EFFECT OF HANDS-ON LEARNING STRATEGY ON PERFORMANCE IN THINKING INVOLVED ON ECOLOGY IN SENIOR SECONDARY SCHOOL ZARIA EDUCATION ZONE, NIGERIA.

BY

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DECLARATION

I declare that this Dissertation entitled "**Effects of Hands-on Learning Strategy on Performance and Critical Thinking in Ecology among Senior Secondary School Students in Zaria Education Zone, Nigeria**" was carried out by me under the supervision of Dr. J.O. Olajide and Dr. M.R. Bawa in the Department of Science Education, Faculty of Education, Ahmadu Bello University, Zaria. The information derived from the literature has been duly acknowledged in the text and list of references. No part of this dissertation was presented for the award of degree or diploma at any institution.

_______________________   _________________

Abdulsalam IBRAHIM   Date

P14EDSC8049

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CERTIFICATION

This Dissertation entitled "**Effects of Hands-on Learning Strategy on Performance and Critical Thinking in Ecology among Senior Secondary School Students in Zaria Education Zone, Nigeria**'' by Abdulsalam IBRAHIM meets the regulations governing the award of degree of masters in Biology Education of the Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

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Dean, School of Postgraduate Studies

DEDICATION

This study is dedicated to my mother, Hajiya Safiya Muhammad Lawal and my late father Alhaji Ibrahim Abdussalam (May his soul rest in perfect peace, Amin), my scholars, my wife Ruqayyah Abdurrahman, my children Aishah, Khadeejah and Abdullahi Abdulsalam.

.

ACKNOWLEDGEMENT

My immense gratitude goes to Almighty Allah (SWT) who educated me with His Wisdom and sustained me with His Great Bounty throughout my course of study in Ahmadu Bello University, Zaria. I wish to express my unqualified appreciation to my humble major supervisor Dr. J.O. Olajide whose guidance, suggestions, support, positive and constructive criticism had helped me to see the completion of this work successfully. Am indebted to acknowledge and thank my second supervisor Dr. M. R. Bawa for support, suggestions and valuable criticism towards making the completion of this work a reality.

At this juncture, I am also pleased to express my sincerely and heart-felt gratitude to my role models and humble lecturers, H.O.D Prof. S.S. Bichi, Prof. A. I. Usman, Dr. M.O. Ibrahim, Dr. S. B. Olorukooba, Prof. F. K. Lawal, Prof. M. Musa, Dr. M. K. Falalu, Prof. T. E. Lawal, Prof. A. A. M. Shaibu, Prof. A. M. Atadoga, Prof. B. Abdulkarim, Prof. M. A. Lakpini, Dr. S. S. Obeka, Prof. J. S. Mari, Dr. I. H. Usman, Prof. K. Y. Korau, Dr. S. M. Tudunkaya, Dr. B. M. Ribah, Prof. A. D. Kankia, Prof. C. Bolaji, Dr. A. U. Ginga, and Prof. W. S. Japhet, for their ruthless observation and words of encouragement. I am also delighted to extend my regards to all the lecturers in both Science Education Department and Biology Section for their expedient contributions to knowledge. I specially appreciate the efforts of Mr. U. Ojo who carried the statistical analysis of this dissertation. May God bless you all.

I am fully indebted to my parents, uncle Mukhtar, brothers and sisters, my entire teachers of all status, whose efficacious memory and images can never be forgotten in terms of encouragement, patience, and financial support to see that, dreams of my education came true. I say a very warm thanks to you all. My special gratitude to Prof. Aisha Mohammed and Dr. Gidado Lawal Likko, Department of Psychology, Ahmadu Bello University, Zaria, for their suggestions, criticism, encouragement and moral support.

Let me not forget to thank all the principals, teachers and students in Zaria metropolis who participated in the study. My appreciation equally goes to the Director and Principal; Prof. Nafiu Abdu and Malam Bello Nakaka respectively, Management and entire staff of Albaniy Science International Academy, Zaria, for their support and encouragement throughout my study.

Finally, I convey my fervent appreciation to my friends as well as sincere well-wishers whose names are not mentioned whereas their images remain intact in my heart, especially those whom I came across at various stages of my education. I say 'Al-hamduliLLah'! "Getting education has played a tremendous role in raising my level of self-awareness, and confidence".

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ABBREVIATIONS USED

ECCTQ	-	Ecology Concepts Critical Thinking Questionnaire
ECPT	-	Ecology Concepts Performance Test
FRN	-	Federal Republic of Nigeria
HLS	-	Concept of Hands-on Learning Strategy
MT-TEST	-	Multivariate Analyses of Covariance
MKO	-	More Knowledgeable Other
NECO	-	National Examinations Council
NERDC	-	Nigerian Educational Research and Development Council
NPE	-	National Policy on Education
NTI	-	National Teachers Institute
ORASS	-	Operation Reach all Secondary Schools
PM	-	Physical Manipulative
PTA	-	Parents Teachers Association
RAFT	-	Resource Area For Teaching
SCORE	-	Science Community Representing Education
STAN	-	Science Teachers Association of Nigeria
STME	-	Science, Technology and Mathematics Education
VM	-	Virtual Manipulative
ZPD	-	Zone of Proximal Development

OPERATIONAL DEFINITION OF TERMS

The following terms have been used to suit this study:

Academic Performance: Is an exhibition of knowledge attained or skills developed by students in a subject designed by test scores assigned by teachers after training.

Biology: Is a natural science subject concerned with the study of life and living organisms, including their structure, function, growth, evolution, distribution, and taxonomy taught at secondary school.

Critical Thinking (CT): Is the process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and evaluating information to reach an answer or conclusion

Ecology: Is the study of biotic and abiotic components in the ecosystem and relationship with the environment.

Hands-on Learning Strategy (HLS): Is an educational strategy that directly involves learners by encouraging them to do something in order to learn about it. It is therefore, learning by doing.

ABSTRACT

This study investigated the Effects of Hands-on Learning Strategy on Performance and Critical Thinking in Ecology among Senior Secondary School Students in Zaria Education Zone, Nigeria. Quasi-experimental pretest and posttest design was used for the study. The population of the study comprised 4138 biology students of SS II in sixteen public secondary schools in Zaria Education Zone. Simple balloting was used to select four schools that were pilot tested. Two schools whose students do not differ significantly were later selected. The sample comprised 263 out of which 198 were males and 65 were females. The experimental group was exposed to Hands-on learning strategy while the control group was taught using conventional (Lecture) method. Two instruments; Ecology Concept Performance Test (ECPT) with reliability coefficient of r = 0.72 and Ecology Concept Critical Thinking Questionnaire (ECCTQ) which yielded r = 0.85, were used to collect data for the study. Four research questions with their corresponding null hypotheses were raised and tested at $p \leq 0.05$ level of significance. The data collected were analyzed using T-test and Mann Whitney. Major findings from the study were: Biology students taught using Hands-on learning strategy performed significantly better in performance test than those taught using lecture method. Hands-on learning strategy (HLS) was gender friendly to academic performance and critical thinking. Based on the findings, it was recommended that Hands-on learning strategy be used by biology teachers in the teaching and learning of biology to improve students' academic performance and should also be incorporated together with other methods of teaching for better result.

CHAPTER ONE

THE PROBLEM

1.1 Introduction

Science as a concept is a process that is geared towards problem solving in order to enhance the living standard of man. Nwago (2005) defines science as intellectual activity carried out by humans and designed to discover information about the natural world in which he lives as well as to discover the ways in which information can be organized to benefit human race. Similarly, the Microsoft Encarta Reference Library (2005) defines science to consist of the following: the systematic observation of natural events and conditions in order to discover facts about them and to formulate laws and principles based on these facts; the organized body of knowledge that is derived from such observations and that can be verified or tested by further investigation.

From these definitions, science can be seen as not just mere acquisition of facts but rather active involvement of students through activity-based methods such as, discussion method, project method, fieldtrip, discovery, co-operative learning, and guided inquiry. These teaching methods make teaching and learning of science more meaningful in such a way that students would be able to unfold concepts by themselves as a means of achieving one of the objectives of the National Policy on Education, (FRN, 2014). Students' interest and performance in science should therefore be aroused at the secondary school level in order to prepare them for further studies in science courses the tertiary level to realize these goals.

In every school setting, students are perpetually in search of academic success, the success of academic performance is their ultimate goal. Academic performance can be expressed in the form of good scores and prizes as a result of hard work and exceptional performance in class room tests, assignments and examination (Robinsonm, 2001).

Biology is a natural science subject consisting of contents from microscopic organisms to the biosphere in general, encompassing the earth's surface and all living things (Okwo & Tartiyus, 2004). Considering its fundamental characteristics and importance, biology is today a standard subject of instruction at all levels of our educational systems, from pre-primary to tertiary. It is the only core science subject at Secondary School Certificate Examination (SSCE), whose study is very relevant to man's successful living (Akindele, 2009). Araoye (2009) opined that exposure to biology education offers the learners a wide range of relevance to all aspects of life.

As a subject discipline, it is quite popular at all levels of Nigerian education. It has a large student enrolment than any other science subject especially at the upper basic level of the Nigerian education (Ofoegbu, 2003).This has been attributed to several factors including the students' perception of the subject as simple and non-availability of other science subjects in some schools such that biology is made compulsory for both science and non-science students. In spite of the popularity of biology among students, the failure rate has remained very high (Akubuilo, 2004).

Biology is a natural science concerned with the study of life and living organisms, including their structure, function, growth, evolution, distribution, and taxonomy. Modern biology is a vast and eclectic field, composed of many branches and sub disciplines. However, despite the broad scope of biology, there are certain general and unifying concepts within it that govern all study and research, consolidating it into single, coherent fields. In general, biology recognizes the cell as the basic unit of life, genes as the basic unit of heredity, and evolution as the engine that propels the synthesis and creation of new species. It is also understood today that all organisms survive by consuming and transforming energy and by regulating their internal environment to maintain a stable and vital condition (Alberts, 2002).

Biology education is meant to expose the learners to biological nature (facts, principles and concepts), processes and attitudes and then equip them with skills of a professional Biology teacher. The objectives (goals) of Science Education in Nigeria as provided in the National Policy on Education (FRN, 2014) stated that there will be provision for:

a. Cultivating inquiring, knowing and rational mind for the conduct of a good life and democracy;
b. Produce scientists for national development;
c. Service studies in technology and the cause of technological development; and,
d. Provide knowledge and understanding of the complexity of the physical world, the forms and the conduct of life.

Teachers who are the implementers of the curriculum have the sole obligation in ensuring that Biology students attain the above goals. However, the learners may have their peculiar characteristics which may demand special learning needs (Elliot, Kratochiwill, Cook & Travers, 2001) learners expected that the materials and method of instruction should be easily transferable to the real world. Thus, the task of the Biology teacher according to Moses and Olajide (2008) include, among others, to provide the materials and experiences to aid learning and meet the learner's expectations.

The National Policy on Education (FRN, 2014) stated that "the aim of education is to inculcate in the child, the spirit of inquiry and creativity through the exploration of nature. Therefore, education should equip students to live effectively in our modern age of science and technology. According to James (2000), the objectives of National Policy on Education will not be achieved as desired if appropriate teaching methods, among other factors are closely monitored in the teaching/learning of scientific concepts at various level of education.

In line with these objectives, the three basic science subjects that are taught at senior secondary school level in Nigeria are Biology, Chemistry and Physics. Biology is compulsory for both Arts and Science oriented students. Biology is also a requirement for admission into Nigerian Universities as stated in JAMB Brochure 2007/2008, for many science disciplines among which are Botany, Nursing, Medicine, Pharmacy, Biological Science, Science Education, Agriculture and Environmental studies, in which a pass grade between A1 and C6 must be obtained by the candidates. In this study, an investigation was made on the Effect of Hands-on Learning Strategy on Performance in Biology and Students Perception Level of Critical Thinking involved in Zaria, Nigeria.

For the term critical thinking, Facione (2011) described that the word critical, derives its meaning from the word ‘critic’ which implies a critique; it identifies the intellectual capacity and the means "of judging", "of judgement", "for judging", and of being "able to discern" Critical thinking is variously defined as: "the process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and evaluating information to reach an answer or conclusion", "disciplined thinking that is clear, rational, open-minded, and informed by evidence", "reasonable, reflective thinking focused on deciding what to believe or do", "purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based".

Core critical thinking skills includes: observation, interpretation, analysis, inference, evaluation, explanation, and metacognition. According to Reynolds (2011), an individual or group engaged in a strong way of critical thinking gives due consideration to establish for instance:

a) evidence through reality;
b) context skills to isolate the problem from context;
c) relevant criteria for making the judgment well;
d) applicable methods or techniques for forming the judgment; and,
e) applicable theoretical constructs for understanding the problem and the question at hand

Critical thinking can be used or taught. Teaching it involves breaking down the process or thinking of it as a number of steps. Each step needs to be explained and practiced explicitly and students given opportunity for undertaking this practice as part of formative assessment (Tittle, 2011). In this regard, the steps can be taught, the actual process, however, of thinking cannot. The academic needs to take the role of facilitator (instead of instructor) in supporting students to develop an explicit understanding of the critical thinking process. Students then need to be allowed time to practice and to receive feedback (Black and Parks, 2006). In this regard, Critical thinking is the art of analyzing and evaluating thinking with a view to improving it. Hence, it is self-directed, self-disciplined, self-monitored, and self-corrective thinking. It requires rigorous standards of excellence and mindful command of their use. It entails effective communication and problem solving abilities and a commitment to overcome our native egocentrism and sociocentrism.

Thinking is a neural activity aimed at maintaining homeostasis, that is, when the brain functions well. When the thinking process disrupts homeostasis, we usually can say that the subject has a mental disorder or stupid or crazy. The brain correlates the input data from the eyes, ears, taste.

The term hands-on is used commonly in science education. It means that teacher should do more than lecturing about science. It allows the students to experience science by doing it involving using the hands.

Like many other terms in educational practice, these terms have no standard definition that has one meaning for all practitioners. It may also be defined as any activity that allows the learner to handle, observe or operate a scientific process. In hands-on science activities, learners interact with materials and equipments (Lumpe, & Oliver, 1991 in Munir & Mumtaz, 2013). Hands-on strategy has a long and successful legacy in the sciences and math (Basista & Matthews; Bredderman, Haury & Rillero in RAFT, 2013), and shows promise for teaching social studies, history, English and other subject areas. By using hands-on strategy, educators are fostering the 21st century skills that students need to be successful: critical thinking, communication, collaboration, and creativity. Hands-on activities encourage a lifelong love of learning and motivate students to explore and discover new things (Bass, Kristin, Danielle and Julia, 2011). Thus, Hands-on learning can be described as an educational strategy that directly involves learners by encouraging them to do something in order to learn about it. It is therefore, learning by doing.

The concept "gender" refers to the amount of masculinity or femininity found in an individual. The influence of gender on students' performance has a long time been a concern to many educational researchers. But surprisingly, no consistent results have been obtained (Muhammad, 2008). Thus, Aliakbari and Sadeghdaghighi (2011) surveyed 84 University students regarding their critical thinking skills and found male students gain more critical thinking skill compared to female students.

In general, educators using hands-on activities reported an increase in students' engagement, knowledge retention, and learner independence. Teachers who see these results more engagement and excitement to learn want to keep that spark alive in their students. The poor performance in Biology has been the major concern of parents, teachers and the general public. Studies have shown that students perform poorly in biology. In relation to this study, Yilwa, (1998), Jibrin and Nuru (2007), independently identified poor methods of teaching and improper use of instructional materials as some of the deficiencies of science teachers. Okebukola (2009) also attributed the poor performance in Biology to the use of ineffective teaching and learning strategies and lack of appropriate learning environment under which Biology teaching take place. In this study, the Effect of Hands-On Learning Strategy on Critical Thinking and Performance in ecology concept among SSII Biology Students, Zaria Zone, Kaduna State, Nigeria was investigated.

The Chief Examiners Report of West African Examination Council (2005 & 2009) identified some weaknesses of secondary school students in Biology to include poor mathematical skills, inability to plot graphs, inability to interpret tabulated results, poor performance in questions requiring detailed explanation, comprehensions, wrong spellings of technical terms and labels and application questions. This study therefore investigates the effect of Hands-On Learning Strategy on Critical Thinking and Performance in ecology among secondary school students, Zaria, Kaduna, Nigeria.

The effectiveness of teaching science subject is measured in terms of the knowledge of what to teach, how to teach it and when to teach it. The 'how' of teaching constitutes what is called teaching (Hermann, 2005). Differences in intellectual functioning among learners required variations in instructional strategies. Students learn effectively if the teaching methods emphasize practical applications in terms of use of instructional materials like hands-on learning. So in science much of the instructions are hands-on in order to enhance students understanding in many abstract concepts (such as Evolution and Genetic concepts in Biology), developed cognitive and psychomotor skills as well as appropriate attitudes towards science and technology.

One of the most common methods of teaching science at senior secondary level is lecture method. According to Bichi (2002) this is a method of teaching that emphasizes "talk and chalk" in the teaching of science subject. More than 80% of the scientific information and principles are delivered as lectures. Teachers embrace this method for easy coverage of the school syllabus. It is characterized by one way flow of information from the teacher who is always active, to the students who are always passive. In its true nature, the lecture method is not effective for science teaching. Bichi (2002), James (2000) and Usman (2000) all argued against it because it does not promote meaningful learning. Hence, Science teachers have been using lecture method of teaching effectively. This may be due to shallow knowledge of the subject matter on the part of the teachers, insufficient or non-availability of instructional materials or the need to cover syllabus within a short period of time for examination. Bichi (2002), James (2000) and Usman (2000) opined that the use of lecture method of teaching lead to rote learning, leading to missing essential part of science learning. However, this method of teaching should not be totally discouraged, but there is need to improve on it for effective teaching and learning of Biology using hands-on learning in enhancing critical thinking and performance in the learners. Academic performance is defined as the exhibition of knowledge attained or skills developed by students in a subject designed by test scores assigned by teachers (Ogundokun & Adeyemo, 2010). The teaching learning process has to do with the attainment of set objectives of instruction that is reflected on the academic performance of the students. In science education, for instance, if a learner accomplishes a task successfully and attains the specified goal for a particular learning experience, he is said to have achieved (Eze, 2005). The attainment of the science education is a major concern of education policy makers and one of such goal is the inculcation of good academic performance for all by the end of the 21st century.

According to Aremu (2000), poor academic performance is adjudged by the examinees/testees as falling below an expected standard. The interpretation of this expected or desired standard is better appreciated from the perpetual cognitive ability of the evaluator of the performance. The evaluator or assessor can therefore give different interpretations depending on some factors. While Bakare in Abdullahi (2013), described poor academic performance as any performance that falls below a desired standard. The criteria of excellence can be from 40% to 100% depending on some subjective criteria of the evaluator or assessor. Just as in universities in Nigeria, any grade below 40% is considered as poor or failed.

1.1.1 Theoretical Framework of the Study

The theoretical framework of this research is based on Swiss psychologist Piaget. Piaget (1896-1980) is renowned for constructing a highly influential model of child development and learning. Piaget's theory is based on the idea that the developing child builds cognitive structures–in other words, mental "maps," schemes, or networked concepts for understanding and responding to physical experiences within his or her environment. Piaget further attested that a child's cognitive structure increases in sophistication with development, moving from a few innate reflexes such as crying and sucking to highly complex mental activities. Hence, to a constructivist, learning is seen as the construction of meanings by the learner. This theory stemmed from the philosophical school of thought has influenced educational view of learning. Constructivism learning theory evolved from the extensive study of cognitive development theory of Piaget. Piaget (1940) described elements that helped predict what children learn at different stages of development.

