaf, root and their modifications
- iii. Describe the different types of tissues and their functions

Introduction to, and general description of, spermatophytes and their subdivisions.

General characteristics of gymnosperms and classification.

Similarities and differences with higher cryptogams. Development of seed in gymnosperms and factors responsible for seed development. Structure and lifecycle of a conifer e.g. Pinus.

Development of embryo in gymnosperms.

Alternation of generation in plants. Characteristics of different angiosperm families. External morphology of angiosperm-stem; leaf, root and their modifications. Flower – concept of whorls, inflorescence and types. Pollination, fertilization, megasporogenesis and microsporogenesis, Development of embryo in angiosperms. Seed and fruit formation. Fruits and their classification.

Dispersal of fruits and seeds.

Importance of spermatophytes as sources of food, medicine, shelter, etc

- Cell types, distribution, and structure in relation to function
- Different types of tissues and their functions
- Anatomy of root, stem and leaf of monocot and dicot plants
- Primary and Secondary thickening.

BIO 123 BIOLOGY METHODS 2 Credits Compulsory

Objectives

At the end of the course, students should be able:

i. State the Aims and objectives of teaching biology in Secondary Schools

ii. List the resources/strategies used in teaching biology.

- Aims and Objectives of teaching Biology in Secondary Schools

- Syllabus, Scheme of work, lesson plan and lesson note.

- Stating aims and instructional objectives in biology

- Resources for teaching biology

- Improvisation in biology teaching

- Methods/strategies of teaching biology e.g. discussion, Lecturer, demonstration, small group approaches, activity approach, independent study etc.

- Evaluation of Biology learning outcomes:

Cognitive: (memory, comprehension and application objectives)

Affective: (interest, value, receiving, responding, valueing)

psychomotor: how to use hand lens, microscope, etc (manipulative skills)

- Scientific attitudes – honesty, curiosity, critical/open mindedness etc

- Micro-teaching

- Further strategies in biology teaching: questioning, inquiry, discovery, fieldtrips, use of resource persons, tours and excursions, projects etc.

- Classrooms management. Evaluation in biology i.e. types of tests and test construction in biology. Developing tests at the cognitive (all the six levels). Affective and psychomotor domains. Development organization and characterization of test items.

- Further micro-teaching with emphasis on the importance of teaching aids

Practical work on improvisation of teaching aids in biology equipment and materials (models, charts, mock ups, realia etc). Preparation of charts and posters on core message of Population/Family life education and Sexually Transmitted diseases (STD)/AIDS.

BIO 124 BIOLOGY PRACTICALS II 1 Credit Compulsory

Objectives:

At the end of the course, students should be able:

- i. Observed/identify and draw, label amoeba, Euglena, paramecium, Hydra, planaria, taenia, class insect, typical gymnosperm and angiosperm
- ii. Measure various factors of Ecosystem

AMOEBA:

- Observation of slides of Amoeba with false feet (Pseudopodia), food vacuoles and contractile vacuoles

EUGLENA

- Make temporary slides of specimen collected from a slow flowing stream or pond to identify Euglena with flagellum
- Observe permanent slide of Euglena and study the physical appearance

PARAMECIUM

- Observe the slide of Paramecium to identify the structure (shape, cilia, mega nucleus, micronucleus, star-shaped to contractile vacuole, food vacuole).

HYDRA

- Identify the tentacles, hypostome (mouth), two body walls– Ectoderm and Endoderm separated by mesoglea
- Observe L/S of the body wall.

PLANARIA

- T.S. slide of Planaria to show the three layers of body walls – (ectoderm mesoderm, endoderm)

TAENIA

- Observe slide to Taenia showing suckers and segmentation

LUMBRICUS (EARTHWORM)

- Collect living earthworms and study the physical appearance
- Observe the T.S. of earthworm

ACATINA

- Collect and observe the general appearance of snail.

CRUSTACEA

- Collect and study the structure of crayfish or any other suitable crustacean

MYRIAPODA

- Study the physical appearance of centipedes and millipedes (note many legs of the myriapode).
- Draw and label (use preserved specimen or freshly killed) specimen in chloroform.