Similarly Piaget in his stages of cognitive development emphasized the use of concrete materials such as hands-on learning materials for enhancing cognitive development of individual. The influence of Piaget stages is age dependent, as in the formal operation stage which is between the ages of 11-15 years and above is regarded as the final period of intellectual development. This period coincides with the Senior Secondary School period and the adolescent period which is characterized by attainment of the intellectual skills of the adult to do abstract and critical thinking. Therefore when concept such as ecology, genetics and evolution among others are taught with the aid of hands-on learning, it will enable students to understand and explain the concept, processes, structures and relationships.

The concept of critical thinking is supported with the works of Bloom (1956), who identified six levels within the cognitive domain, each of which related to a different level of cognitive ability. Knowledge focused on remembering and reciting information. Comprehension focused on relating and organizing previously learned information. Application focused on applying information according to a rule or principle in a specific situation. Analysis was defined as critical thinking focused on parts and their functionality in the whole. Synthesis was defined as critical thinking focused on putting parts together to form a new and original whole. Evaluation was defined as critical thinking focused upon valuing and making judgments based upon information. In the context of this study, critical thinking is deemed to take place when students are required to perform in the Analysis, Synthesis, and Evaluation levels of Bloom's taxonomy.

To provide the greatest benefit to students, teachers should provide many opportunities for students such as hands-on teaching strategy to engage in the upper levels of Bloom's taxonomy where critical thinking takes place. While most teachers believe that developing critical thinking in their students is of primary importance (Albrecht & Sack, 2000), few have an idea exactly what it is, how it should be taught, or how it should be assessed (Paul, Elder, & Batell, 1997).

1.2 Statement of the Problem

The problem of effective teaching and learning of science in Nigerian schools has become a sensitive issue that needs urgent attention. It has been observed that the issue is affecting the performance of students at the secondary as well as higher levels of education in both internal and external examinations adversely. It has also been discovered that the poor academic performance of students is related to the conventional lecture method used to teach them by the teachers, as it was observed by Gyuse (2009) that many students experienced difficulty in science courses as a result of the lecture method used by their teachers. Hence, Olayinka (2016) identified that poor method of teaching and improper use of instructional materials as being the cause for the poor performance of students. Deep understanding of scientific concepts is of utmost importance, particularly at the secondary school level, because misconceptions as well as negative attitudes acquired at this level could translate into poor performance and create negative disposition towards learning the sciences (Esiobu, 2005). Biology is generally conceived by most students as the easiest science subject and so, enjoys larger number of enrolment than other basic science subjects (Ajewole, 2006). However, the yearly percentage pass in the subject is very low compared with students' performance in other basic sciences as well as other subjects. This, it should be stated, does not translate to it's being easy (Nzelum, 2010). It was observed by Olajide (2002) that, students do not perform well academically in biology at secondary school level. Empirical studies such as, Ibe and Maduabum (2001), and Daramola and Gbore (2013), respectively, argued that candidates' performance at the Senior School Certificate Examination (SSCE) conducted by West African Examination Council have consistently remain poor, with biology having the highest enrolments and poorest result over the years; looking at the importance of biology to the national development and considering the state of poor academic performance in this very subject at the secondary level, the poor academic performance observable in the biology result of the students should be a thing of serious concern to any citizen of Nigeria. These have also shown that students perform poorly in biology and also in ecology, which is an aspect of biology (Chief Examiner's report of West African Examination Council, 1999; & 2007). One of the reasons preferred was that students have poor understanding of the basic concepts in biology. The West African Examination Council (2005-2017) reported that students perform poorly in the area of ecology and revealed that only very few number of candidates attempt questions on ecology. Despite the various innovations on the use of activity-based teaching strategy and others such as questioning method, demonstration, process approach, cooperative learning, laboratory activity method, the low performance of students still persist in biology at senior secondary school level. However, the WAEC and NECO Chief Examiners report of 2010 to 2014 revealed that only 34% to 53% of the students pass biology annually at credit level and above. Table **1.1** and **1.2** show the students' performance from 2010-2017 for both WAEC and NECO biology results, though the failure rate is not consistent, where; pass at Credit Level (%) and Rate of Failure (%) referred to those with A1– C6 and D7 – F9 respectively. Note that, A1 - C6 determined the requirement grade for Admission into any university for science courses, and those with D7 - E8 can be admitted into other courses apart from the Sciences (such as Arts and Social Sciences) while those with F9 would/are not considered.

Table 1.1 Biology Results for WAEC Students from 2010-2017 in Kaduna State, Nigeria

Year	Total	Pass at Credit Level (%)	Rate of Failure (%)
2010	1,467,121	34.20	65.80
2011	1,445,311	33.90	66.10
2012	1,611,232	43.38	56.62
2013	1,578,049	48.62	50.38
2014	1,597,247	46.09	53.91
2015	1,562,323	45.70	54.30
2016	1,438,679	52.97	47.08
2017	180,253	40.35	59.65

Source: West African Examination Council 2010-2017 Annual report.

Table 1.2 NECO Examination Result for Biology Students from 2010-2017 in Kaduna State.

Year	Total	Pass at Credit Level (%)	Rate of Failure (%)
2010	1,249,028	52.27	47.73
2011	1,268,213	47.04	52.96
2012	1,348,528	41.95	58.05
2013	1,306,535	42.98	57.02
2014	1,508,965	52.17	47.83
2015	1,427,096	51.90	48.10
2016	1,022,474	84.54	15.46
2017	180,253	40.35	59.65

Source: National Examination Council 2010-2017 Annual report.

The report attributed to this poor performance in biology to low performance in ecology concepts among others and visible improvement is not yet in sight. This is of great concern to the researcher. If this trend is not checked, the result is that the teaching of biology in senior secondary schools and development of science in the nation will be affected. Students can learn if well taught but no teacher can give what he does not have when teaching. This situation calls for intervention in method employed by teachers. This has necessitated the need to employ approaches/strategies for improving teaching and learning of students in ecology which will enhance their critical thinking and performance at secondary schools. The approaches considered in this study for improvement is Hands-on Learning Strategy (HLS). Although HLS is purported to have the potential to enhance student critical thinking and performance, it is not quite clear whether HLS may be more effective in enhancing critical thinking and sustain student performance in ecology. It is on the above premise that the study is carried out to determine the Effect of Hands-on Learning Strategy on Performance in Biology and Students Perception Level of Critical Thinking involved in Zaria, Nigeria

1.3 Objectives of the Study

This study has the following objectives: to;

1. determine the effect of hands-on learning strategy on academic performance of Senior Secondary II Students in ecology.
2. determine the effect of hands-on learning strategy on critical thinking skills of SSII students in ecology.
3. find out the effect of hands-on learning strategy gender on hands-on learning strategy of teaching ecology among senior secondary school students.
4. find out the effect of hands-on learning strategy on the mean Critical thinking scores of Male and female students in ecology.

1.4 Research Questions

The following research questions were formulated for answering as follows:

1. What is the effect of hands-on learning strategy on mean academic performance of Senior Secondary II Students in ecology?
2. What is the effect of hands-on learning strategy on critical thinking skills of SSII students in ecology exposed to hands-on learning strategy and those exposed to lecture method?
3. What is the effect of gender on hands-on learning strategy of teaching ecology among senior secondary school students?
4. What is the effect of hands-on learning strategy on the mean Critical thinking scores of Male and female students in ecology?

1.5 Research Hypotheses

The following Hypotheses were formulated and tested at $P \leq 0.05$ level:

H_{01}: There is no significant difference between the mean academic performance score of students in ecology concept exposed to hands-on learning strategy and those exposed to lecture method.

H_{02}: There is no significant difference between the mean critical thinking skills of students in ecology exposed to hands-on learning strategy and those exposed to lecture method.

H_{03}: There is no significant difference between the mean academic performance scores of male and female students taught ecology when exposed to hands-on learning strategy.

H_{04}: There is no significant difference between the mean Critical thinking skills scores of male and female students exposed to hands-on learning strategy of teaching ecology.

1.6 Significance of the Study

Researches in science education have been geared towards improving the methods of teaching science in order to improve students' performance in science subjects. In progressing search for more effective methods or strategies for teaching science and for enhancing meaningful learning of science subjects, hands-on learning strategy in relation to critical thinking has been proposed to have significant impact/ benefit to the following:

1. **Biology Teachers** will benefit from the present study by adopting the strategies used in teaching of sciences, biology in particular. The strategy will assist the teacher to identify if critical thinking skills have effect in teaching and learning of sciences in our secondary schools. By adopting the strategy of activities by the teachers, this will make their lessons interesting and real. Hence, this study could provide new teaching techniques to other teachers in stimulating the interest of our esteemed students in knowledge construction.

2. **Biology Students** will also benefit when suitable methods of instructions are introduced that will promote their performance in ecology. Thus, ecology is one of the most important topic/area in biology which informs students how they are influenced by, and have influence on, the ecosystems and the biosphere. In addition, understanding ecology facilitates the understanding of photosynthesis and respiration easily (Anderson, Sheldon, & Dubay, 1990; Çapa, 2000, Özkan, 2001); for example, students have to learn distinction between producer and consumer before photosynthesis (Çapa, 2000; Özkan, 2001). Students will be able to cope with more complex concepts as a result of clear, more efficient and dynamic presentation. It could also enhance and increase students' engagement, critical thinking and academic performance which are evidence by student at-task activities through manipulation of object(s) and solve personal problems during the learning. Provide a teaching method for teaching ecology in order to inculcate in students the skills of diligent search/manipulation and enhance critical thinking skills toward ecology.
3. It is also hoped that this research will be of great benefit to both **Education Planners** and **Science Curriculum Planners** to modify where necessary the current science curriculum by incorporating the arranged hierarchical concepts (pre-requisite concepts) before embarking on the higher concepts. This will serve as a source of motivation. Hence, the study will assist the curriculum planners in developing learning strategies inform of activity base that will be more of student-centered. This will motivate and encourage interaction among students.
4. The findings from this study will also help **government** concern or **policy makers** to know the implication of lecturing in sciences and value the activity-based method or strategy, especially in our secondary schools. The findings will help them to take more appropriate step in making sure that teachers are enhancing critical thinking skills among the learners.

5. **Professional Bodies** and **associations** such as National Education Research Development Council (NERDC), National Teachers Institute (NTI), Science Teachers Association of Nigeria (STAN), and Mathematics Association of Nigeria (MAN) will benefit from this study by way of production of basic science course materials in schools in order to reflect the process skills and products of science in our schools or localities. Through courses, seminars, conferences and workshops that shall be organized from time-to-time, teachers will improve in their pedagogical approach of teaching basic sciences, particularly biology.
6. **Textbooks Authors** should emphasize on hands-on learning strategy as an instructional procedure that should be adopted for effective teaching and learning of various concepts in biology.
7. **Researchers:** The findings of this study serve as a foundation for researchers who may develop interest to carry out further investigations on the effect of Hands-on learning strategy on Critical Thinking and Performance of senior secondary biology students. And also the study will add new information to the existing literature in basic science education which other researchers can refer to.
8. **Philanthropic Organizations** such as Parents-Teachers' Association may benefit from this research.

1.7 Scope and Delimitation of the Study

This study is aimed at investigating the Effect of Hands-on Learning Strategy on Performance in Biology and Students Perception Level of Critical Thinking involved in Zaria, Nigeria. SS II students were used for the study because of their stability. Two (2) senior secondary schools were used; one for experimental and the other one for control. Ecology concept was chosen for the study because it is one of the widest area and also one of the difficult topics (Oyedokun, 2002 &

WAEC, 2006) for students' understanding among other concepts in biology. Furthermore, the study of ecology is very important to the students in that, it is fully exploring the potentials of environment. The SSII students were considered due to the fact that they were rooted and more knowledgeable in biology concept than SSI students who have not yet gained much academic while SSIII students are busy preparing for Senior School Certificate Examinations (SSCE). The concept that will be taught using hands-on learning strategy is ecological Basic ecological concepts, Components of ecosystem, Population studies, Functioning ecosystem, Ecological factors, Trophic levels, Energy transformation in nature. The study was delimited to two public senior secondary schools; both male and female schools (Co-educational). This is out of sixteen public senior secondary schools in Zaria Education Zone, Kaduna State.   Two instruments were used for this study; Ecology Concept Performance Test (ECPT) and Critical Thinking Questionnaire (ECCTQ).

1.8 Basic Assumptions

In carrying out this study, it is based on the following assumptions that:

i. All the variables in this research work are measurable;

ii. The schools are operating using the same National Curriculum;

iii. The students of SSII are taught by qualified biology teachers;

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

The study investigated Effect of Hands-on Learning Strategy on Performance in Biology and Students Perception Level of Critical Thinking involved in Zaria, Nigeria. This chapter outlines previous studies that have direct relevance to this study. Also, it highlights some theories which could guide Science teachers to select appropriate strategies for teaching biology. The chapter is organized under the following sub-headings:

2.2 Teaching of Biology at Secondary Schools Level

2.3 Methods of Teaching Science

2.4 Concept of Hands-on Learning Strategy (HLS)

2.4.1 Benefits / Needs for Hands-on Learning Strategy in Science Education

2.5 Concept of Critical Thinking (CT)

2.5.1 Studies on Critical Thinking and Academic Performance in Sciences

2.5.2 Educator's Role in Developing Critical Thinking Skills

2.5.3 Critical Thinking and its Usage in this study

2.5.4 Relationship between Critical Thinking and Creative Thinking

2.6 Hands-on Learning/Active Learning for Enhancing Critical Thinking and Performance

2.6.1 Hands-on Learning on Academic Performance and Gender

2.7 Overview of Similar Studies

2.8 Implications of the Literature Reviewed for the Present Summary

2.2 Teaching of Biology at Secondary School Level

According to Ormrod (2004), learning is observed when a change in behavior is seen. Science education has become very central in the emerging globalization of knowledge particularly at the higher education levels. This is because of the observable impact of science and technology on the world of today and the future (Marginson & Van der Wende, 2007). Science had become the hub of national growth and when it is well applied, it further boosts technology astronomically without exaggeration. Science in the context of this study encompasses biology otherwise known as life science, chemistry and physics (physical sciences). The study of biology is usually well embraced especially at the senior secondary and Further Education and Training (FET) levels as a key subject for the study of medicine and other health science courses at the university level. It is, therefore, expected that schools should have adequate number of trained and qualified biology or life science educators to teach this very important subject from the grass-root to the higher levels.

The National Policy on Education (FRN, 2014) refers to secondary education as the education given in institutions for children aged 11 to 16 years old. It further stresses that since the tertiary education system is built upon it, the Primary education being the foundation and followed by secondary level, is the key to the success or failure of the whole national educational system. In other words, the secondary education is the second tier of the 6-3-3-4 educational system which is for six years duration in Nigeria. According to Ali, Toriman and Gasim (2014), Adepoju (1998), secondary education is the type of education which is exposed to children in secondary institution, whether students acquire fundamental knowledge, skills, thought, feelings and actions, which are considered necessary for all citizens, regardless of social status, vocation or sex. It should be noted that secondary education has direct impact on development of citizen or nation as a result of the cognitive skills of literacy.

Biology is a natural science that deals with the living world: How the world is structured, how it functions and what these functions are, how it develops, how living things came into existence, and how they react to one another and with their environment (Umar, 2011). It is a prerequisite subject for many fields of learning that contributes immensely to the technological growth of the nation (Ahmed, 2008).This includes medicines, pharmacy, nursing, agriculture, forestry, biotechnology, nanotechnology, and many other areas (Ahmed & Abimbola, 2011). Biology is seen as one of the core subjects in Nigerian secondary school curriculum. Because of its importance, more students enrolled for biology in the senior secondary school certificate examination (SSCE) than for physics and chemistry (West African Examination Council, 2011). Biology is introduced to students at senior secondary school level as a preparatory ground for human development, where career abilities are groomed, and potentials and talents discovered and energized (Federal Republic of Nigeria, 2009). The quality and quantity of science education received by secondary school students are geared toward developing future scientists, technologists, engineers, and related professionals (Kareem, 2003). Even those students who are not science oriented often offer biology as a science subject, in order to gain scientific literacy. Thus, the Senior Secondary School Biology Curriculum places the basic ecological concepts to be studied under year one. And some include the ecological system, ecosphere/biosphere, lithosphere, environment, habitat, biome, food chain, food web, measuring instruments etc. Thus, the curriculum specified the performance objectives to be achieved as well as activities to be carried out in the course of teaching and learning process to facilitate understanding of the concepts being taught (Nzewi, 2008).

In spite of the importance and popularity of biology among Nigerian students, performance at senior secondary school level has been poor (Ahmed, 2008). The implication of this failure in education is that Nigeria may have shortages of manpower in science and technology-related disciplines. This may affect Nigeria's vision to become one of the 20 industrialized nations in the world by year 2020. Poor teaching methods adopted by teachers at senior secondary school level in Nigeria have been identified as one of the major factors contributing to poor performance of students in biology (Kareem, 2003; Ahmed & Abimbola, 2011; Umar, 2011). The conventional teaching method is classroom-based and consists of lectures conducted by the teacher. This teacher-centered method emphasizes learning through the teacher's guidance at all times. Students are expected to listen to lectures and learn from them. Just passing the tests, consisting of descriptions, matching, and other forms of indicators, is all that matters to complete the curriculum (Adegoke, 2011; Umar, 2011).

The persistent use of lecture method makes students passive rather than active learners. It does not promote insightful learning and long–term retention of some abstract concepts in biology (Kareem, 2003; Ahmed & Abimbola, 2011; Umar, 2011; Ahmed, 2008). The results of the Senior Secondary School Certificate Examination (SSCE, 2010 to 2015) of biology students in Nigeria are highly disturbing, considering the fact that the students would become future scientists. Thus, in this 21st century, a motivating and captivating approach should be encouraged to help students better learn, understand, and retain biology concepts and promote their future involvement.

A review of students' enrolment in science subjects in the senior secondary school in Nigeria showed that students enrolled more in biology than other science subjects. Though student enrolment in biology is high, their academic performance in this subject is low particularly in the senior secondary certificate examination (James, 2013). Even in schools with well-equipped science laboratories, qualified science teachers and other facilities needed for the teaching and learning of science subjects, many students still perform poorly particularly in biology. The poor performance of students in science subjects is of major concern to all and particularly to those in the mainstream of science education in Nigeria. This is probably because the special position that science and technology now occupy in the race for national development dictates that all of our students should be achieving very positively in school science. In addition, there is a worldwide trend of science for all currently sweeping through the globe (Adu and Olatundun, 2007). The aim is to make every one literate in science. Underachievement in the subjects in schools does not only make nonsense of the drive but points to its failure and a possible negative attitude of the general populace to the learning of science.

2.2.3 Recognizant Survey

The Zaria Education Zone is the terrain where the recognizant survey case study took place. The researcher undertook the reconnaissance survey case study within Zaria and its environs. The researcher discovered that, the ecology of population study is characterized with different types of ecosystem ranging from biotic and abiotic components/factors of ecosystem which described functioning ecosystem in biotic components that identify food chain, food web and tropical level. The researcher undertook the reconnaissance survey at the following areas: Kofan Kuyan Bana, Dakace, Gyallesu and Tudun Jukun etc. The surveyed areas share in common the types and patterns of Ecology/Ecosystem in the study area.

2.3 Methods of Teaching Science

A method can simply be described as the way in which one does something. The method a teacher uses to bring the desired outcome in the teaching and learning process cannot be over-looked. There are various methods available for achieving effectiveness and the teacher has full responsibility for selecting the most appropriate method for the prevailing circumstances in order to achieve the aims of teaching Science in Secondary Schools. The methods of teaching Science in the Secondary Schools among others are laboratory, practical work, demonstration, project, guided discovery, inquiry methods and hands-on learning strategy.

Laboratory Method

The laboratory is an indispensable tool in the teaching of Science which provides students with a place or setting, to attack and solve problems, collect data, prove ideas and carry out investigations which emphasizes learning by "doing". Arubayi (2009 & 2015) opined that, the laboratory method of teaching comprised of variety of activities ranging from the experimental investigations to confirmatory exercises and skill learning. Arubayi (2003 & 2015) summarized the major objectives sought in laboratory work, as the development of skills, concepts, cognitive abilities and understanding of the nature of Science. Skills such as manipulative, inquiry, investigation, organizational and communicative, can be developed from laboratory experiences.

Also, concepts such as hypothesis, theoretical models and taxonomic category are developed. Cognitive abilities such as critical thinking, problem solving, application, analysis, synthesis, evaluation, decision making, and creativity are developed through laboratory experiences. Through well planned and carefully executed laboratory work the participant is able to gain a better understanding of the nature of Science.. The laboratory method of teaching Science assists learning and it is the true nature of Science which teaches practical skills; help to develop some desired traits such as appreciation which are necessary for problem solving and skill acquisition. Unfortunately, Operation Reach all Secondary Schools (ORASS) 2006, findings revealed that less than 10% of Secondary Schools in Nigeria have well equipped laboratories. Again, Inomiesa (2010) opined that most of the laboratories are empty and equipment for the laboratories are seldomly bought and it is not uncommon for Secondary Schools Students to migrate from one School to the other for external examinations such as West African Examination Council (WAEC) and National Examination Council (NECO), in search for equipment and chemicals for laboratory work.

Practical Work

Another method of teaching Science is Practical Work. Science Community Representing Education (SCORE), 2008 in the report "Practical work in science: A report for a strategic framework" admits that, "good quality practical work; can engage students, help them to develop important skills, help them to understand the process of scientific investigation and develop the understanding of concepts. Students understand scientific concepts better through the full adoption of practical works in science teaching. Woodley (2009) said that "practical science supports skills development, experimental learning, independent learning, learning in different ways and the development of personal learning and thinking skills". The concept of practical work may be extended to include simulated experiences and even students exercises involving pencil and paper calculations. Practical work may be done in the laboratory but not strictly at the laboratory. Inomiesa (2010) opined that practical works are carried out to help the learner, clarify and extend the learner's experience of natural phenomenon. It provides opportunities for students to practice the correct use of apparatus. Students develop manipulative skills; develop ability to form concepts and the ability to communicate the results of the finding.

If practical method of teaching Science is carefully and properly planned and utilized, it will enhance effective teaching of Science in Secondary Schools.

Demonstration Method

Another method of teaching Science is the Demonstration Method. Enemali (2006) described this method of instruction as a showing procedure, to explain, teach and inform students, while Arubayi (2009) described demonstration method as a visible presentation of ideas, skills, attitudes, processes and other intangibles. Demonstration lessons include facts and principles used along with materials for showing or teaching someone else. For demonstration methods to be effective, the lesson should be planned ahead of time, have all necessary materials and equipment needed for the demonstration lesson. Participants should be given clear and simple instructions. The sitting arrangement for the demonstration should be organized so that participants can see and hear clearly. After demonstrating generally, the students should be given opportunity to practice individually or in groups. The teacher should provide assistance and guidance to students who have not gasped the basic concept yet. Demonstration method of teaching Science has many merits and demerits. One very important merit of using demonstration method is that it aids learning, as the students see, hear and do. Despite this very valuable merit, a poorly planned and executed demonstration lesson will not promote optimum learning and may not make room for individual differences.

Project Method

Another method of teaching Science in Secondary Schools is Project Method. Uzoka (2002) described project method as an activity unit that learners do usually mentally and physically learn in a real life situation under the guidance of a teacher. The main purpose is to allow students first-hand experience on how to do something. A student may select a project from a prepared list of projects given by a teacher, or the learner may submit an idea to the teacher for approval. The project method of teaching can only be effective if the learner selects a problem the learner is interested in, which will motivate the learner to complete a selected project. The learner should be aware of the duration of the project, the point for which marks will be awarded and the type of report expected. The learner with teacher's supervision decides and plans activities for completing his project. The project method of teaching Science can provide practical experience to students and help to make learning from that particular experience permanent. Thus, furnishing real-life setting for the person doing the project which will motivate students and sustain the interest in the learning situation. Project work encourages independent thinking and teaches the participants the ability to make decisions on their own. The project method of teaching can require a large amount of time to complete a project, and if students' works are not properly supervised it can create problems. The teacher's role is to ensure that the project work is well planned and the student must clearly know what to do. The curiosity of students will be awaked thus creating a demand for new information.

Guided Discovery Method

Guided discovery is another method of teaching Science in Secondary Schools. Inomiesa (2010) recommended the use of guided discovery approach in teaching Science in schools. This recommendation is in line with the suggestion from the Federal Government as enshrined in the National Policy on Education (2004 & 2014), that guided discovery approach should be adopted for teaching Science. It is the hope of the Federal Government that through this method, students will learn Science better. Activity based Science teaching allows students to explore their environment and discover nature. To successfully adopt the guided discovery approach, students must perform certain mental processes, such as: observing, classifying, measuring, predicting, inferring, and hypothesizing. Thus, a lot of inquiry goes on in the class room where the teacher mainly serves as a moderator, moving from point to point to guide the learning of students and help them to overcome difficulties. The teacher is the resource person who guides students' sources of information. To be successful, an inquiry based classroom should operate in a free and democratic atmosphere in which discipline is relaxed but not laxed. The students may work in a variety of locations while the classroom is filled with a variety of instructional materials, these could be real objects or models, pictures or diagrams. These could help students to concretize the information gathered from the learning situation.

Experimental Method

Experiment is core of doing investigation in science classroom. Teachers tend carryout experiment as it encourages students' interest in learning science via provision. Students often find the opportunities to manipulate objects, test hypothesis, and work together to solve or prove something exciting. Also, through experiments, students are usually able to 'see' or 'relate' concepts better, hence contributing to sound science conceptions. For instance, Olympiou and Zacharia's (2011) study found that the use of a blended combination of physical manipulative (PM) and virtual manipulative (VM) enhanced students' conceptual understanding in the domain of light and colour topic more than the use of PM or VM alone. Demeo (2005) also noted that experiments –particularly the transformation of traditional laboratory instruction to one using teaching of manipulative skills - help produce more "mature" type of science education. It is said that the teacher's actions of redistributing authority between teacher and student when laboratory pedagogy is taking place, as well as the nature of interaction when discussing science issues and findings, do contribute to such outcome.

Field Study/Trip Method

Field work is an academic or other investigative studies undertaken in a natural setting, rather than in laboratories, classrooms, or other structured environments (Noel, 2007). Often when a field study is carried out, students learn science content or concepts via observation,(structured or unstructured) discussions as well as through analysis of other forms of collected data. The collected data could be in the form of specimens, video and/or audio recorded objects and phenomenon. Field study does not only allow students' active engagement with each other but also helps develop an understanding of the experience and process of learning in natural settings. Preusch (2009) who used field study as an approach to teaching found his students accurately described plants and animals they had observed in different habitats during the field trip. Also, they were able to develop 'continuity' between theory and reality via discussions on the lessons learned in classrooms, and relating those with their home life and other experiences in the outdoors. Other advantages of field trip as highlighted by Harder (2010) are students and teachers found the activity enjoyable, learning was more real and more challenging than those done inside the classroom, and learning activities and environment promote aspects of discovery, open discussions, and the freedom to choose how to find and record information deemed most beneficial.

Inquiry Method

The method of inquiry is adopted in the teaching of Secondary School Science which evolved from man's inquiring ways, which are refined by the development of attitudes and methods which became part of the scientific enterprises. Stephenson (2011) opined that "the power of an inquiry-based approach to teaching and learning of Science is its potential to increase intellectual engagement and foster deep understanding through the development of hands-on, minds-on and research based disposition towards teaching and learning" The nature of inquiry is complex, the complex nature of inquiry technique, has accounted for the minimal use of this method of teaching Science. The inquiry method of teaching can be most effectively used when students are actively involved in the learning process and the learning environment permit freedom of movement and expression. The teacher must provide this kind of climate so that students can collect data, form and test their theories using their own methods. Inquiring technique can help the learners develop ability to think critically and aid in the development of skills such as defining, questioning, observing classifying, generalizing, verifying and applying. These skills are very vital in the acquisition of the knowledge and nature of Science.

It has long been known that active learning is better than passive learning (Scholes, 2002). A shift from the traditional to a progressive mode of education had led to an increased interest in learners' individual differences. The new paradigm is Student-centered, based on inclusiveness, cooperative learning and encouraged diversity (Zywno, 2002). An increasing amount of research in the past years points out that the interactive process between individual student and the teacher is very important in determining the nature and quality of learning and development that result from instruction (Nwagbo, 2001). Some researchers have taken the position that it is the teaching method and not the teacher that is the key to the learning of science. While Olajide (2017) opined that, it is both the teaching method and the teacher since the teacher uses the method(s). It is believed that most effective learning takes place when the interactive process is one that is best suited to the individual students in terms of learning styles (Zywno, 2002).

Learning can be considered as any response to stimuli that leads to residual change in behavior. Learners learn when they interact with resources in their environment that results in change of behaviour. To foster learning teachers decide, usually ahead of time, how they will teach a given objective, for example a concept, a skill or an attitude (Muzumara, 2007& Muhammad, 2014). This signifies that, sorting and understanding methods/strategies by teachers to use and teach a given objective is inevitable. Effective teaching and learning in any subject at any institution are dependent on the individual strategies used and other variables (Muhammad, 2001). Muzumara (2007) pointed that, there are a number of factors that determine what strategy a teacher should use to accomplish a given learning outcome. These factors may include age level of pupils, amount of time available, type of weather, availability of teaching/ learning resources and the topic being delivered. The choice of the type of strategy to be used for a particular lesson or topic is entirely up to the teacher and he/she feels appropriate for that topic. These being the case it is not usual to see teachers teaching the same topic using different strategies and even if the strategy may be the same the way it is used will differ from teacher to teacher and from class to class. What is important is for the teacher to know and understand his/her pupils. Muhammad, (2001) noted that instructional strategy is a major responsible for the level of performance in any subject by the students. Learning difficulties can be solved to a great extent by using appropriate teaching methods. Teaching methods/strategies may be classified in different ways; those in which the teacher is directly in control are referred to as 'teacher-centred'. These include lecture method, teacher demonstration and teacher questioning. Strategies in which pupils/learners are actively involved are referred to as 'learner-centred'. They include laboratory activities, hands-on learning, panel discussions, quizzes, and pupils'/learners' project and so on. Teacher-centred such as lecture method, keeps learners passive and do not benefit most while pupils/learners-centred such as hands-on allows learners to be actively involved in learning and generate meaningful ideas / experiences. Teacher usually utilizes a variety of teaching methods in one lesson for them to successfully accomplish their tasks. Students can acquire different skills and experiences when allowed to interact among themselves and exchange ideas. Several methods could be used to teach biology practical which provide skills and experiences. These methods include laboratory methods, hands-on learning, group learning, discovery method, pupil-led seminars, programed instruction and so on.

From the fore-going, it has been alluded to a major reason alluded to the persistent poor performance in science subjects at School Certificate level is that, most science teachers in secondary schools in Nigeria probably do not generally vary the teaching strategies they use. Consequently, they are not to cope with some specific difficulties associated with the teaching and learning of science by both the teachers and the students respectively (Anchor, 2003; Ogbeba, 2009). Hence, classroom teachers could be knowledgeable in the science content but in the pedagogical aspects. For instance, studies have shown that most science teachers do not possess the prerequisite knowledge needed for activity-based learning (Nwosu, 2004; Johnson, 2004). The Consequence of this is that the most prevalent method of teaching has been the 'chalk and talk' (lecture) method. Buttressing this, Ezeliora (2004) pointed that most of the time: science is taught to the learners using the descriptive or lecture method instead of hands-on learning strategy. The possible ineffectiveness of this approach is strongly supported by persistent poor performance of students in public examinations in Nigeria.

Science teachers are expected to deliver a particular content (that is, knowledge) in a specific term, week and time of the year to learners. However, how to put the required knowledge across to learners is often a problem to teachers. This problem could arise from either having to teach much in short time (that is workload) or not having the pedagogical wherewithal (that is, preparation and knowledge of available methods). Further, it is found that some teaching strategies could be more facilitative than others when used in teaching. However, this depends on the subject or topic/concept. Much and specific work by researchers in this area (Longjojhn, 2009; Ogbeba, 2009; Umoren and Ogong, 2007; Barbosa, Jofili and Watta, 2004). Hence, the objective of this study is to investigate the effect of hands-on learning strategy on performance and critical thinking in ecology among SSII biology students in Zaria, Kaduna State, Nigeria.

2.4 Concept of Hands-on Learning Strategy

A learning/teaching strategy refers to an approach, method or combination of carefully designed classroom interactions that could be followed meticulously to teach a topic, concept or an idea (Olorundare, 2000). There are however many teaching and learning strategies or methods that a classroom teachers could use as mentioned earlier. Hands-on learning strategy is not completely a new idea in the literature but it broadens the meaning from the past terms such as "laboratories" to cover a variety of settings i.e. from laboratories to classrooms. Descriptions of science education have shifted from vocabulary and text materials to activities. Teachers are now seeking to recognize what students are learning as a consequence of busy hands (Flick, 1993 in Munir and Mumtaz, 2013). The term hands-on is used commonly in science education. It means that teacher should do more than lecturing about science. It allows the students to experience science by doing it involving using the hands. Like many other terms in educational practice, these terms have no standard definition that has one meaning for all practitioners. It may also be defined as any activity that allows the learner to handle, observe or operate a scientific process. In hands-on science activities, learners interact with materials and equipments (Lumpe, et al in Munir et al, 2013).

Hands-on science activities may also be defined as a variety of activities that may or may not be actual experiments, such as observation or measurements, not necessarily carried out in laboratories (Ruby, 2001). Generally hands-on science activities are defined as the activities that allow the students to handle, manipulate or observe the scientific processes (Lumpe, et al in Munir et al, 2013). In these hands-on activities, students interact with materials to observe scientific phenomena. Flannery (2001) states that hands-on science foster the mind in more basic ways by extending the links between the brain and the hand. Different memories have been identified for different functions. Those are auditory, visual, tactile and body motor functions (Korwin and Jones, 1990 in Munir et al, 2013). It implies that any information which utilizes all four memories would be a stronger and easily retrievable. Because hands-on activities utilize all these memories, therefore the information gathered through these, would be more powerful and easily retrievable.

Science educators have attempted to classify hands-on science activities into different categories. One dimension addressed by various experts in science education is inquiry. It has been argued by prominent educators and psychologists that science is an inquiry based subject and should be taught in that fashion. Within the inquiry dimension, distinctions might be made keeping in view the level of inquiry involved. Lumpe and Oliver, 1991 (Lumpe, et al in Munir et al, 2013) differentiated the verification activities from inquiry activities that verification activities are those activities in which the learner knows the result of the activity prior to conducting the activity while in inquiry activities; the learner has no understanding of the concept or phenomenon prior to conducting of activity.

The abstract nature of science content and teaching put unpleasant effects on learners. Currently, almost all major science curriculum development projects have emphasized on hands-on practical activities as both an effective and enjoyable way of learning science content. These activities provide the students concrete experiences as far as possible to reduce the abstraction (Johnson et al in Munir & Mumtaz, 2013). Effectiveness of hands-on activities in learning science has long been hotly debated and accepted by science education community (Klahr, 2005). The need of concrete experiences in science instruction is advocated because they enhance students' learning and provide a more authentic view of science (Yore, 2000). He believed in doing first and reading and writing later. According to (Korwin & Jones, 1990 in Munir & Mumtaz, 2013) John Dewy was of the strong opinion that experiences specifically hands-on activities are vital in educational process. Physical operations provide feedback of learning that allows learners to see it happen.

Hands-on learning strategies/activities are effective learning experiences. Research has evidenced that hands-on approach in science improves understanding of concepts resulting in better performance score and success in science subject area, such as biology. In a study conducted by (Korwin et al in Munir et al, 2013) on 50 eighth graders in teaching technical concept on geodesic domes, it was found that there existed a significant difference between learning with and without hands-on activities. They concluded that hands-on activities are effective in learning any applicable concept. It was found in a study conducted by (Stohr-Hunt,1996 in Munir,2013) that the students who were engaged in hands-on activities every day or once a week scored significantly higher on a standardized test of science performance than the students engaged in hands-on activities once a month or never. Young and Lee (2005) conducted a study on 399 fifth graders. The study provided evidence that the students who were taught through science kits outperformed as compared to the students taught science without using science kits (Young & Lee, 2005).

In a study conducted by (Randler, & Hulde, 2007) on 123 fifth and sixth graders from a middle school, it was found that the students involved in hands-on activities scored significantly better than those taught through teacher centered experiments (lecture method). Similar results were found in the study conducted by (Odom, Stoddard & Lanasa 2007) on a sample of 611 seventh and eighth grade students enrolled in middle school science, it was concluded that near daily implementation of hands-on activities yield the greatest positive impact on students' performance.

Various interpretations of what is meant by "hands-on learning" has been proposed so far and the most common and accepted definition was that hands-on learning strategy is learning by doing (Ozlem & Jale, 2011). Hands-on learning has also been defined as any science laboratory activity which allows the students to handle, observe and manipulate a scientific process (Lumpe & Oliver, 1991; Ozlem & Jale, 2011). Hands-on instruction has a long and successful legacy in the sciences and math (Basista and Matthews; Bredderman; Haury and Rillero, 2002), and shows promise for teaching social studies, history, English and other subject areas. By using hands-on instruction, educators are fostering the 21st century skills that students need to be successful: critical thinking, communication, collaboration, and creativity. Thus, Hands-on activities encourage a lifelong love of learning and motivate students to explore and discover new things (Bass, Kristin, Danielle & Julia, 2011). RAFT (Resource Area For Teaching, 2013) is a non-profit organization founded in 1994 to help educators inspire the joy and discovery of learning through hands-on teaching. While hands-on learning in education is a proven best practice for engaging and motivating learners, educators are faced with many challenges to adopting this approach (RAFT, 2013). So, why do most teachers spend so much time talking? First be reminded that most young people have an attention of only 3 to 10 minutes depending upon their age, maturity level, and disability.