ARACHNIDA

- Study the physical appearance of Spider: Note two body divisions, four pairs of legs

INSECTA:

Study the appearance of cockroach – a representative of insect

Note three body divisions, three pairs of jointed legs, two pairs of wings

Note position of wings on thorax (meso and meta thorax)

Note segmented abdomen and spiracles on abdominal segments

Study mouth parts of these insects:

Diptera: (Housefly, Mosquitoes)

Hymenoptera: (bees, ants)

Lepidoptera: (butterfly and moth)

DIVERSITY OF SPERMATOPHYTES

- External morphology of typical Gymnosperm and Angiosperm
- Preparations of Keys for identifying Angiosperms
- Flowers and inflorescence
- Study placentation of seed in fruits, types of fruits and adaptation for dispersal

ECHINODERMATA – Collect and study general external features of star fish

ECOLOGY

- Habitat studies: on suitable aquatic and terrestrial environments
- Mini project on specific habitat study
- Measurement of physical factors e.g. Temperature, Light intensity, humidity, wind direction and speed, dissolved gases turbidity, depth speed of flow PH in relevant habitats
- Edaphic factors – soil porosity, water holding capacity, soil texture, PH percentage humus, and land slope, soil temperature at various depths and time

APPENDIX V

NCE II - FIRST SEMESTER

BIO 211 DIVERSITY OF CHORDATES 2 Credits Compulsory

Objectives:

At the end of the course, students should be able:

- i. Identify and outline the various classes of chordates
- ii. Explain the evolutionary advancement classes of chordates

a) General Characteristics of Chordates

b) Classification and general distinguishing characteristics of:

- i. Sub phyla protochordata and vertebrata
- ii. Super classes Agnatha and Gnathostomata
- iii. Agnatha - Class Cyclostomata.
- iv. Gnathostomata - Classes: Pisces

Amphibia

Reptilia

Aves

Mammalia

c) Evolutionary advancement, adaptive radiation, success and special features of interest in the various groups

- d) i. The transition from water to land and the problem of land life in amphibians
- ii. The development of the cleidoic egg in the Amniota
- iii. The dominance of mammals over other chordates.

BIO 212 RESEARCH METHODS AND BIOMETRY 1 Credit Compulsory

Objectives:

At the end of the course, students should be able:

- i. Describe the procedure involved in conducting a research
 - Meaning, Purpose and relevance of Research and Biometry
 - Types of Research (Experimental, Survey, Case Study etc)
 - Choice of Research Topic
 - Hypothesis (Types, Source, Formulation)
 - Data Collection (Types and Sources)
 - Population, Sample and Sampling techniques
 - Data Presentation: Frequency Distribution, Cumulative frequency, graphs (line, histograms)
 - Bar Charts, Pie Charts etc)
 - Measures of Central tendency (Mean and Median)
 - Measures of Dispersion (Mean Deviation, Variance and Standard Deviation)
 - Measures of Relationship (Chi square (χ^2) Correlation Coefficient, T-test and ANOVA)
 - Project reporting.

BIO 213 POPULATION EDUCATION 1 Credit Compulsory

Objectives:

At the end of the course, students should be able:

- i. Identify the factors effecting population growth
- ii. List the problems associated with over population and the remedies

World Human Population Growth and Problems

- Factors accounting for population growth (causes of population change in Nigeria e.g. socio-culture practices and religious beliefs.
- Population policies and strategies
- Methods and problems of estimating human population (e.g. school community) and interpretation of results
- Population and development of resources
- Solutions to problems of population growth.
- Birth control measures involving male and female reproductive organs controversies and consequences. Reproductive behaviour (e.g. early marriage, premarital sex, teenage pregnancy) – consequences.
- Biological, psychological, social and economic readiness of male and female for reproduction.
- Ethical implications of biotechnology.

BIO 214 PLANT PATHOLOGY 1 Credit Elective

Objectives:

At the end of the course, students should be able:

- i. Identify common diseases of crop plants.
 - ii. Explain basic principles plant protection.
- Meaning of plant pathology and pathogenicity.
 - Plant pathology as it affects food production and quality of life.
 - Differences between diseases, parasites and pests
 - Classes of diseases, modes of transmission of pathogens
 - Entry of pathogens in tissues of hosts
 - Diseases enhanced by abiotic factors such as adverse weather conditions and mineral deficiencies
 - Phenomenon of infection and factors influencing it.

- Features of the major groups of plant pathogens (viruses, algae, fungi bacteria, worms and nematodes)
- Diseases of food crops such as maize, yams, cassava, rice, tomatoes and any other suitable food crops.
- Biology and control of diseases; a few selected diseases (biological control)
- Diseases of cash crops such as tobacco, groundnut, oil palm and any other suitable cash crop.
- General principles of plant protection.

BIO 215 ANIMAL HISTOLOGY 1 Credit Elective

Objectives:

At the end of the course, students should be able:

i. Describe the various tissues and organs of human body.

- History of various tissues should be studied e.g.

Epithelia

Connective tissue

Muscular Tissue

- Histology of the following organs

Skin

Liver

Kidney

Ovary and testis

- Histology of the following:

Blood

Bones

Cartilages

Muscles

Nerves

BIO 216 BIOLOGY PRACTICALS III 1 Credit Compulsory

Objectives:

At the end of the course, students should be able:

- i. Prepare and observed slides of different plants pants.
- ii. Identify and draw different types of organisms in chordates.

Anatomy and Histology of Plants

- Preparation of temporary slides for T.S. of root, stem and leaf of monocots and dicots
- Observation of permanent slides of root, stem and leaf of dicots and monocots field observation of Primary and Secondary Thickening.

Diversity of Chordates

- Observation of living forms of fishes (bony and cartilaginous e.g. Tilapia and dogfish), observation of Primary and Secondary thickening
- Observation of living forms of birds (Aves) e.g. pigeon/chicken for external and adaptive features in flight.
- Examination of the various types of mammals. Observation of living and preserved specimens of mammals.

APPENDIX VI

NCE II – SECOND SEMESTER

BIO 221 PLANT PHYSIOLOGY 2 Credits Compulsory

Objectives;

At the end of the course, students should be able:

- i. Explain basic physiological processes in plants

Water Relations

Absorption of water

Transpiration in details

Mineral Nutrition in plants

The various mineral requirements of plants: sources and roles of each mineral element (including trace elements) in plant metabolism; Nutrient deficiency, diseases in plants.

Photosynthesis

Plants as Primary producers of food for populations. General description of the process. Raw materials and products of photosynthesis, Mechanism of photosynthesis, chloroplast as the site for photosynthesis: light reaction conversion of light energy into energy; photochemical splitting of water, Calvin cycle, Dark reaction.

Translocation of manufactured food. Reduction of nitrates and production of amino acids.

Respiration

General description of aerobic and anaerobic respiration in plants.

Growth and Movements

Growth of plants in length and measurement. Movement in plants e.g. tropism, taxism and nastism

Excretion in Plants

Excretion materials and their removal from the plant body.

BIO 222 VERTEBRATE ANATOMY AND PHYSIOLOGY 2 Credits Compulsory

Vertebrate Anatomy

Objectives:

At the end of the course, students should be able:

- i. Out line and explains the various systems of the body.
- ii. Describe the functions of the various systems.

- Meaning, scope and description of vertebrate anatomy and physiology
- Study of the following systems in mammals and amphibians
- Digestive system
- Circulatory system
- Respiratory system
- Compare male and female reproductive organs of human being
- Nervous system
- Skeletal system

Nutrition

- Meaning of nutrition, components of food and balanced diet, mineral requirement in animal.

Digestive System and Digestion in Mammals and Amphibians

- Function of liver with emphasis on deamination

Enzymes

- Definition and nature of enzymes
- Main categories of enzymes and the system of naming them
- Factors affecting enzyme activity and the mechanism of enzyme action
- Co-enzymes and Prosthetic groups.

The Circulatory System

- Structure and functions of the circulatory system
- Blood circulation and control of heart beat.
- Structure and functions of blood, mechanism of blood clotting
- Blood transfusion, body resistance and AIDS
- Importance of blood screening (to detect cancer, malaria parasites hepatitis, leukemia etc)

Respiratory System and Respiration

- Structure and functions of respiratory system

- Mechanism of inhalation and exhalation; aerobic and anaerobic respiration, glycolysis and the Krebs's cycle.

- Significance of respiration.