Hands-on science is not completely a new idea in the literature but it broadens the meaning from the past terms such as "laboratories" to cover a variety of settings i.e. from laboratories to classrooms. Descriptions of science education have shifted from vocabulary and text materials to activities. Teachers are now seeking to recognize what students are learning as a consequence of busy hands (Flick in Munir & Mumtazl, 2013). The term hands-on is used commonly in science education. It means that teacher should do more than lecturing about science. It allows the students to experience science by doing it involving using the hands. Like many other terms in educational practice, these terms have no standard definition that has one meaning for all practitioners. It may also be defined as any activity that allows the learner to handle, observe or operate a scientific process. In hands-on learning strategy/science activities, learners interact with materials and equipments (Lumpe & Oliver, 1991 in Munir & Mumtaz, 2013).

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Hands-on learning strategy is important to enhance learners' success because students are actively involved in the learning process by manipulating objects or materials to gain knowledge; so that they can construct their own understanding of scientific concepts. By working with materials or objects, students become more motivated and excited to join the lesson. It enables them to become critical thinkers, active learner, and researcher. Hands-on activities also enhance students' interest and curiosity to follow and understand environmental problems or scientific phenomena in real life (Poude, Vincent, Anzalone, Huner, Wollard, Clement, DeRamus & Blakewood, 2005).

Science teachers and researchers can get benefits about how to implement hands-on activities enriched instruction in science, and how hands-on activities affect students' science achievement and attitude toward science in the topic of sense organs. By this way teachers will have an opportunity to use of hands-on activities with simple and low-cost daily life materials in their classrooms to attract students' attention and to make science lesson fun. Besides, students can make connections between science concepts when they carry out different hands-on activities for different subjects of the science (Ozlem & Jale, 2011).

Research of Haury and Rillero (2012) showed that once educators incorporate hands-on teaching, they are more likely to continue using hands-on learning in their classrooms. Hands-on learning can be accommodated to a typical classroom because students can participate in hands-on activities while remaining at their desks or coming together in small groups. Hands-on learning incorporates the applicability of cognitive active learning, making it a practical and feasible learning approach. It also supported by Piaget's theory of the stages of cognitive development, specifically his theory that children from ages seven to twelve are in the concrete operational stage. In the concrete operational stage, children are able to "reason logically about concrete objects and events" (Siegler, Deloache, & Eisenberg, 2006).While they are able to think and reason about concrete objects and events, children in this stage still have trouble thinking and reasoning about abstract ideas. This theory of the concrete operational stage suggests, then, that children between the ages of seven and twelve-approximately between second grade and seventh grade-learn better by using concrete objects and events rather than referring to abstract ideas. Hands-on learning, which allows children to learn through the use and manipulation of concrete objects and activities, seems to be an appropriate and logical extension of Piaget's theory.

Most of the previous literature focuses on various types of active learning, but few studies focus specifically on hands-on learning. An example of a study that does focus on hands-on learning was done by Ward, Sadler, and Shapiro (2008), who found that hands-on learning groups significantly outperformed traditional learning groups in an astronomy curriculum. In the study by

Ward Sadler and Shapiro (2008), approximately 750 third- through sixth-grade students were assigned as the hands-on group. Using the Astronomy Resources for Inter-curricular Elementary Science (ARIES) curriculum, they participated in hands-on activities relating to exploring the concepts of time, light and color, and the earth in motion. Approximately 650 fourth- through sixth-grade students were assigned as the traditional group; they were taught the same three topics using traditional methods. Results showed that students in the hands-on ARIES group performed significantly better on post-tests, which consisted of open-ended questions about the topics covered, than students in the traditional group (Ward, Sadler, & Shapiro, 2008). This study suggests that hands-on learning is more beneficial than traditional learning and therefore provides support for the implementation of hands-on activities into the traditional classroom curriculum. However, open-ended questions are not typical of standardized assessments, and there is a debate over whether non-traditional approaches to learning, such as hands-on learning, would lead to gains on standardized assessments.

2.4.1 Hands-on and Minds-on Activities

Hands-on science is defined mainly as any instructional approach involving activity and direct experience with natural phenomena or any educational experience that actively involve students in manipulating objects to gain knowledge or understanding (Haury & Rillero, 1994; Ateş & Eryilmaz, 2011). Some terms such as materials-centered science and activity-centered science are used synonymous with hands-on science or terms such as materials-centered activities, manipulative activities and practical activities are used synonymous with hands-on activities (Doran, 1990; Hein, 1987; Ateş & Eryilmaz, 2011). Unlike the laboratory works, hands-on activities do not necessarily need some special equipment and special medium. According to Jodl and Eckert (1998), Ateş and Eryilmaz (2011) hands-on activities are based on the use of everyday gadgets, simple set-ups or low-cost items that can be found and assembled very easily. McGervey (1995), Ateş and Eryilmaz (2011), state that "some hands-on activities can be done for less than a dollar per hand, a few have zero cost. Thus, it will be no disaster if a piece breaks or disappears". Thus, hands-on activities were perceived as an enjoyable and effective form of learning of almost all the major U.S science curriculum reforms of the late 1960s and early 1970s (Hodson, 1990; Ateş & Eryilmaz, 2011).

For students to truly learn science concepts, they both need practical opportunities to apply knowledge and also need help in integrating or exchanging the knowledge they gain. According to the U.S. National Science Education Standards (1995), students should have minds-on and/or heads-on experiences during hands-on activities. While doing hands-on activity, the learner is learning by doing but while minds-on learning, the learner is thinking about what she or he is learning and doing. Hofstein and Lunetta (1982), Ateş and Eryilmaz (2011) state that a minds-on science activity includes the use of higher order thinking, such as problem solving compared to the hands-on activity. Therefore, students should be both physically and mentally engaged in activities that encourage learners to question and devise temporarily satisfactory answers to their questions (Victor & Kellough, 1997; Ateş & Eryilmaz, 2011).

As collection of the most popular methods, interactive engagement methods also give emphasis to hands-on activities (usually) as well as minds-on activities (always), which provide immediate feedback through discussion with peers and/or instructors (Hake, 1998; Ateş & Eryilmaz, 2011).

2.4.2 Benefits / Needs for Hands-on Learning Strategy in Science Education

There are several benefits of Hands-on Learning Strategy. They are:

i. Develops critical thinking skills. By investigating the subject matter through hands-on activities, students learn both content and thinking strategies (Hmelo-Silver, 2004). Hands-on activities support problem-based approaches to learning by focusing on the experience and process of investigating, proposing and creating solutions. As a result, students learn how to gather information and solve problems.

ii. Encourages communication and builds language skills. Hands-on activities use real objects to support multiple modes of communication, linking visual learning to what is being said and discussed (Lee, Penfield, and Maerten-Rivera, 2009). Hands-on activities enable students to discuss, debate, verbalize and explain processes and concepts while working together. An observation of hands-on learning noted that students' demonstrated strong communication tied to working in teams (Bass, Kristin, Danielle & Julia, 2011).

iii. Restores focus and spark engagement. With the right kind of planning and presentation, hands-on teaching can restore focus and spark engagement. An independent observation of teachers using hands-on learning noted that students were enthusiastic and generally stayed on-task during guided hands-on activities (Bass, Kristin, Danielle & Julia, 2011).

iv. Provides a path to success for disadvantaged students. It has been demonstrated that students who are disadvantaged economically or academically gain the most from activity-based programs (Bredderman & Ted, 2012).

Every learner is provided with the same materials and guidance, and can interact with the lessons in the way that builds on their unique level of prior knowledge, past experiences and current abilities. Hands-on learning inspires all students to meet and exceed high standards for learning and participation, while engaging multiple senses (sight, sound, touch, and so on). The learner can interact with the materials in a way that makes sense for them (for example, students who tend to learn visually may connect with the colors and sights while tactile learners can appreciate being able to manipulate objects).

v. Teaches Teamwork. Business leaders regularly complain that our education system fails to teach students the 21st-century skills they need for the work world, such as problem-solving, communication, and the ability to work well in teams (Casner-Lotto and Barrington, 2006). In the course of doing a hands-on project, students learn to work well with other team members who may have different socioeconomic backgrounds, different learning styles, and different cultures. As a result, students are better prepared to take their place in the business world.

Case in point: Dr. Anna Pollack, a fourth-grade teacher and former pediatrician, has noted that while using hands-on activities in her classroom, the kids discover that one person's weakness is another person's strength. Students are then able to learn from, and appreciate, the skills of their peers while developing their own skill-sets. *"*With hands-on learning, kids can be successful wherever they're coming from" (Anna in RAFT, 2013).

vi. Improves the Teaching Experience. The benefits for educators are also numerous. For example, professional development workshops that stress hands-on learning are significantly more successful in improving teacher confidence in math and science instruction (Basista and Mathews, 2002). Hands-on activities help teachers cut the time needed for remediation, improve classroom management by unifying students around a common organized activity, and foster a greater interpersonal and supportive emotional connection with students through sharing the process of learning with them (rather than one-way lecturing).

vii. Makes Teaching and Learning fun (again). Finally, hands-on teaching is fun. Not just for students but for educators who are eager to go beyond merely presenting information and administering tests. Larry Laskowski, a middle school instructor, emphasizes this fact: *"*Students want to have more fun. If it's fun, the experience stays with you." Dr. Pollack shares Laskowski's sentiment: “You don’t hear a lot of laughter without hands-on. I love this about hands-on. The students laugh. They enjoy learning” (RAFT, 2013).

One recommended strategy is Hands-on Learning Strategy (Hmelo-Silver & Cindy, 2004). By investigating the subject matter through hands-on activities, students learn both content and thinking strategies. Hands-on activities support problem-based approaches to learning by focusing on the experience and process of investigating, proposing and creating solutions. As a result, students learn how to gather information and solve problems. Teachers are expected to diversify their teaching strategies to create conducive learning environment that promote effective teaching and learning. The benefits for educators are also numerous. For example, professional development workshops that stress hands-on learning are significantly more successful in improving teacher confidence in math and science instruction (Basista and Mathews, 2002). Hands-on activities help teachers cut the time needed for remediation, improve classroom management by unifying students around a common organized activity, and foster a greater interpersonal and supportive emotional connection with students through sharing the process of learning with them (rather than one-way lecturing).

Hands-on teaching is an extremely effective strategy for increasing performance and depth of knowledge and supports the 21st century skills that target learning and innovation abilities (the 4Cs): communication, creativity, collaboration, and critical thinking (Partnership for 21st Century Skills). Well-designed hands-on activities focus learners on the world around them, spark their curiosity, and guide them through engaging experiences all while achieving expected learning outcomes (RAFT, 2013).

2.5 Concept of Critical Thinking (CT)

According to Paul and Elder (2009) they define critical thinking in the following way, "A well-cultivated critical thinker raises vital questions and problems, formulating them clearly and precisely gathers and assesses relevant information, using abstract ideas to interpret it effectively comes to well-reasoned conclusions and solutions, testing them against relevant criteria and standards thinks open-mindedly within alternative systems of thought, recognizing and assessing as need be, their assumptions, implications, and practical consequences, and communicates effectively with others in figuring out solutions to complex problems". According to a definition analysis by Kompf and Bond (2001), critical thinking involves problem solving, decision making, metacognition, rationality, rational thinking, reasoning, knowledge, intelligence and also a moral component such as reflective thinking. Critical thinkers therefore need to have reached a level of maturity in their development, possess a certain attitude as well as a set of taught skills. Thus, Critical thinking may be a key organizing concept for all educational reform (Bulach, Lunenburg, & Potter, 2012).

Critical thinking involves the formation of logical inference (Cottrell, 2011). Some scholars and educators erroneously assume critical thinking to be higher order thinking (Brookhart, 2010). According to Paul and Elder (2003), critical thinking is best understood as the ability of thinkers to take charge of their own thinking based on sound criteria and standards. Leicester (2010) refers to critical thinking as the active, purposeful, and organized effort to make sense of our world by carefully examining our thinking, and the thinking of others, in order to clarify and improve our understanding. According to Cottrell (2011), critical thinking involves solving problems, formulating inferences, calculating likelihoods, and making decisions.

2.5.1 Studies on Critical Thinking and Performance

The Association of American Colleges and Universities, Standards for Accreditation of Medical Education Program, Accreditation Council for Pharmacy Standards and Guidelines for the Professional Program in Pharmacy, American Dental Education Association, and many more organizations list critical thinking as a major intellectual and practical skill, particularly in the area of health science education (Rowles, Morgan, Burns, & Merchant, 2013). This major intellectual and practical skill seems to be a skill that the majority of students coming into higher education and the workforce are not only lacking in function, but also in understanding what the concept is (Rowles, Morgan, Burns & Marchant, 2013; Choy & Cheah, 2009; Henderson Hurley & Hurley, 2013). Oftentimes, critical thinking is something that has been overlooked at the elementary, middle, and high school levels where students are taught how to learn, as well as how to analyze information. When these students make it to the level of higher education or the workforce, the educators and trainers are forced to begin by teaching critical thinking skills as opposed to beginning with the information that needs to be conveyed. Halx and Reybold (2005) determined, after much review and research, that learning requires effort, but critical thinking requires maximum exertion of intellectual capability and that students and teachers alike find critical thinking discomforting because it requires personal reflection. For this reason and the lack of time available to K-12 /Secondary educators, much critical thinking has been left for higher education to teach and utilize.

It can be argued that critical thinking skill (CTS) and reasoning skill as some authors call it, is a purposeful, self-regulatory judgment which results in analysis, evaluation, deduction, induction as well as explanation of evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based (APA, 1990). Critical thinking skills can be set apart from problem solving (McWhorter, 2010) in that problem solving is a linear process of evaluation, allowing the inquirer to properly facilitate each stage of the linear problem solving process. According to Black and Parks (2006), CTS is an active, purposeful and organized effort to make sense of our world by carefully examining thinking, and the thinking of others, in order to clarify and improve our understanding. Brookhart (2010) argues that CTS is thinking that is purposeful, reasoned and goal directed. It is the kind of thinking involved in solving problems, formulating induction, calculating likelihoods, and making decisions.

Brookfield (2011) maintains that it is a way of reasoning that demands an adequate support for one's beliefs and a willingness to be persuaded unless support is forthcoming. David (2011) defines it as a reasonable, reflective thinking that fuses analysing arguments and generating insights into particular meanings and interrelation. On the other hand, content specialists are of the view that CTS involve analytical thinking for evaluating what we read (David, 2011).

Recently, Brookhart (2010) and Lavery, Hughes, & Doran (2009) attempted to define CTS as a conscious and deliberate process, used to interpret or evaluate information or experiences with a set of reflective attitudes and abilities that guide thoughtful experiences with a set of reflective attitudes and abilities that steer thoughtful beliefs and actions.

Critical thinking skills are a process that supports belief and action. Fisher (2001) asserted that CTS depend on belief in its value and attitudes towards it. CTS can facilitate reasoning and understanding of past, present, and future events (Brookfield, 2006). It is goal directed, purposeful, abstract, logical, rational, and evaluative; it is also moral thinking and justification of ideas and knowledge (Daly, 1998). CTS are central to reflective thinking, and it is a principled process employing the cognitive skills of analysis, evaluation, deduction and induction.

a) **Analysis:** Determine significance, interpret meaning, and detect possible inferential relationships.

b) **Evaluation:** Testing the efficiency and validity of a statement and the strength of argument and solutions.

c) **Deduction:** Reasoning is one in which it is claimed that it is impossible for the premises to be true but the conclusion false. Thus, the conclusion follows necessarily from the premises and inferences. In this way, it is supposed to be a definitive proof of the truth of the claimed conclusion.

d) **Induction:** Reasoning is one in which the premises support the conclusion in such a way that if the premises are true, it is improbable that the conclusion would be false. Thus, the conclusion follows probably from the premises and inferences.

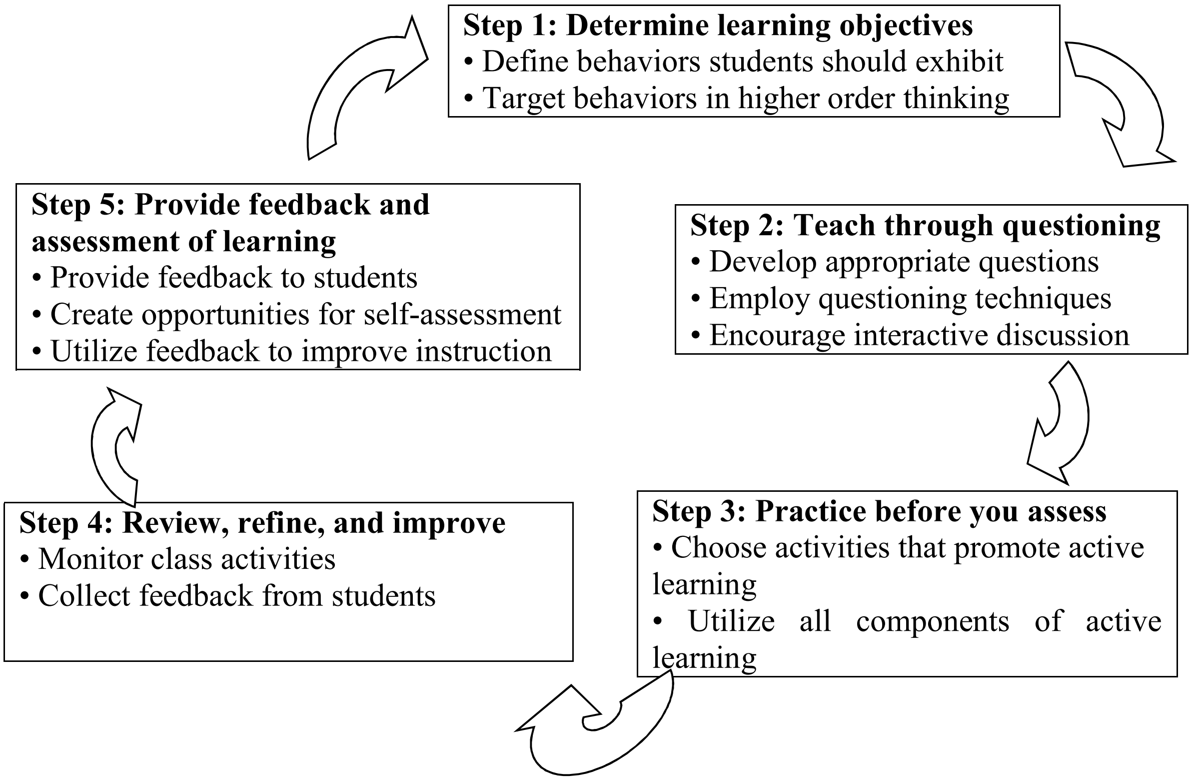
In order to be successful in inculcating and developing CTS, it was argued that a significant mechanism is demanded, that the public at large must acknowledge CTS as essential to the education of today's learner and dependent on the several definitions above. The researchers believe that critical thinking is a complex process, and it is generally higher order thinking or cognitive processing. A critical thinker is able to solve problems, make decisions, evaluating information and formulating inferences. This means that CTS involve the ability to use our mind to achieve our goals (Nazem, Abu-Hayati & Talib, 2013).

Therefore, it is an established fact that in deductive reasoning, the conclusion is certain while in induction, the inference is probable. The deduction reasoning is logical while the induction statements are based more on observation. In induction, the inference may be true even if some of the evidence is false. However, in a deduction, if the evidence is false, it will lead to a false inference. The difference between deduction and induction is mostly in the way the arguments are expressed. Any induction can also be expressed deductively, and any deduction can also be expressed inductively.

The theory of critical thinking began primarily with the works of Bloom (1956), who identified six levels within the cognitive domain, each of which related to a different level of cognitive ability. Knowledge focused on remembering and reciting information. Comprehension focused on relating and organizing previously learned information. Application focused on applying information according to a rule or principle in a specific situation. Analysis was defined as critical thinking focused on parts and their functionality in the whole. Synthesis was defined as critical thinking focused on putting parts together to form a new and original whole. Evaluation was defined as critical thinking focused upon valuing and making judgments based upon information. In this regard, critical thinking is deemed to take place when students are required to perform in the Analysis, Synthesis, and Evaluation levels of Bloom's taxonomy.

To provide the greatest benefit to students, teachers should provide many opportunities for students to engage in the upper levels of Bloom's taxonomy where critical thinking takes place. While most teachers believe that developing critical thinking in their students is of primary importance (Albrecht & Sack, 2000), few have an idea exactly what it is, how it should be taught, or how it should be assessed (Paul, Elder, & Batell, 1997). The following model (Figure 2.1) is a 5-step framework that can be implemented in any classroom or training setting to help students gain critical thinking skills.

Figure 2.1: 5-Step Model to develop/move Students toward Critical Thinking



5-Step Model to move Students toward Critical Thinking (Duron et al., 2006)

Step 1: Determine learning objectives. Considering the importance of a course, its placement in a program of study, and its role in providing a base of knowledge to be built upon by other courses, a teacher should first identify the key learning objectives that define what behaviors students should exhibit when they exit the class. To make critical thinking happen, these learning objectives, as well as the activities and assessments, must include those tied to the higher levels of Bloom's (1956) taxonomy.

A well-written objective should include a behavior that is appropriate for the chosen level of the taxonomy. Bloom's Knowledge level requires an answer that demonstrates simple recall of facts. Questions at this level could ask students to answer who and what and to describe, state, and list.

Comprehension requires an answer that demonstrates an understanding of the information. Questions at this level might ask students to summarize, explain, paraphrase, compare, and contrast. Application requires an answer that demonstrates an ability to use information, concepts and theories in new situations. Questions at this level may ask students to apply, construct, solve, discover, and show. Analysis requires an answer that demonstrates an ability to see patterns and classify information, concepts, and theories into component parts. Questions at this level could ask students to examine, classify, categorize, differentiate, and analyze. Synthesis requires an answer that demonstrates an ability to relate knowledge from several areas to create new or original work. Questions at this level might ask students to combine, construct, create, role-play, and suppose. Finally, Evaluation requires an answer that demonstrates ability to judge evidence based on reasoned argument. Questions at this level may ask students to assess, criticize, recommend, predict, and evaluate (Duron, Libach & Waugh, 2006).

Step 2: Teach through questioning. Questioning is a vital part of the teaching and learning process. It allows the teacher to establish what is already known and then to extend beyond that to develop new ideas and understandings. Questions can be used to stimulate interaction between teacher and learner and to challenge the learner to defend his or her position, (that is, to think critically). Clasen and Bonk (1990) posited that although there are many strategies that can impact student thinking, it is teacher questions that have the greatest impact. He went on to indicate that the level of student thinking is directly proportional to the level of questions asked. When teachers plan, they must consider the purpose of each question and then develop the appropriate level and type of question to accomplish the purpose. All students need experience with higher level questioning once they become familiar with a concept. Thoughtful preparation on the part of the teacher is essential in providing that experience.

Questioning techniques can be used to foster the thinking ability of students. Questions can be categorized in a number of different ways. One simple method is to use the general categories of convergent and divergent questions. Convergent questions seek one or more very specific correct answers, while divergent questions seek a wide variety of correct answers. Convergent questions apply to Bloom's lower levels of Knowledge, Comprehension, and Application and may include questions like “Define nutrition,” “Explain the concept of investing,” and “Solve for the value of X.” Divergent questions apply to Bloom's higher levels of Analysis, Synthesis, and Evaluation; are generally open-ended; and foster student-centered discussion, thereby encouraging critical thinking (Duron, 2006).

Step 3: Practice before you assess. In the past decade, a major shift has taken place in education; that shift is toward active learning. Teachers that have used this approach generally find that the students learn more and that the courses are more enjoyable. In Duron (2006), Bonwell and Eison (1991) described hands-on/active learning as involving the students in activities that cause them to think about what they are doing. Fink (2003) indicated that the concept of hands-on/active learning supports research which shows that students learn more and retain knowledge longer if they acquire it in an active rather than passive manner. To make learning more active, we need to learn how to enhance the overall learning experience by adding some kind of experiential learning (hands-on) and opportunities for reflective dialog.

According to Fink (2003), there are two guiding principles that should be considered when choosing learning activities. First, activities should be chosen from each of the following three components of active learning: Information and Ideas, Experience, and Reflective Dialog. Information and Ideas include primary and secondary sources accessed in class, outside class, or online; Experience includes doing, observing, and simulations; Reflective dialog includes papers, portfolios, and journaling. Second, whenever possible, direct kinds of learning activities should be used. Examples of direct activities include doing in an authentic setting, direct observation of a phenomenon, reflective thinking, service learning, journaling, and dialog in or outside of class.

Step 4: Review, refine, and improve. Teachers should strive to continually refine their subjects/courses to ensure that their instructional techniques are in fact helping students develop critical thinking skills. To accomplish this, teachers should monitor the classroom activities very closely. To track student participation, a teaching diary can be kept that identifies the students that participated, describes the main class activities, and provides an assessment of their success.

Step 5: Provide feedback and assessment of learning. Teacher feedback, like assessment, compares criteria and standards to student performance in an effort to evaluate the quality of work. However, the purpose of feedback is to enhance the quality of student learning and performance, rather than to grade the performance, and, importantly, it has the potential to help students learn how to assess their own performance in the future. Feedback allows the teacher and student(s) to engage in dialogue about what distinguishes successful performance from unsuccessful performance as they discuss criteria and standards (Fink, 2003).

Teachers should provide good feedback to their students through frequent opportunities to practice whatever they are expected to do at assessment time. Teachers should spend ample time helping students to understand what the criteria and standards are and what they mean. Student peers may also provide feedback and evaluation. Each of these techniques help students learn to distinguish between satisfactory and unsatisfactory performance.

Finally, it is important to note the importance of assessment to the 5-step model itself. Information gleaned from student feedback and assessment provides an immediate and significant source of information to the teacher with respect to which objectives were met, the effectiveness of specific learning activities, things to start or stop doing, effectiveness of feedback on standards, and so on.

John (2010) opined that thinking critically means asking questions. Instead of accepting 'at face value' what you read or hear, critical thinkers look for evidence and for good reasons before believing something to be true. This is at the heart of what it means to be a scientist, researcher, scholar or professional in any field. Whatever you are studying, critical thinking is the key to learning and to making progress. Hence, the common question words: what, who, where, when, how, and why will help you to get started; along with the phrases: what if, what next, and so what. Attempting to answer these questions systematically helps fulfil three vital functions for any serious study - description, analysis and evaluation. These are the things you need to do:

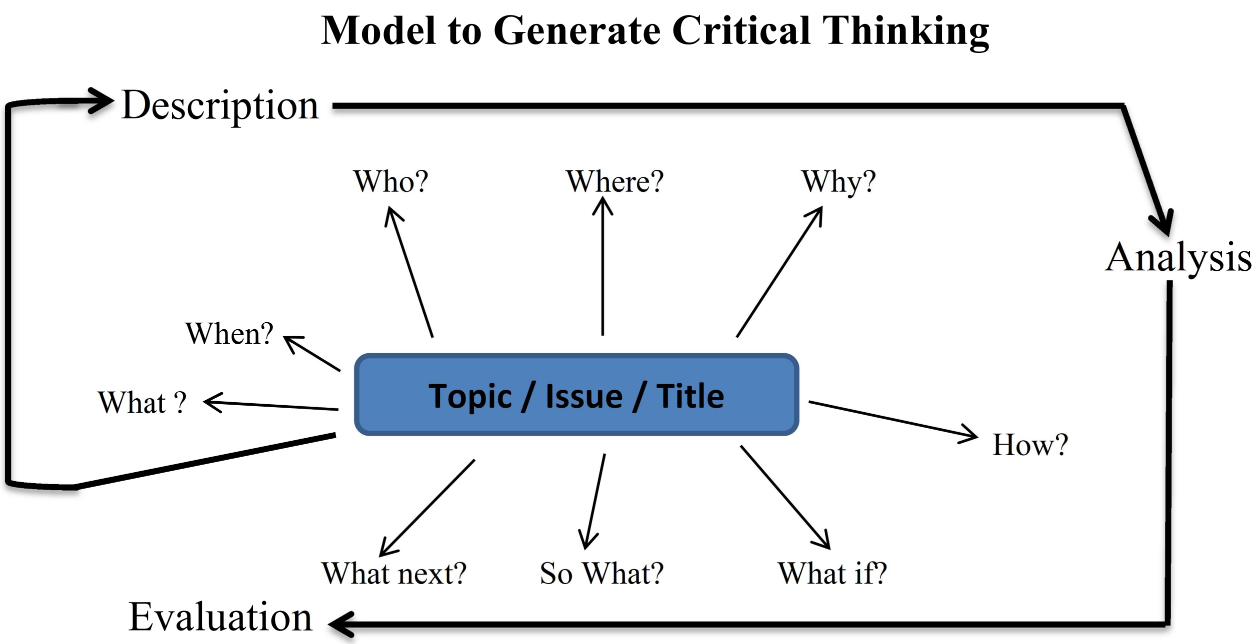
Describe ... for example; to define clearly what you are talking about, say exactly what is involved, where it takes place, or under what circumstances. Fulfilling this function helps you to introduce a topic. More complex description will become analysis.

Analyse ... for example; examine and explain how parts fit into a whole; give reasons; compare and contrast different elements; show your understanding of relationships. In this way analysis forms the main part of any in-depth study.

Evaluate ... for example; judge the success or failure of something, its implications and/ or value. Evaluations lead us to conclusions or recommendations and are usually found at the end of a piece of academic work, a paper, chapter or other text.

To summarise what were discussed so far, the diagram in figure 2.2 shows how asking and answering questions helps to fulfil the three key connected functions of description, analysis and evaluation. This is a reliable basis for introducing, discussing and drawing conclusions about your topic. Beginning with 'what', this systematic questioning will encourage you to consider every aspect of your topic or question.

Figure 2.2:



Source: John Hilsdon (2010), Learning Development Advisor. University of Plymouth.

You should aim to address most, but not necessarily all, of these questions for your topic and subtopics. The crucial questions for almost any topic are: 'what', which identifies the issue; 'why', which explores it in depth, addressing causes and using theory; 'how', which helps you look at the processes at work; and 'so what', which helps you make judgements or conclusions, showing that you have reflected on implications.

The model can be used in a number of ways at different stages of tackling an assignment. Use it before and during your reading; for planning the structure of a whole assignment; and also to structure each point within it.

Model to Generate Critical Thinking

1. Identify a topic. This can be your essay title, a subtopic, or a point you might want to explore in a particular section or paragraph. Write key words in the middle of a sheet of paper, or a blank document screen. This is the 'Topic or Issue' in the diagram above. Or you could do it in a linear way and put these keywords in the place of a title, with the questions that follow spaced out in the margin, or as subheadings.

2. Try to answer the questions on the diagram starting with **'what'** questions. Your answers may become part of an introduction, defining your terms or identifying issues.

3. Using the **'who'**, 'when' and 'where' questions, generate descriptive background information. This will provide context or scene-setting material which is also useful for an introductory section.

4. 'How' requires consideration of the ways that something operates or works – e.g. processes or procedures. Attempting to answer questions using 'how' takes you from descriptive to more analytical work.

5. 'Why' also moves you deeper into analytical territory. It gets you to find reasons, explanations or causes. Think about all the possible questions to do with 'why' (see the model below for some suggestions). Answers to such questions are likely to emerge over time from your reading and use of specific theories and findings reported in academic journals; published books and research reports; or from other authoritative sources such as policy documents.

6. Asking questions using **'what if'** moves you into a more evaluative phase of your thinking. It helps you to consider the possible implications or results of a particular action. This question is also useful for considering predictive work done by others, or engaging in forecasting of your own.

7. ‘So what?’ is really the key question for an evaluation. It gets you thinking about value or values, meaning and significance. It is also about discriminating between more or less important factors in any situation. It helps you to think through and justify your own position, and discuss its implications.

8. ‘What next?’ might refer to recommendations and predictions that your argument has brought to light. It leads you to consider and plan for more specific actions that might be necessary in certain kinds of assignment, such as a project or business report.

Nazem, Abu, Hayati, and Talib (2013) conducted a study to measure the Critical Thinking Skills (CTS) of undergraduate students at Universiti Putra Malaysia based on a pilot study involving 433 students randomly selected. The main purpose of the study was to describe the process in determining the suitability of all the items in the CTS instrument which would be used in the actual study. Four factors of the CTS (Analysis, Evaluation, Deduction and Induction) were tested for their validity and reliability. The CTS knowledge test comprised of 22 multiple-choice questions with two alternatives. All the four factors in the instrument were adapted from (Choi et al., 2007, Goel et al., 1997, & Stanovich and West, 1997). Results from the pilot study have shown that the items to measure CTS have good discriminating quality, validity and reliability.

Research suggests that a more in-depth focus on enhancing critical thinking skills in K-12 (Secondary school) can add academic rigor and increase the scores on the standardized assessments (VanTassel-Baska, Bracken, Feng, & Brown, 2009; McCollister & Sayler, 2010; Snodgrass, 2011; Tsai, Chen, Chang, & Chang, 2013). By utilizing activities to enhance critical thinking, students are better able to understand why something has occurred as opposed to just understanding what has occurred. This deeper understanding allows the students to better analyze the circumstances surrounding the occurrence and differing viewpoints about the occurrence (Tsai, Chen, Chang & Chang, 2013). "In order to engage students in critical thinking, the educator needs to act as a facilitator to allow for discussion and encourage a freer thought process …"

Critical thinking can be infused in lessons throughout all disciplines by utilizing in depth questioning and evaluation of both data and sources (McCollister & Sayler, 2010). Having students track patterns in information forces them to look at the information as a process instead of simply information to be memorized and helps them develop skills of recognition and prediction. Evaluation of information and sources helps students to learn appropriate procedures for finding and utilizing credible information, as well as helping students learn acceptable and appropriate ways to use discretion (McCollister & Sayler, 2010). These are skills that will help with reading comprehension and problem-solving skills, both of which play an important role in standardized assessments (VanTassel-Baska, Bracken, Feng, & Brown, 2009; McCollister & Sayler, 2010; Tsai, Chen, Chang & Chang, 2013).

These types of activities could be worked into the normal instructional time, with little additional time needed, simply by utilizing things such as online discussion boards, in-class discussions, Hands-on strategy or alternative modes of assessment in classroom settings (Snodgrass, 2011). It is also important that any changes to the curriculum be met with training about the new activities and how to utilize them to their full effect. The establishment of professional learning communities allows educators to think critically about the methods they are using to teach, and is a good starting point for ideas about inclusion of critical thinking skills in the classroom (Smith & Szymanski, 2013). Thus, Tsai, Chen, Chang, & Chang (2013) found that enhancing the critical thinking among students in science classes helped the students better understand the scientific process as well as encouraging students to become more experimental and questioning of the different aspects of the sciences. Choy and Cheah (2009) and Rowles, Morgan, Burns, and Merchant (2013) all found that while educators feel they are teaching critical thinking skills, their teaching can be enhanced by having a more standard definition of what critical thinking entails. This definition would allow educators at all grade levels to enhance their current curriculum with activities and lessons that help to develop critical thinking among students and educators.

2.5.2 Educator's Role in Developing Critical Thinking Skills

It is important for educators to understand that the role they playing developing critical thinking is different than the role they are typically playing. In order to engage students in critical thinking, the educator needs to act as a facilitator to allow for discussion and encourage a freer thought process, as well as to encourage understanding that thinking critically does not always end with a right answer, but instead sometimes ends in more questions or differing evaluations of the topic (Halx & Reybold, 2005; Arend, 2009). The educator's role as facilitator also encourages a peer review process, even in the youngest of children, and helps students to learn appropriate responses to conflicting evaluations and opinions (Henderson-Hurley & Hurley, 2013; Tsai, Chen, Chang & Chang, 2013).

Activities such as writing essays, Hands-on activities and utilizing questions that adhere to Bloom's Taxonomy higher order thinking are examples of ways to engage students in critical thinking in the classroom(Smith & Szymanski, 2013). Another option for an activity that helps to enhance critical thinking is the use of wikis in education. This activity can be utilized by having students create a wiki about the subject content they are studying or by having them analyze the information currently available in existing wikis (Snodgrass, 2011). This utilization of wikis, a web 2.0 application, also appeals to education in that it enhances the student's skills in technology, another vital skill for both higher education and the workplace.

It is suggested that this endeavor for more critical thinking is a holistic endeavor, which would require cooperation among different departments, divisions, and classes (Henderson-Hurley & Hurley 2013). The development of critical thinking skills is not only applicable to core subjects such as reading, math, language arts, science, and social studies. Kokkidou (2013) sets forth ways that critical thinking can be developed in music education by examining musical environment, comparing and contrasting different eras or pieces of music, and self-evaluation of performance.

2.5.3 Critical Thinking and its Usage in this Study

Critical thinking is a complex mental process involving paying attention to details, selecting relevant information, analysing carefully and skeptically, making judgments, and metacognitive thinking such as reflection and higher-order planning (Cottrell 2005). It is an essential skill for both academic achievement and for dealing with various real-life problems. Critical thinking, as a generic thinking skill, is emphasized in a variety of content areas of curriculum planning documents across cultures, for example, the US (National Commission of Excellence in Education 1983), Hong Kong (Curriculum Development Council 2007), Singapore (Sale, Leong and Lim 2001), Taiwan and Japan (Li, 2010). Critical-thinking curriculums are relatively more difficult to implement in Asian classrooms because the teachers and students are more accustomed to the passive, transmissive, and knowledge-based model of learning; thus, more clear practice guidelines and more transitional time are needed for Asian learners to practice and acquire this essential skill (Vandermensbrugghe 2004). The trend of moving away from a knowledge-based, examination-driven system to a student-centred, performance-driven system is widely emphasized across cultures, although it may be at different stages in different contexts due to historical and cultural reasons. For example, the United States (US) has a hybrid of examination-driven and performance-driven culture, Canada generally has a performance-driven culture, and Asia predominantly has an examination-driven culture in their educational systems (Hudson 2009). It has been recognized that knowledge, skills and understanding are three essential elements of learning, and the ties among them set guidelines for curriculum designers (Skelton 2002). Important learning abilities and skills (for example, critical thinking, creative thinking, metacognitive ability) have emerged as important educational goals indicated in the curriculum objectives across different educational systems. Constructivist approaches and student-centred approaches are supported by contemporary learning theories. A brief comparison of the educational objectives in the US common core, European framework and Hong Kong curriculum council shows many commonalities and overlap in the educational objectives across the three educational systems. Those educational objectives and standards are demonstrated in the curriculum enactment and pedagogical strategies across different disciplines and also show how those curriculum guidelines are enacted in teaching mathematics, language and science.