Excretion

- The need for excretion and major metabolic wastes in vertebrates

- Excretory organs and their functions (the skin, lungs, kidneys)

- Processes of excretion (nitrogenous and gaseous excretion)

Nervous System and Co-ordination

- Structure and functions of the central and peripheral nervous system]

- Functions of a nerve cell, nerve impulse, synapse, nervous control and coordination.

- Nervous integration, description of the reflex arc

- Sense organs – eye, ear, skin, tongue, nose etc.

Skeletal and Muscular Systems

- Structure and functions of mammalian skeleton. Mechanism of muscular contraction.

Hormonal Co-ordination

- Meaning, properties and functions of hormones; the pituitary and tropic – hormones (their sources and effects in the body).

- Thyroxin, adrenalin and hormones of the reproductive system (their glands and effects in the body).

Reproductive System and Reproduction

Structure and functions of the male and female reproductive systems in mammals.

Fertilization, gestation and birth in a named mammal. A brief mention of menstrual cycle is needed.

BIO 223 EMBRYOLOGY 1 Credit Elective

Objectives:

At the end of the course, students should be able:

- i. Describe the developmental stages of an organism
- ii. Explain the process involved in gestation in mammals.

- The concept of embryology

Fundamental processes in embryonic development: Determination, differentiation, morphogenesis (growth and organogenesis), Gametogenesis (spermatogenesis and oogenesis).

- The structure of spermatozoa and egg cell of a named mammal at the time of fertilization.

- The meaning stages, characteristics, types and significance of cleavage

- Outline of the development of a fertilized ovule and the production of seed and fruit in a dicotyledonous plants

- An outline of the development of an amphibian (frog or toad) or bird, to the neurula stage only.

- Embryonic membranes in birds and mammals

- Functions of the placenta in birds and mammals

- Gestation and abortion: birth in mammals.

BIO 224 BIOLOGY PRACTICALS IV 1 Credit Compulsory

Objectives;

At the end of the course, students should be able:

i. Conduct simple biological experimental

ii. Dissect

- Experiments to demonstrate that Chlorophyll light and carbon dioxide are necessary for photosynthesis.

- Experiments to show that starch and oxygen are products of photosynthesis

- Experiments to show tropisms in plants

- Examination of various excretory products from plants e.g. tannins gums, resins and salts, etc.
- Experiments on Transpiration to show:
 - Evidence of transpiration in plants
 - Rate of transpiration.
 - Factors affecting transpiration rates.
 - Study of slides in spermatogenesis and oogenesis.
 - Gross and microscopic structures of the kidney.
 - Slides of various tissues should be examined under strict supervision and guidance of the teacher.
 - Examination of slides of various organs.
 - Population studies using sampling techniques.
 - Observation of succession in the suitable habitat e.g. plant succession
 - Identification of diseases associated with cash crops mentioned in the syllabus. Interpretation of data, where available, on distribution of plant diseases and STDs/AIDS in Nigeria.
 - Dentition in herbivores, carnivores and omnivores compared
 - Enzyme action of food substances, e.g. action of salivary amylase on starch.
 - Factors affecting enzyme action
 - Measurement of heart beat and effect of exercise on heartbeat.
 - Measurement of breathing rate and effect of exercise on breathing rate.
 - Determination of various taste sites on the tongue
 - Determination of the blind spot on the eye
 - Effect of sight on balancing
 - Dissection of mammals showing the location of various organs and system.
 - Digestive system
 - Respiratory system

- Excretory system
- Circulatory system
- Reproductive system
- The system above could also be shown in the frog/toad for comparison.

BIO 225 EVOLUTION 1 Credit Elective

Objectives:

At the end of the course, students should be able:

- i. Discusses the various evidences in favour of evolution.
 - ii. State Darwin's theory and its implications in modern world.
- Concept of Evolution
 - Evidence for Evolution
 - The geological timetable
 - Trends and theories of Evolution including pre-Darwinism and Neo- Darwinism theories.
 - Darwinism theories.
 - Darwin's theory of natural selection.
 - Competition with particular emphasis on competition for food, space and other resources among human population.
 - Competition, variation and survival of the fittest.
 - Mutational changes as causes of evolution.
 - Adaptive radiation
 - Isolating mechanisms
 - The origin of life
 - Fossils and human evolution.