Critical thinking has been studied since at least the 1910s, when John Dewey first published his landmark book, How We Think (1910/1933), and it is included in many models of skills that are important for education and workforce success (Trilling & Fadel, 2009), including the P21 Framework for 21st Century Learning as one of the Learning and Innovation Skills (www.P21.org/ Framework). Also known as the “4 Cs,” these skills include critical thinking, creativity, collaboration, and communication. Reasoning, logic, and judgment are all widely understood to be useful cognitive skills, in both schools and the workplace, and as these are important components of critical thinking, it becomes clear why educators have pushed for the inclusion of critical thinking instruction within their classrooms (Wagner, 2008).

Arum and Josipa (2011) argue that a goal of instruction is students learn to solve problems and think critically. Questions arise, such as: What is critical thinking? What are the differences between thinking, creative thinking, and critical thinking? Can critical thinking simply be explained as operating on the higher levels of Bloom's (1956) cognitive taxonomy? Does one determine if a student is able to think critically by self-report, tests, or behavior? What specific student behaviors and classroom instructional strategies lead to thinking critically and what can teachers do in their classrooms to move students towards developing critical thinking skills? Indeed, scholars and practitioners alike have wrestled with questions about the nature of thinking and critical thinking for decades.

Many traditional educators cite Bloom's (1956) cognitive taxonomy (whether it be the original one devised in the 1950's or the more recent adaptation by Anderson and Krathwohl (2001)) as the best way to model and determine critical thinking skills. The three highest levels of operation (analysis, synthesis and evaluation) all involve the ability to think critically. At the analysis level students must determine how to divide something into its component parts and determine how those parts relate with one another. At the synthesis level, students must be able to create something new, given their ability to operate successfully at the four lower levels. Creativity is also cited as evidence of the ability to think critically, but evaluation and the ability to make discerning judgments is most frequently cited as a critical thinking skill.

Moore (2009) defines thinking as "the act of withholding judgment to use knowledge and experience in finding new information, concepts, and/or conclusions," and reinforces Lipman's definition of critical thinking as "the ability to analyze complex situations critically, using standards of objectivity and consistency". Moore (2009) also lists non-thinking behaviors that negatively affect the development of thinking skills in the classroom which include (on the part of the student) impulsiveness, overdependence on the teacher, dogmatism, and inflexibility. On the other end of the scale he lists activities which contribute to critical thinking which include brainstorming, inductive thinking, inference making, problem-solving, analysis, and interpretation.

Paul and Elder (2009) define critical thinking in the following way, "A well-cultivated critical thinker raises vital questions and problems, formulating them clearly and precisely gathers and assesses relevant information, using abstract ideas to interpret it effectively comes to well-reasoned conclusions and solutions, testing them against relevant criteria and standards thinks open-mindedly within alternative systems of thought, recognizing and assessing as need be, their assumptions, implications, and practical consequences, and communicates effectively with others in figuring out solutions to complex problems".

Bean (2011) suggests the Instructor adopt the role of coach, "the teacher presents students with critical thinking problems, gives students supervised practice at addressing them, and coaches their performance by critiquing their solutions, providing helpful intervention and advice, and modeling critical thinking themselves". Bok (2006) said that instructors who do best at teaching critical thinking tend to follow a set of four principles. First, instructors concentrate on what they want their students to learn and not just focus on what material should be covered in the syllabus. This includes delineating what reasoning skills should be mastered in order to handle the problems posed. Second, they think about how to awaken students' curiosity and generate intrinsic interest in the subject. Third, instructors search out, expose, and debunk any misconceptions students bring to the course that may interfere with their thinking, thus opening up new possibilities for transformation and growth. Fourth, they "encourage learners to think for themselves by challenging them with interesting questions and using class discussions, collaborative projects, and other forms of active-learning to develop habits of critical thinking and respect for the power of careful reasoning and analysis".

In this regard, the researcher sees critical thinking as skillful and responsible thinking that is conducive to good judgement because it is sensitive to context, relies on criteria and it is self-correcting. While some experts based on their consensus regarding critical thinking and the ideal thinker say that, "we understand critical thinking to be purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based (Facione and Peter, 2011).

2.5.4 Relationships between Critical and Creative Thinking.

Creative and critical thinking skills are considered essential for students (Crane, 1983; Baker & Rudd, 2001). Crane (1983; Baker &Rudd, 2001) expressed the importance of both of these skills when she wrote: "When reasoning fails, Imagination saves you! When Intuition fails, reason saves you! There has been an abundance of research on each construct but very little examining if they are related. Scriven (1979), Baker and Rudd (2001) stated "Critical skills go hand in hand with creative ones". Only by understanding if there is a relationship between these two essential constructs will educators be able to enhance the capacity of their students to utilize both creative and critical thinking (Baker & Rudd, 2001).

2.6. Hands-on Learning/Active-Learning as a Means for Enhancing Critical Thinking and Performance

Hands-on Learning/Active-Learning does not necessarily imply mental activity. Students can be physically active and/or verbally active in a learning experience, but neither of these actions ensures the student is mentally involved or developing any kind of thinking skill. Hands-on Learning/Active-Learning strategies that teach students to think critically must therefore be the type of activities that are designed to mentally stimulate and engage thinking in a relevant context. Therefore, the question becomes which active-learning strategies lead to the acquisition of critical thinking skills defined above?

Bean (2011) describes many active-learning exercises as strategies that make students more powerful thinkers and better performance. He recommends the use of case studies, role-playing, small group work, and creative activity which stretches thinking skills that can be applied to applicable situations. Bean warns that the goal of the small group work is not to come up with the right answer, rather develop reasonably supported answers that students are asked to defend later in front of the class. According to Browne and Freeman (2000), the strength of the active-learning classroom is that it facilitates personal involvement with the material, thereby provoking students into relevant discussion and evaluation. Burbach, Matkin, and Fritz (2004) found that the active-learning strategies they used (small groups, scenarios, case study, and so on) did improve critical thinking skills as measured by the Watson-Glaser Critical Thinking Appraisal, which assesses decision making ability as well as predicts judgment, problem solving, and creativity.

The concept of critical thinking may be one of the most significant trends in science education relative to the dynamic relationship between how teachers teach and how students learned (Mason, 2010). Critical thinking shifts classroom design from a model that largely ignores thinking to one that renders it pervasive and necessary (Cohen, 2010; Tittle, 2010; Vaughn, 2009). Critical teaching views content as something alive only in minds, as modes of thinking driven by questions, as existing in textbooks only to be regenerated in the minds of students. Once we understand content as inseparable from the thinking that generates, organizes, analyzes, synthesizes, evaluates, and transforms it, we recognize that content cannot in principle ever be "completed" because thinking is never completed. To understand content, therefore, is to understand its implications. But to understand its implications one must understand that those implications in turn have further implications, and hence must be explored thoughtfully. The problem with didactic teaching is that content is inadvertently treated as static, as virtually "dead". Content is treated as something to be mimicked, to be repeated back, to be parroted. And since students only rarely process content deeply when they play the role of passive listeners in lecture-centered instruction, little is learned in the long term. Furthermore, because students are taught content in a way that renders them unlikely to think it through, their minds retreat into rote memorization, abandoning any attempt to grasp the logic of what they are committing to memory. Those who teach critically emphasize that only those who can "think" through content truly learn it (Numrich, 2010). Content "dies" when one tries to mechanically learn it. Content has to take root in the thinking of students and, when properly learned, transforms the way they think. Hence, when students study a subject in a "critical" way, they take possession of a new mode to thinking which, so internalized, generates new thoughts, understandings, and beliefs. Their thinking, now driven by a set of new questions, becomes an instrument of insight and a new point of view. History texts become, in the minds of students thinking critically, a stimulus to historical thinking. Geography texts are internalized as geographical thinking. Mathematical content is transformed into mathematical thinking. As a result of being taught to think critically, students study biology and become biological thinkers. They study sociology and begin to notice the permissions, injunctions, and taboos of the groups in which they participate. They study literature and begin to notice the way in which all humans tend to define their lives in the stories they tell. They study economics and begin to notice how much of their behavior is intertwined with economic forces and needs.

There are ways, indeed almost an unlimited number, to stimulate critical thinking at every educational level and in every teaching setting (Dunn, 2010; hooks, 2009; Liecester, 2010). When considering technology for this stimulation, the World Wide Web (WWW) is important to instructional design; it contains three keys to educational value: hypertext, the delivery of multimedia, and true interactivity (Stewart, 2010). These values are operant and alive in the classroom through such applications as: graphics, sound, and video which bring to life world events, museum tours, library visits, world visits, and up-to-date weather maps (Griffin, 2010).

2.6.1 Hands-on Learning on Academic Performance and Gender

The classroom and instructional methods, as environmental factors have a significant role in the dynamics of learning. Gender studies in the last 25 years have sought to identify what role gender has on the learning of, involvement in, and success in science and science related fields, especially in females (Kahle & Meece, 2004). Though in the last 20years, programs have focused on encouraging women to participate in the sciences, the end result is still yielding limited involvement by females (Fuselier & Jackson, 2010). In light of science education, studies have observed different male and female behavior starting in early education years (Osborne et al., 2003). Many countries are experiencing a growing gender gap in students entering science and technology fields (Sjoberg, 2001). Science in general and biology or life science in particular is expected to be humanistic and not gender-biased in nature (Ochonogor, 2006). This implies that irrespective of natural gender differentiation, all learners (old or young) in any given science class are expected to be taught in a common learning environment, using non-stereotyped pedagogical approaches, contents and activities. With such foundation for all recipients of science knowledge contents, their performances can, therefore, be evaluated and analyzed on a common platform.

Academic performance in students' learning has been a matter of concern in the present day research. Busari (2000) in Ogundokun and Adeyemo (2010) defined academic performance as the display of knowledge attained or skills developed by students in the school subject. It is the level of performance in the subject as exhibited by an individual. Thus, Academic performance is the exhibition of knowledge attain or skills developed by learners in the school subject usually designed by test scores or by marks assigned by teachers which can be low or high.

In agreement with the ongoing discussion, Poopola, (2010) ascertained that, academic performance is an expression used to present student scholastic standing and which is a function of a various factors such as method of teaching, teachers qualifications, child's home background, school environment, attitude, interest among others.

Several researches conducted by scholars on the effect of academic performance on gender in science education showed significant differences between boys and girls (Mari, 1994; Bichi, 2002; Usman, 2007, and Obeka, 2009) while others opined no difference between gender and academic performance (Haruna, 2000 & Usman, 2010). Alpha (2007), in his research on Gender disparity on performance in mathematics of senior secondary school, opined that performance of boys is higher than that of girls. In support of this, Usman (2007) in his work "relationship between Students performance and their academic achievement in Biology using NISTEP mode of teaching revealed that senior secondary male biology students perform well in any rigorous work than their female counterparts.

Nuruddeen, (2013) findings from research studies, which have demonstrated differences due to gender in various academic achievements, have become popular and generally accepted by scholars. Isotuok, averred that females tend to score higher on verbal test and always do better on coding tests, which call for short memory, speed and draftiness. The males on the other hand, invariably achieved higher score on arithmetic, although there is no enough evidence that males and females differ in average intelligence, the constitutions of intelligence, in the two sexes are far from similar.

Oloyede, (2011) in his findings showed that there was no significant difference between the achievements of male and female chemistry students taught with pictorial and written organizers. The non-significant difference in the achievement of male and female chemistry students agreed with the findings of Nsofor, (2001) who reported that both male and female could do well in science if exposed to similar learning conditions. Bacchus, (2004) in his analysis of the two genders believe that womens' tendencies are toward the emotional and psyche, whereas mans' tendencies are towards intellectualism and materialism.

Nuruddeen, (2013) averred that many scholars have carried out research on gender and reported out varying result for example, Ohikpe, (2000), Umo, (2001) and Anyanwu, (1995) reported that gender was a major factor that determined achievement, whereas Asogwa and Nwarogwu (2010), Uzoegwu, (2004) Okoll (1995) and Preston, found otherwise. In a similar vein Obeka, (2009) conducted a research on EOODEWALAD and Power Simulation Games on Geographical and Environmental Education. His findings, among others, revealed that gender was a significant factor in students' achievement in environmental education concepts of Geography with male students perform than their female counterparts.

The work of Maikano, (2007) revealed that there is no significant difference in the academic performances of male and female students taught ecological concepts using the outdoor laboratory instructional strategy. Mari, (2010) supports this assertion in his study on entry qualification and performance. The result showed that male and female students admitted with the same entry qualification have no difference in their performance. Also, Usman (2010) opined that teaching methods (outdoor and indoor) enhances academic achievement of students in integrated science concepts inspite of their gender. In this study, an attempt is made to determine if academic performance in genetic concepts of biology is gender sensitive. Data obtained from students' academic performance pre-test and posttest of Biology Performance Test (BPT) were used, activity based/grouped based on gender and analyze using t-test to determine if there is difference in gender academic performance.

2.7 Overview of Similar Studies/Related Literature

The relevance of Hands-on Learning Strategy and Critical Thinking in science education has attracted multidimensional researches to be carried out by various educators. The following are some research studies carried out in Nigeria and elsewhere in the world, which are directly or indirectly related to this study.

Randler and Hulde (2007) studied on the effect of hands-on programme on student's achievement about soil ecology. A population of 123 fifth and sixth grade students contributed in the study. Result indicated that students in the hands-on group demonstrated higher achievement than students in traditional textbook based programs. Similarly, Taraban, Box, Myers, Pollard and Bowen (2007) studied with 408 students from high schools who investigated the effect of a hands-on inquiry laboratory programme on students' biology achievement. The results revealed that use of hands-on inquiry laboratory gave an advantage to students to become more active learner, to enhance content knowledge and to develop science process skills. The present study therefore unlike Randler and Hulde (2007) was carried out to examine the Effect of Hands-on

Learning Strategy on Performance and Critical Thinking in Ecology among senior Secondary School Students in Zaria Education Zone, Nigeria.

Margareta, Mojca, and Nataša (2008) investigated the impact of the hands-on approach to visible spectrometry on students' academic performance and its correlation with students' motivational orientations was envisaged as one of the important outcomes of the Leonardo da Vinci project "Hands-on Approch to Analytical Chemistry for Vocational Schools II", LLP-LDV-TOI-2008-SI-15. Altogether, 295 students from Slovenia and Poland took part in the study. While for 104 students from the UK only results of the motivation questionnaire were obtained. The average age of the participating students was 18.2 years – altogether 59% females and 41% males. In order to identify the number of clusters in the data set based on the motivational dimensions defined by controlled and autonomous motivation, k-means clustering was used. The results revealed two distinct motivational orientations; that is, profiles): cluster I– low quantity motivation group (with low autonomous and controlled motivation) and cluster II – good quality motivation group with high autonomous and low controlled motivation. Students' cluster membership is reflected in their academic achievements and their attitudes towards the hands-on approach. Students from the good quality motivational group achieved higher scores at the post-test and they expressed more positive attitudes towards the hands-on approach than students from the low quantity motivational group. Apart from students' motivational orientation, the study program also contributes to the students' academic achievements. Students enrolled in the chemistry technician program with a solid chemistry background achieved the highest scores at the pre-test and post-test respectively. The study also revealed that the hands-on approach supports not only the achievement of better understanding of the concepts taught, but also the capability to apply knowledge in a new situation, and data analysis. The present study unlike Margareta, Mojca, Nataša (2008) was carried out to investigate the Effect of Hands-on Learning Strategy on Performance and Critical Thinking in Ecology among senior Secondary School Students in Zaria Education Zone, Nigeria.

Nina, Dietmar and Susanne (2010) investigated the influence of hands-on activities on students' interest. This is to find out whether students with experience in specific hands-on activities show higher interest in these activities than students without experience. Furthermore, the relationship between the quality of the hands-on experience and interest in the respective activity was examined. In total, 28 typical hands-on activities of biology education were considered. The activities were divided into the categories experimentation, dissection work with microscopes, and classification. A total of 141 students from the 11th grade completed questionnaires on interest in the hands-on activities, their experience with each activity, and the quality of the respective experience. Students' interest in experimenting, working with microscopes, dissecting and classifying tends to benefit from performing hands-on activities. However, findings indicated that the performance of various hands-on activities can influence students' interest differently. For seven hands-on activities, it was identified that a positive effect of hands-on experience on interest exist, while in one case, practical work appeared to have influenced students' interest negatively. However, for most hands-on activities, no effect of experience on interest was found. The quality of hands-on experiences showed positive correlations with interest in the respective hands-on activities. Therefore, it was argues in favour of designing biology lessons that allow for experiences with hands-on activities that also interest students. The present study unlike Nina, Dietmar and Susanne (2010) was carried out to determine the Effect of Hands-on Learning Strategy on Performance and Critical Thinking in Ecology among senior Secondary School Students in Zaria Education Zone, Nigeria.

Ateş and Eryilmaz (2011) investigated the effectiveness of hands-on and minds-on activities on ninth grade students' achievement in and attitudes towards simple electric circuits. Quasi-experimental design was adopted for this study. The study was conducted with 130 students, 70 of which were assigned as experimental group and instructed by hands-on/minds-on activities, while the 60 were assigned as control group and instructed by the traditional method. Three instruments (measuring tools) were used for the study; the Physics Achievement Test, Physics Attitude Scale, and observation checklist. When the data were analyzed by using multivariate analysis of covariance (MANCOVA), the results indicated that there was a significant difference between the means of the students' physics achievement in favor of the experimental group. However, the analyses failed to show any significant differences between the means of the students' attitudes towards simple electric circuits. The results of this study are important especially for developing countries that cannot use expensive materials to make students physically active. The present study unlike Ateş and Eryilmaz (2011) was carried out to determine the Effect of Hands-on Learning Strategy on Performance and Critical Thinking in Ecology among senior Secondary School Students in Zaria Education Zone, Nigeria.

Ozlem and Jale (2011) conducted a research in Turkey on the effectiveness of hands-on activity enriched instruction on sixth grade students' achievement and attitudes toward science. The design of the research was Multivariate Analyses of Covariance (MANCOVA). Two instruments; Science Achievement Test and Science Attitude Scale were used to assess students' achievement on sense organs and students' attitudes toward science respectively. Two teachers with four classes and total population of 140 sixth grade students were participated in the study. One class of each teacher was assigned as experimental group and treated with hands-on activity enriched instruction and other class was assigned as control group and treated with traditional instruction.

The Science Achievement Test and the Science Attitude Scale were administered twice as pre-test and after three weeks of treatment a post-test was administered to both experimental and control groups to measure students' achievement and attitudes. Multivariate Analyses of Covariance (MANCOVA) results revealed that hands-on activity enriched instruction were more effective than traditional instruction. This means that, the findings showed that the experimental group performed significantly better in the achievement test, than the control group. Based on the findings, the study strongly recommended the use of Hands-on instructional Strategy by secondary school teachers in teaching biology. However, the study was similar to the present as both involved the use of hands-on learning strategy on performance. The present study investigated the Effect of Hands-on Learning Strategy on Performance and Critical Thinking in Ecology among senior Secondary School Students in Zaria Education Zone, Nigeria.