APPENDIX VII

NCE III FIRST SEMESTER

EDU 311 TEACHING PRACTICE

NCE III 2ND SEMESTER

BIO 321 LABORATORY MANAGEMENT 1 Credit Compulsory

Objectives:

At the end of the course, students should be able:

- i. Outline the procedures in effective laboratory management
- ii. Improvise basic materials for biology practical.
 - The planning of a biology laboratory
 - Location, size, height, spacing and facilities such as windows, doors
 - Lighting and other fittings like cupboard and working benches
 - Ordering of equipment.
 - Inventory, care and maintenance of the equipment
 - Common accidents in the Laboratory-fire, acid & alkaline burns, animal bites, stings, inhalation of dangerous gases, cuts, electrical shocks etc.
 - Safety in the laboratory.
 - Safety devices such as fire-extinguisher, fire blankets and bucket.
 - First aid: (first aid kit, first aid measures)
 - Knowledge of electrical wiring in the laboratory: fuses, bulbs and fluorescent tubes.
 - Improvisation in biology laboratory: importance of local production, basic skills in improvisation and local production of local production, basic skills in improvisation and local production in wood work, glassblowing, brick laying, metal work and electrical/electronics. Such skills should be usable in construction simple biological equipment.
 - Biological garden and outdoor laboratory.

- Setting up of a school biological museum and preparation of museum materials, preservation, display etc. (Taxidermy)

- The herbarium – construction and setting up of a herbarium.

BIO 322 APPLIED BIOLOGY 2 Credits Compulsory

Objectives:

At the end of the course, students should be able:

- i. Explain simple health habits
- ii. Explain how the activities of man affect his environment.
- iii. Identify problems associated with drug abuse

Man's Diseases and Health

Disease – meaning, common tropical diseases, their causes, cure and prevention. Effects of parasites on man e.g. malaria parasite, sleeping sickness parasite etc. Public health and roles of voluntary and international organizations in health control.

Social and health problems of Tobacco consumption and the effect of smoking on the body;

Drugs, their uses and abuses (mentioned use of cocaine, hemp and other dangerous drugs)

Family life education. Sexually transmitted diseases /HIV-AIDS.

Other social problems such as: prostitution) sex abuse and the effects on human health and productivity.

- Ecological Consequences of Agriculture

Relationship between monoculture and spread of plant diseases and pests

Ecological effects of herbicides, pesticides and chemical fertilizers.

- Ecological Consequences of Urbanization and Industrialization

Overpopulation and pressure on social amenities e.g. transportation and housing, undesirable social habits such as delinquency, truancy, prostitution, pollution, conflict in land use.

Solution to problems of population growth

□ Birth control measures.

□ Reproductive behavior e.g. early marriage, pre-marital sex, teenage pregnancy, abortion, their prevention and control.

Population education in Biology – Preparation of charts and posters on core messages/slogans of effects of uncontrolled population.

- Effects on Man on his Environment

Effects of man on vegetation, atmosphere, soils, water and water resources, other natural resources.

- Pollution

Definition: types of pollution (air pollution, water pollution, land pollution), Causes of pollution, Effects of pollution (effects of air pollution, water pollution and land pollution)

Control of pollution

N.B. Special mention should be made to sewage and other forms of urban pollution e.g. noise, radiation and ocean pollution, unburnt gases or smokes from motor cars exhaust pipes or motorcycle silencers.

Conservation of Natural Resources

- Wildlife, minerals, forests, soil, water, atmosphere, fuel (e.g. crude oil)

Methods of conservation and preservation of these resources.

Field Trips

Field Trips to game reserves to study rare species in their natural habitats

- Visit to areas of gully and sheet erosion

- Visit to notable areas of pollution e.g. polluted streams; mechanic workshops etc and observe pollution. Watch films on polluted habitats.

N.B. Field trip/Excursion to game reserves or major areas of biological importance is compulsory. Its report is to be presented for accreditation purpose and should form a minimum of 20% of this course.

BIO 323 INTRODUCTORY PARASTOLOGY 1 Credit Compulsory

Objectives:

At the end of the course, students should be able:

- i. Identify various parasites and their life cycles.