Salvador, Debra, Janette and Peter (2011) examined on a study which compared student perceptions of critical thinking practice in four types of courses offered at an English immersion liberal arts university in Japan. Students were provided with an on-line survey containing 80 items describing critical thinking practices in interpretation, analysis, evaluation, inference, explanation, and self-regulation. Upper-class students (N=62) identified third and fourth year content courses taught in English by a single instructor as the type of course in which critical thinking practice was significantly more prevalent compared to both English and Japanese language courses taught by a single instructor, as well as to 1st/2nd year team-taught content courses taught in English. First year students (N=48) identified single instructor English language courses as the type of course for which they perceived critical thinking practice to be most prevalent. These results are discussed in the context of future assessment of critical thinking practice by type of course as well as by individual instructor. In this regard, the present study unlike Salvador, Debra, Janette and

Peter (2011) was carried out to investigate the Effect of Hands-on Learning Strategy on Performance and Critical Thinking in Ecology among senior Secondary School Students in Zaria Education Zone, Nigeria.

Munir and Mumtaz (2013) examined the Impact of Hands-on Activities on Students' Achievement in Science: An Experimental Evidence from Pakistan. The study aimed to investigate the effectiveness of hands-on activities on 8 grade students' achievement in science. The study was conducted on 342 students (145male, 197 female) of which 169 were assigned as experimental group and instructed by hands-on activities, while the 173 were assigned as control group and instructed by the traditional method. For the study, Science Achievement test was used to collect the data. The data were analyzed by using Independent Sample t-test through SPSS. The results indicated that there was a significant difference between the means of the students' science achievement in favour of the experimental group. The results of this study are important especially for developing countries that cannot afford to use expensive science equipments to make the students physically active and engaged in learning science. In this regard, the present study unlike Munir and Mumtaz (2013) was carried out to investigate the Effect of Hands-on Learning Strategy on Performance and Critical Thinking in Ecology among senior Secondary School Students in Zaria Education Zone, Nigeria.

Nelson (2013) investigated the Impact of Critical thinking on Performance in Mathematics among Senior Secondary School Students in Lagos State. The study would benefit students and teachers by promoting creativity in solving mathematical problems. Quasi-experimental design was adopted for the study. Multi-stage sampling was applied to generate a sample of 195 students for the study. Mathematics performance test and Watson-glaser Critical Thinking Appraisal were used for the study. Three hypotheses were formulated and tested using Analysis of covariance

(ANCOVA). The study revealed that there was a significant difference in Mathematics performance test scores among the experimental groups. The study also found out that there was no significance gender difference in Mathematics performance test. Critical Thinking Skills was also an effective means of enhancing students' understanding of Mathematics concepts. It therefore recommended that in teaching Mathematics in secondary schools, Critical thinking skills should be infused in the curriculum of teacher education so as to improve students' performance in Mathematics. The present study unlike Nelson (2013) was carried out to examine the Effect of Hands-on Learning Strategy on Performance and Critical Thinking in Ecology among senior Secondary School Students in Zaria Education Zone, Nigeria.

Ishola (2014) investigated Hands-on/Minds-on Activity-Based strategy: The effect on Pre-Service Teachers subject matter knowledge in Primary Mathematics Methods Course. The research findings of this study have shown that this strategy is not adopted in training pre-service primary mathematics teachers in colleges of education in Nigeria rather, direct instruction is commonly used. Past studies on activity-based have focused more on the effectiveness of such strategies on pupils/students' performance but did not sufficiently determine the effect of the strategy on the teachers' subject matter knowledge (SMK), hence this study. Pretest-posttest control group quasi-experimental research design was adopted and the participants were 215 pre-service primary Mathematics teachers in two colleges of education in Southwestern Nigeria. Primary Mathematics Achievement Test (0.81) and two instructional guides were the research instruments used. Hands-on/Mind-on activity-based strategy enhanced pre-service primary mathematics teachers' subject matter knowledge more than the conventional strategy. This study has shown the instructional strategy that can be used to develop the capacity of pre-service primary mathematics teachers in the area of subject matter knowledge in a way to ensure sustainable effective mathematics learning. It was recommended that lecturers of primary school mathematics methodology courses in the colleges of education should be encouraged to acquire and utilize hands-on/mind-on activity-based strategy. The present study unlike Ishola (2014) was carried out to examine the Effect of Hands-on Learning Strategy on Performance and Critical Thinking in Ecology among senior Secondary School Students in Zaria Education Zone, Nigeria.

Anabelie, Annaliza Samsia, and Manis (2015) carried out a research on Developing Critical Thinking through Activity-Based and Cooperative Learning Approach in Teaching High School Chemistry. The study aimed to develop critical thinking in chemistry using the Third International Mathematics and Science Survey Questionnaire (TIMSS-Like Test Items) and to lessen or eradicate misconception of students in the scientific concepts. A total of 99 third year Muslim students were selected and grouped into experimental and control group based on their respective section assignment. The experimental group underwent treatment using activity-based learning in a cooperative learning environment, while the control group used only the chalk and board discussions without hands-on. Three (3) instruments were used namely: activities lifted from the TIMSS-R manual, the TIMSS-Like test items, and the self-assessment questionnaire. Both groups were exposed to pre-test and post-test after the conduct of the study. Findings revealed that the experimental group performed better than the control group. Majority of the students in the experimental group realized that the treatment motivated them to think critically. Through hands-on, their misconceptions was corrected and lessened. Moreover, they also realized that the activity-based technique in the teaching-learning process is interesting, more fun and encouraging. The present study unlike Anabelie, Annaliza Samsia, and Manis (2015) was carried out to determine the Effect of Hands-on Learning Strategy on Performance and Critical Thinking in Ecology among senior Secondary School Students in Zaria Education Zone, Nigeria.

Cecilia, Ekon and Dorthy (2015) investigated the impact of Hands-on-approach on the students' academic performance in Basic Science and Mathematics based on the students' opinion about this activity-based methodology. The general objective was to assess the impact and provide another platform for students to display their understanding of what they have learnt other than the usual written tests with memorized formulae. The activity focused on Mensuration and Geometry (with 25% questions in each area) and separation of mixtures (pure and impure substances). This paper includes the analysis of the feedback of the pre-test and post-test scores of the students before and after the Hands-on-approach was given as well as students' interview responses. The study showed positive improvement on both the students' performance and participation on mathematics and basic science activities and willingness on the part of the teachers to use Hands-on-approach in communicating mathematical and scientific concepts to their students. The present study unlike Cecilia, Ekon and Dorthy (2015) was carried out to examine the Effect of Hands-on Learning Strategy on Performance and Critical Thinking in Ecology among senior Secondary School Students in Zaria Education Zone, Nigeria.

Jacob, Sababa, and Filgona (2016) investigated the Effect of Hands-On Learning Strategies on Senior Secondary School Students' Academic Achievement in Topographical Map Studies in Ganye Educational Zone, Adamawa State, Nigeria. Four null hypotheses were raised to guide the study. The research design employed was the quasi-experimental non-equivalent pre-test, post-test control group design. The sample size for the study was 263 senior secondary school (SS II) geography students from six intact classes in public senior secondary schools in three Local Government Areas of Ganye Educational Zone. A 40-item Topographic Map Achievement Test (TMAT) constructed by the researcher but structured in line with WAEC/NECO standardized test items in practical geography was used to obtain data. The instrument was validated by two experts from Geography Education and Test and Measurement. A reliability index of 0.80 was obtained using Guttmann's Split half statistic. One Way Analysis of Variance (ANOVA) was used to test hypotheses one and two; and Tukey's Honestly Significant Difference (HSD) Post Hoc Mean Comparisons Test was used to establish the effect size. The independent samples t-Test statistic was used to test hypotheses three and four. The findings from this study revealed that: there was a statistically significant difference in the mean scores of students taught topographical maps using hands-on learning strategy alone, conventional method alone and hands-on learning strategy combined with conventional method in senior secondary schools of Ganye Educational Zone, Adamawa State ($F (2, 260) = 52.105, p < 0.05$). There was a significant difference in the retention scores of students taught topographical maps using hands-on learning strategy alone, conventional method alone and hands-on learning strategy combined with conventional method ($F (2, 260) = 48.477, p < 0.05$). There was no statistically significant difference in the mean scores of male and female students taught topographic maps using hands-on learning strategy ($t = 0.880$, $df = 95$, $p > 0.05$). There was no significant difference in the mean scores of male and female students taught topographic maps using hands-on learning strategy combined with conventional method ($t = 0.544$, $df = 83$, $p > 0.05$). Based on the findings of this study, it was recommended that geography teachers should endeavour to use hands-on learning strategy as an alternative strategy or incorporate this instructional technique with other teaching methods in order to improve the teaching and learning of topographical maps in senior secondary schools. The present study unlike Jacob, Sababa, and Filgona (2016) was carried out to examine the Effect of Hands-on Learning Strategy on Performance and Critical Thinking in Ecology among senior Secondary School Students in Zaria Education Zone, Nigeria.

Jacob, Joel and, Linus (2016) investigated the Effect of Hands-On Learning Strategy on Senior Secondary School Students' Achievement in Topographical Map Studies in Mayo Belwa Local Government Area, Sokoto State, Nigeria. Four null hypotheses were formulated to guide the study. The study adopted a quasi-experimental non-equivalent pre-test, post-test control group design comprising two groups made up of one experimental group and a control group. Four schools and two hundred and five (205) SS III Geography students made up the sample size of the study. Four intact classes (two each) were randomly selected through balloting without replacement and assigned to experimental and control groups. The instrument used for data collection in this study was Topographical Map Achievement Test (TMAT), constructed by the researcher but structured in line with WAEC and NECO standardized test items in practical Geography. The validity of this instrument was established by two experts in Geography Education and Test and Measurement. The reliability of the instrument was established using Kendall t**au** statistic. A reliability index of 0.78 was obtained. Hypotheses one, two and three were tested using independent samples t-test statistic. While hypothesis four was tested using Analysis of Covariance (ANCOVA). The findings of the study revealed that there was a statistically significant difference in the mean scores of students taught topographical maps using hands-on learning strategy and lecture method. There was a statistically significant difference in the retention scores of students taught topographical maps using hands-on learning strategy and lecture method. There was no significant effect of gender on the achievement of students taught topographical maps using hands-on learning strategy. There was no significant interaction effect of treatment and gender on students' achievement in topographical map studies Based on the findings of this study, it was recommended that geography teachers should use hands-on learning strategy as an alternative strategy or incorporate this strategy with other instructional methods in order to promote effective teaching learning outcomes of students in topographical map studies. The present study unlike Jacob, Joel and, Linus (2016) was carried out to examine the Effect of Hands-on Learning Strategy on Performance and Critical Thinking in Ecology among senior Secondary School Students in Zaria Education Zone, Nigeria.

Elizabeth, Linus, and Jacob (2017) investigated the Effect of Hands-On Teaching Strategy on Students' Academic Achievement in Keyboarding Skills Acquisition in Federal Polytechnic, Mubi, Adamawa State, Nigeria. Three hypotheses were formulated and tested in the study. The research design adopted was the quasi-experimental non-equivalent pre-test, post-test, control group design. The sample comprised of 120 ND I students purposively selected from the department of Office Technology and Management, Federal Polytechnic, Mubi. A research instrument titled ''Keyboarding Achievement Test (KAT)'' was constructed by the researcher and used to obtain data. The instrument was validated and pilot tested. The Guttmann statistic was used in calculating the reliability coefficient. This gave a reliability index of 0.72. The independent samples t-test statistic and Analysis of Variance (ANOVA) were used in analyzing data obtained from the study. The Scheffes post hoc test was used to establish the magnitude of significance between the experimental and control groups' mean scores. The study revealed that students exposed to keyboarding skills acquisition through hands-on teaching strategy achieved remarkable results than their counterparts taught using the conventional method. There was no significant effect of gender on academic achievement of students exposed to keyboarding skills acquisition using hands-on teaching strategy with conventional method. It was concluded that hands-on teaching strategy was effective in teaching keyboarding skills; hence teachers should be encouraged to use the strategy in teaching keyboarding from the onset of the ND programme. The present study unlike Elizabeth, Linus, and Jacob (2017) was carried out to examine the Effect of

Hands-on Learning Strategy on Performance and Critical Thinking in Ecology among senior Secondary School Students in Zaria Education Zone, Nigeria.

Emil and Joana (2017) conducted a study which aimed to assess the academic performance, critical thinking skills, and problem solving skills in mathematics of Grade-7 students in the five central public secondary schools of Area 2, Division of Batangas, Philippines. This study utilized descriptive method of research. Three hundred and forty one (341) students of the public secondary schools out of the total of 2,324 Grade-7 students were selected through systematic random sampling as the subjects of the study. It was found out that the level of performance in Mathematics of the Grade-7 students is proficient. The level of critical thinking skills of students from the different schools is above average as well as their level of problem solving skills. The mathematics performance of the students is positively correlated to their level of critical thinking skills and problem solving skills. Students considered the following learning competencies in the different content areas of Grade-7 Mathematics as difficult to master: solving problems involving sets, describing the development of measurement from the primitive to the present international system of units, finding a solution of an equation or inequality involving one variable, using compass and straightedge to bisect line segments and angles, and analyzing, interpreting accurately and drawing conclusions from graphic and tabular presentations of statistical data. The present study unlike Emil and Joana (2017) was carried out to determine the Effect of Hands-on Learning Strategy on Performance and Critical Thinking in Ecology among senior Secondary School Students in Zaria Education Zone, Nigeria.

Oluwatosin (2017) conducted a study on the effect of hands-on activities on senior secondary chemistry students' achievement and retention in stoichiometry in Zone C of Benue State. The moderating effect of gender was also examined. The study adopted the pretest, posttest, control group, quasi-experimental research design. The instrument used for data collection was Stoichiometry Achievement Test (SAT) with the reliability value of 0.92 using Pearson Product Moment Coefficient. The target population of this study was 8381 which was the population of SSII chemistry students in study area. A sample of 292 students comprising 158 boys and 134 girls drawn from 8 schools within 4 Local Government Areas (LGA) out of nine (9) LGA in the Zone selected using Multi-stage sampling techniques. Four (4) research questions and six null hypotheses guided the study. The research questions were answered using Mean and Standard Deviation scores while the hypotheses were tested at 0.05 level of significance using Analysis of Covariance (ANCOVA). The study revealed that students taught Stoichiometry using hands-on activities had significantly higher mean achievement scores than those taught using demonstration method $F=555.374$, $P(0.0001<0.05)$ and students taught Stoichiometry using hands-on activities had significantly higher mean retention scores than those taught using demonstration method $F=117.523$, $P(0.0001<0.05)$. There was no significant difference between the mean achievement scores of male and female student taught stoichiometry using hands-on activities. Based on the findings, it was recommended among others that Chemistry teacher's trainee should be trained on the use of hands-on activities and serving teachers should use it. Hands-on activities teaching method is not gender sensitive therefore both male and female students should be involved in hands-on activities to enhance their achievement and retention in stoichiometry. The present study unlike Oluwatosin (2017) was carried out to determine the Effect of Hands-on Learning Strategy on Performance and Critical Thinking in Ecology among senior Secondary School Students in Zaria Education Zone, Nigeria.

2.8 Implications of the Literature Reviewed for the Present Study

Literature reviewed from studies in the area of hands-on learning strategy, critical thinking and academic performance as well as gender differences have been undertaken. The review was on the previous works done pertaining to the problems students encounter/have with learning biology concepts. The problems of lecture method of teaching predominantly used by science teachers for instruction to improve students' performance are vivid example. Several researches have been conducted on the use of hands-on learning strategy (HLS) to aid students learn biology concepts and improve their performance. Other literature have also indicated the effects of critical thinking skills on students' academic performance in biology. From the literature reviewed it was recorded that, effective methods of instruction such as hands-on learning strategy improves students' performance in different angles. Till date, the problems associated with learning biology persist that is why the researcher deemed it necessary to use hands-on learning strategy to help students in their critical thinking and academic performance. However, most of the research works (Ozlem and Jale, 2011; Ishola, 2014; Elizabeth, Linus, and Jacob, 2017; Filgona and Sababa, 2017) done were carried out at national and international levels and in different subjects such as Chemistry, Geography, mathematics, physics and integrated science, while the presenet study is in biology. It was also showed that, students' results based on gender have been consistent. Research work on the use of hands-on learning strategy to improve skills of critical thinking and academic performance is very scanty. Most researches were separately done either on the use of hands-on learning strategy to enhance students' performance or the use of critical thinking skills to enhance students' performance as shown from reviewed literatures. The effect of hands-on learning strategy (HLS) on critical thinking (CT) and performance in ecology concepts among secondary school students is relatively new, more especially in the field of biology at Senior Secondary

School. This signified the need to carry out research on the effect of hands-on learning strategy (HLS) on critical thinking (CT) and performance in ecology concepts among secondary school students. This study therefore, is unique from other studies reviewed and indebted to fill this gap by investigating the Effect of Hands-on Learning Strategy on Performance and Critical Thinking in Ecology among senior Secondary School Students in Zaria Education Zone, Nigeria.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

The aim of this study is to investigate Effect of Hands-on Learning Strategy on Performance and Critical Thinking in Ecology among senior Secondary School Students in Zaria Education Zone, Nigeria. The study will also not ignore the influence of gender, year of study, and participation toward biology, bulky nature and the suitability of hands-on learning strategy. This chapter outlines the methodology adopted to conduct this study under the following sub-headings:

3.2 Research Design

3.3 Population of the Study

3.4 Sample and Sampling Techniques

3.5 Instrumentation

3.5.1 Validation of the Research Instruments

3.6 Pilot Testing of Instruments

3.6.1 Reliability of the Instruments

3.6.2 Item Analysis

3.7 Administration of the Treatment

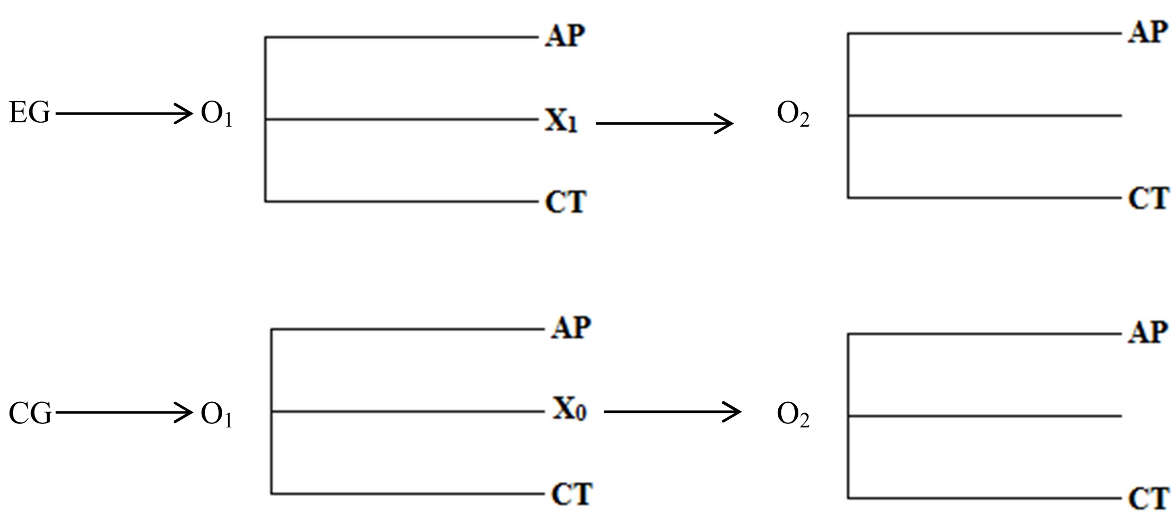
3.8 Data Collection Procedure

3.9 Procedure for Data Analysis

3.2 Research Design

A pretest, posttest, quasi-experimental control groups designed using intact classes which do not allow randomization of the subjects (Sambo, 2005) were employed for this study. Two groups of students were used for data collection i.e the Experimental group (EG) and Control group (CG). A pretest (O_1) was administered to the two groups in order to determine the equivalence of the groups in ability before the commencement of the treatment. Treatment (X_1) was given to the experimental group i.e. students were taught ecology concepts using the Hands-on learning strategy for six weeks. The control group (X_0) was taught the same ecology concepts using the lecture method for six weeks. At the end of the treatment period, a post-test (O_2) was administered to both groups of students in order to evaluate the effectiveness of the treatment in enhancing the learning of ecology concepts among SS II students.