Meaning and scope of parasitology

Parasitism: different types of parasitic relationships between organisms e.g. obligate, facultative, parasitic adaptations including change of antigenic structure as in the AIDs virus (HIV)

Adaptation involved in parasitic mode of life and transmission of STDs/AIDS

Parasitic mode of life of the following: Entamoeba spp, Malaria parasites, (Plasmodium spp) life cycle and control. Trypanosome spp. Life cycle and control, Trichomonas vaginalis lifecycle, cure and control) Helminthes such as Fasciola hepatica: Schistosoma spp.

Nematodes such as Ascaris spp, Hookworms such as Ancylostoma duodenale, Wuchereria bancrofti.

(Note: All these organisms' life cycle, cure and control are expected to be treated).

- Plant parasitic nematodes

- Parasitic insects (Structure, adaptive features and control).

BIO 324 GENETICS 2 Credit Compulsory

Objectives:

At the end of the course, students should be able:

- i. Explain various terminologies used in genetics.
- ii. Describe the application of genetics in medicine and agriculture.

- Heredity and Environment:

- Mendel's work on peas. Meaning of basic genetical terms (genotype, homozygous, heterozygous, alleles, etc). Mono and dihybrid crosses.

Concept of dominance, Incomplete dominance.

- The chromosome theory of inheritance and the gene hypothesis, nucleic acid, DNA genetic code. Salivary gland chromosomes, RNA, protein synthesis, formation of amino acids and lipoproteins.

- Sex chromosomes, autosomes, sex determination and linkage.

- Mutations: lethal mutations, Polyploidy: Examples of new varieties of plants and animals arising by mutation and polyploidy: production of mutations by radiation and other means.

- Human heredity e.g. colour blindness, paternity, blood groups, haemophilia.

- Problems in family that relate to sex determination, intelligence, membership resemblance and diseases.

- Genetic Counselling on family characteristics e.g. blood groups, blood types and sickle cell anaemia

- Applied genetics: in agriculture, medicine etc.

BIO 325 BIOLOGY PRACTICAL V 1 Credit Compulsory

Objectives:

At the end of the course, students should be able:

i. Identify various laboratory skills

ii. Illustrate the roles of various biological structures e.g. herbarium; museum and biological garden.

- Examination of any fossil material, if available

- Excursion to zoological garden to study evolutionary trend among animals

Parasitology

- Observation of slides of Plasmodium, Trypanosome, Taenia, Fasciola, Ascaris, Ancylostoma, Wuchereria etc.
- Observe sterilization techniques in hospitals especially with reference to prevention of HIV infection.
- Observation of structures and adaptive features of some parasitic insects and arachnids e.g. Bed bugs, lice, ticks.

Applied Biology

- Study of population growth in Nigeria
- Town ecology i.e. measurement of pollutants e.g. CO₂, CO, SO₂ at various site in a town.
- Use of lower plants e.g. lichens and mosses as indicators of pollution level.
- Pollutants in a stream e.g. detergents, fertilizer, chemical containers, dyes.
- Effects of various fertilizers and herbicides as pollutants in aquatic habitat on biotic community.
- Estimation of population (school or college)
- Excursion to National Park, Lakes and areas of apparent gully erosion.

Genetics

- Examination of models/charts to illustrate monohybrid and dihybrid crosses in plants and animals.
- Observation of variations (height, weight, finger prints, tongue rolling etc).
- Microscopic examination of the squashed testes of grasshopper or pollen grains for meiosis, other suitable experiments on monohybrid crosses in using suitable plant and animal materials such as maize, guinea pigs and beans.
- Culturing of fruit fly – *Drosophila Melanogaster*

Laboratory Management

- Students should be guided to practice ordering of equipment for the laboratory.
- Students should be familiar with safety and first aid devices in the laboratory.
- Students should carry out exercises on handling glass wares and chemicals, electrical wiring and fuses.
- Observation should be made on sterilization techniques in hospital especially with reference to prevention of HIV infection.
- Organize special lectures/exhibitions on STDs/AIDS prevention and control.
- Students should be guided to construct biological materials that can be used in the laboratory i.e. improvisation e.g. test-tubes, beakers specimen bottles, etc. - Preparation of specimens such as herbarium, skeletons, stuffed materials.