According to John and James (2011) Quasi-experimental research design is useful in research involving cause and effect relationships where the independent variable(s) can be manipulated. In addendum, this design has been recommended by Kerlinger (1973) and used by Bichi (2002), Lawal (2007), and Aliyu (2014). The research design is represented symbolically in Figure 3.1.



EG O_1^A ⟶ X_1 ⟶ O_2^A

CG O_1^A ⟶ X_0 ⟶ O_2^A

Fig. 3.1 Research Design

Where:

EG = Experiment Group

CG = Control Group

X_1 = Teaching using Hands-on Strategy

X_0 = Teaching using Lecture Method

O_1 = Pretest

O_2 = Posttest

AP = Academic Performance

CT = Critical Thinking

Kerlinger (1973), Bichi (2002) and Sambo (2008) affirmed that this design offered numerous advantages such as:

1. It can be used to statistically find out any difference between the groups at the beginning of the study from the results of the pretest, that is to compare the equivalence of the two groups academically.
2. It can be used to give indication gained in understanding of selected test due to application of the treatment.
3. It can also give an indication of the skills gained by students after instruction.
4. The mean scores of the two groups can be calculated. Therefore it is assumed that any difference in the performance of the groups can only be attributed to the treatment given, since the treatment administered is the major difference.

3.3 Population of Students for the Study

The target population for this study constitutes all public secondary schools in Zaria Educational Zone. Kaduna State Ministry of Education Science and Technology has the total number of twelve (12) Zonal Education offices. These are: Anchau Zonal Education; Birnin Gwari; Zaria; Giwa; Rigachikun; Kaduna; Sabon-Tesha; Lere; Kachia; Kafanchan; Godo-godo; and, Zankuwa. But for the sake of this research exercise, attention was focused on Zaria Zonal Education simply because they have peculiar features in common (in terms of students, teachers, curriculum, calendar and so on), and therefore represents the whole town. Zaria Zonal Education has a total number of 49 Public Secondary Schools that are categorized into three:

a. Rearticulated public secondary school;
b. Public Senior Secondary School; and,
c. Public Junior Secondary School.

These Schools cut across five (5) Local Government Areas of Kaduna State; Zaria, Sabon-Gari, Soba and some part of Kudan and Giwa respectively.

The population of this study constitutes 4138 SSII students in sixteen public secondary schools offering biology under Zaria Education Zone, Kaduna State. There are sixteen public secondary schools in the area. Out of this figure, 2575 are males while 1563 were females with age ranging from 16 years and above. The population comprised of five boys schools, three girls schools and eight co-educational schools. The co-educational schools consist of 1625 males and 672 females. The population of the study is presented in Table 3.1.

Table: 3.1 Population of the Study.

S/N	Name of School	Types of School	Male	Female	Total
1.	Govt. Sec. Sch. Dakace	Co-education	119	56	175
2.	Govt. Sec. Sch. Gyellsu,	Co-education	288	139	427
3.	Govt. Sec. Sch. Kaura	Co-education	361	186	547
4.	Govt. Sec. Sch. K/Kuyan-Bana	Co-education	346	60	406
5.	Govt. Sec. Sch. Kugu	Co-education	47	08	55
6.	Govt. Sec. Sch. Magajiya (Senior)	Co-education	149	32	181
7.	Govt. Sec. Sch. Tudun-Jukun,	Co-education	205	180	385
8.	Sheikh Ibrahim Karau-karau (B)	Co-education	110	11	225
9.	Alhuda-huda College	Male	360	00	360
10.	Barewa College, Zaria	Male	386	00	386
11.	Govt. Girls Sec. Sch. (WTC), Zaria	Female	00	250	250
12.	Govt. Girls Sec. Sch. Fada (Senior)	Female	00	235	235
13.	Govt. Girls Sec. Sch. Kofan Gayan	Female	00	299	299
14.	Govt. Sec. Sch. Bogari	Male	12	00	12
15.	Govt. Sec. Sch. Zaria (Senior)	Male	174	00	174
16.	Senior Sec. Sch. Kufena	Male	128	00	128
	Total		2575	1563	4138

Source: Zaria Education Zone, Zaria, Kaduna State **(2018).**

3.4 Sample and Sampling Procedure

Since gender is considered in this research, only co-educational schools were used. Eight schools in the population are co-educational which comprise up 2297 students out of which 1625 are males while 672 are females. Two schools that do not differ significantly were chosen and assigned as experimental and control groups. The names of all the co-education schools in the population written on separate pieces of papers and the papers were put in a container. Four schools were drawn-out one at a time from the container using simple balloting method. The four schools were given the research instruments (ECPT & ECCTQ) to answer in 1 hour 30 minutes each at separate time. The results of the test were analysed using Analysis of Variance (ANOVA) to choose two schools that do not differ significantly. The results of ANOVA test showed no significant difference between the schools. Scheffe's test was also used and no difference was indicated (See Appendix H). Therefore two schools were selected which were later assigned into experimental and control groups by means of throwing a coin. The schools are: GSS Gyallesu (experimental group - A) and GSS Kofan Kuyanbana (control group - B), separated by distance of about 10 kilo metres apart with the total number of students 263 as sample size from which 198 are males while 65 are females. The sample selected was considered viable for research according to Tuckman, (1975), Wallen & Franklrn (2000) and Sambo, (2008). Hence, the choice of sample from the selected schools was guided by central limit theory which recommended a minimum of 30 subjects of a sample for quasi-experimental research (Tuckman, 1975; Sambo, 2005). Detail of the sample is presented in Table 3.2.

Table: 3.2 Sample Schools for the Study

S/N	Name of School	Groups	Male	Female	Total
1.	School **A**	Experimental	95	35	130
2.	School **B**	Control	103	30	133
Total			198	65	263

3.5 Instrumentation

The following instruments were used by the researcher for data collection

1. Ecological Concept Performance Test (ECPT) developed by the researcher from past WAEC and NECO questions due to their standard at both National and International levels.
2. Ecology Concept Critical Thinking Questionnaire (ECCTQ) adapted from Shuaibu (2017) and Van Zyl, Bays, and Gilchrist (2013).

3.5.1 Selection of Topics taught

The following topics in Ecology were taught to the subject of the study:

i. Basic ecological concepts;

ii. Components of the Ecosystem;

iii. Population Studies;

iv. Functioning Ecosystem;

v. Ecological factors;

vi. Trophic levels; and,

vii. Energy Transformation.

These topics were selected because they are part of SSII syllabus. Also, ecology has been used for the study because it has been identified to be contributing to students' poor performances (WAEC, 2010-2014; Agboghoroma & Oyovwi, 2015). The table of specification based on the topics taught is presented in Table 3.3

3.5.2 Ecology Concept Performance Test (ECPT)

The instrument was a 40 items performance test adapted by the researcher from both WAEC and NECO SSCE past questions (2005-2017) to determine the performance of the students in ecology concepts. The topics were developed from the Ecology of Senior Secondary School Biology syllabus (Table 3.3). The (ECPT) items consist of 40 objectives (multiple types) test items each with four alternatives (A-D). The items took into consideration all the seven topics of senior secondary school biology syllabus on ecology in order to ensure equal distribution of the items over the topics. The items were considered under the six taxonomy cognitive domain purported by Blooms to ensure equal distribution. The distribution showed to be knowledge (30), comprehension (21), application (17), analysis (11), synthesis (11) and evaluation (10). The number of questions and weight allocated to each contents/topic are shown in Table 3.3.

3.5.3 Ecology Concept Critical Thinking Questionnaire (ECCTQ)

Ecology Concept Critical Thinking Questionnaire (ECCTQ) is a 30 items critical thinking inventory questionnaire adapted by the researcher from Shuaibu (2017) and Van Zyl, et al, (2013) to determine the critical thinking of students before and after treatment on ecology concepts of Biology. The items were developed using the Likert 5 point rating scale involving; Strongly Agreed (S.A), Agreed (A), Disagreed (D), Strongly Disagreed (S.D) and Undecided (U.D). Each option carries weight in the order of priority from 4-1. The students were asked to freely indicate using their critical thinking on Ecology of Biology by simply ticking one of the four options that suit their critical thinking. It was adapted by the researcher and was validated by three experts with rank not less than senior lecturer in the Department of Science Education and Psychology Department of Ahmadu Bello University, Zaria. ECPT consists of forty multiple short answer questions test items on ecology underlying students' performance the selected ecological concepts. The test consists of two parts. Section "A" seeks information on the respondent personal data such as name, gender, and age, while section "B" consist of twenty objective test items on students' performance of ecology. This instrument was administered when the two groups were post-tested using ECPT. Detail of the instrument in the appendix D.

Table 3.3: Table of Specification for ECPT Based on Construction (Topics Selected)

S/N Content	Weight (%)	Kn. (30)	Co. (21)	Ap. (17)	An. (11)	Sy. (11)	Ev. (10)	Total (100)
Ecology								
1. Basic ecological concepts	(13)	1	0	0	1	1	1	5
2. Components of ecosystem	(18)	1	1	1	1	1	2	7
3. Population studies	(17)	1	1	1	2	1	1	7
4. Functioning ecosystem	(15)	1	1	1	1	1	1	6
5. Ecological factors	(13)	1	0	1	1	1	1	5
6. Trophic levels	(12)	1	1	0	0	1	1	5
7. Energy transformation in nature	(12)	1	1	1	1	1	0	5
Total	100	7	8	5	7	7	7	40

Key: Kn = Knowledge; Co = Comprehension; Ap = Application; Analysis; Sy = Synthesis; Ev = Evaluation

Source: Researcher (2018) adapted from Bloom, (1964).

3.5.4 Validation of the Instruments

Contents Validity was done. Experts in the Department of Biology, Department of Science Education and Department of Educational Psychology and Counseling, ABU, Zaria validated the instruments. All observations and corrections were effected based on the following: whether;

(i) the test items can test/measure what they are meant to test/measure;

(ii) the questions adequately cover the concepts chosen;

(iii) the language expression used is simple, clear, precise and free from ambiguity;

(iv) the questions conform with ability level of the students; and,

(v) suggest possible correction(s) on the observed errors.

The experts made constructive criticisms in the language construction and content of the instruments. The corrections were made leading to the final selection of the items and the respective marking scheme as contained in Appendix A & D. For example, in the case of Ecology Concept Performance Test (ECPT), some items were corrected and modified.

Item 17 initially read thus:

The main kinds of habitats are

A. Arboreal and ground habitat
B. Underground habitats
C. Aquatic and terrestrial habitats
D. Salt and fresh water habitats.

This was modified to:

The main kinds of habitats are

A. Arboreal and ground habitat
B. Underground and Arboreal habitats
C. Aquatic and terrestrial habitats
D. Salt and fresh water habitats.

Item 27 reads as:

An association between two organisms in which both benefit is called

A. Parasitism
B. Symbiosis
C. Commensalism
D. Predation.

This was modified to:

An association between two organisms in which both benefit is known as:

A. Parasitism
B. Symbiosis
C. Commensalism
D. Predation.

Item 32 reads as:

In complex food relationships in a community, the primary, secondary and tertiary consumers are referred to as

A. Symbiosis
B. Omnivores
C. Heterotrophs
D. Autotrophs

This was modified to:

In a complex feeding relationships in a community, where the organisms benefit from each other is referred to as:

A. Symbiosis
B. Omnivores
C. Heterotrophs
D. Autotrophs

In the Ecology Concept Critical Thinking Questionnaire (ECCTQ), some items were also corrected and modified as follow:

Item 3 initially reads:

My teacher asks questions that check that I understand how to do something in terms of classifying organisms around me based on ecology concept.

This was modified to:

My teacher asks questions that check I understand how to do something in terms of classifying organisms around me based on ecology concept.

Item 12 reads as:

My teacher provides opportunities for me to ask questions.

This was modified to:

My teacher provides opportunities for me to ask questions on ecology concepts.

The items after effecting the corrections were used appropriately for collecting the data to be used for the study.

The validators also validated the lesson plans and observations were effected accordingly.

3.6. Pilot Testing of Instruments

The two instruments for the study were pilot tested using SSII students in GSS Tudun-Jukun, Zaria, because they have similar characteristics with the target population. The Ecology Concept Performance Test (ECPT) and Ecology Concept Critical Thinking Questionnaire (ECCTQ) were administered to 30 SSII biology students who were selected randomly from GSS Dogon Bauchi, Zaria.

The purpose of the pilot study according to Bichi (2002) and Muhammad (2014) was to:

(a) determine the reliability coefficient of the instruments before administration;

(b) assess the feasibility of the study before trial;

(c) identify possible problems or difficulties that respondents may encounter with a view to eliminate them; and,

(e) determine the approximate time duration which the subjects would need to answer the test items properly. The appropriateness of the instrument in terms of clearity of the items and the reliability of the test items was determined. Also the discriminative indices and difficulty indices were determined using the students' scores from the pilot study.

3.6.1 Reliability of the Instruments

Reliability is the degree of error or precision in measuring an estimate of a test (Bichi, 2002 and Muhammad, 2014). A test is said to be reliable if repeated measurements using the test gives more or less the same results. Using the data that was obtained from the pilot study, the reliability of the instruments (ECPT & ECCTQ) were calculated by employing test-retest method. The test was administered to SSII Biology Students of GSS Tudun-Jukun, Zaria which was not part of the sample but part of the population. Thus, the instruments were administered twice with the interval of two weeks as proposed by Tuckman (1975) and Sambo (2005). Pearson Product-Moment Correlation Coefficient Statistics was used for analysis. The reliability coefficient of Ecology Concept Performance Test (ECPT) was found to be $r = 0.72$, which shows that the reliability of the instrument is moderate and can be used for data collection for the study. The reliability coefficient of Genetic Concepts Attitude Questionnaire (GCAQ) adapted from Shuaibu, (2017) was r = 0.71 while the reliability coefficient of Ecology Concept Critical Thinking Questionnaire (ECCTQ) was found to be r = 0.85, using Spearman Rank Correlation Coefficient after split half method of the instrument; which showed that the reliability of the instrument was high and can be used for data collection for the study.

3.6.2 Items Analysis of the Instruments.

Item analysis was carried out on the results of the Ecology Concept Performance Test (ECPT) and Ecology Concept Critical Thinking Questionnaire (ECCTQ) to determine the facility indices (FI) and discrimination indices (D.I) of the instruments, from the data collected in the pilot testing. They were derived as follows:

Facility Index (F.I) of the Instruments

Facility index is otherwise called difficulty index. It is the percentage of students who obtain the correct answer on an item. According to Sambo (2008), item difficulty index is the measure of percentage of candidate who got the item right over the total number of candidates that attempted the question. For computing the difficulty index for each item, the steps are as follow:

- The scores on the whole test scripts would be ranked in the order from highest to lowest.
- One third of the scores of the high scoring students and one third of the scores of the bottom scoring students would be selected.
- The percentage of the high scoring one third and the low scoring one third of the total test items would be calculated.
- The items difficulty index were computed by adding the percentage of those that got the items correct in the bottom scoring and high scoring groups and then divide by two, The formula is;

$$P = \frac{RU + RL}{N}$$

Where:

P = item difficulty

RU = number of students that got the item right in upper one third percent.

RL = number of students that got the item right in bottom one third percent.

N = number of students involved in the analysis (not the entire students that sat for the test).

According to Tristan (1999) and facility indices between 0.3 – 0.7 are recommended for selecting good items for performance test. For this study, items which fall between the range of 0.3 – 0.7 were finally selected.

Discrimination Index (D.I):

Discrimination indices of a test refer to the capacity of such a test to discriminate or distinguish or separate between high and low achiever/ranking among students in the sample/test. If an item has positive discrimination, it implies that a large proportion of the more competent students than poor ones got the item right. If the value is zero, the item has zero discrimination, which means that the items are unable to distinguish between the competent and incompetent students. The negative value of discrimination index indicates that more of the low achievers got the item right compared to the more competent ones. Mehrens and Lehmann (1984) emphasized that the higher the discrimination indices the better, recognizing that there are situations where low discrimination indices is to be expected. For example, classroom test. Furst (1958) identified that discrimination indices which range from 0.30 to 0.7 are described as moderately positive and above this are highly positive. The discrimination index was calculated using the formula given by (Olorukooba 2001; Muhammad, 2014).

$$D.I = \frac{RU - RL}{\frac{1}{2} N}$$

Where:

D.I = discrimination index

RU = number of upper 27% of respondents

RL = number of lower 27% of respondents

N = total number of respondents

Tristan (1999), Field (2006) and Sambo (2005) recommended discrimination indices between 0.3 – 0.7 for selecting good items for performance test. For this study, items which fall between the range of 0.3 – 0.7 were finally selected. Items with discrimination indices between 0.0 – 0.29 are difficult and should be rejected, while those between 0.3 – 0.7 are moderately positive and should be selected, and those with discrimination indices above 7.0 are highly positive and should be rejected. For this study, items with discrimination indices between 0.3 – 0.7 were selected and those with very low indices were discarded and some reconstructed and finally selected. This is in line with Field (2006) and Sambo (2008).

3.7 Administration of Treatment / Treatment Procedure

The treatment that was administered to the participants involved teaching the concept of ecology by the researcher using: Hands-on Learning Strategy model adapted from Jegede, (2004), Aliyu (2014), and Shuaibu (2017). One intact Biology SS II class containing 83 students were used. The model was adapted because it has the following advantages for the present research.

a) It is a students learning centered in it characteristics

b) It provides opportunity for activity based teaching and learning.

c) It provides room for teamwork learning.

d) It identification of prior ideas step provide flexibility for Hands-on learning i.e. to acquired students communal beliefs and personal beliefs at the beginning of the lesson on ecology concept.

Lesson plan was prepared to teach the selected Biology concepts for the period of six weeks. That is, the instruction was designed based on Hands-on Learning Strategy cycle model, which includes five specific components: Identification of prior ideas, exploration, discussion, application, and evaluation.

The identification of prior ideas stage of the model is meant to elicit questions on prior knowledge from students and, of course, to motivate them to learn. During the exploration stage students will carry out activity using Hands-on Learning Strategy by collecting data, making observations, etc. and these explorations will give formal names in the discussion stage. In the application stage students have the opportunity to extend their learning to other topics or to satisfy previously held questions. Seemingly self-explanatory, the evaluation stage will provide both teachers and students with the chance to both formally and informally reflect upon what was learned (Jegede, 2004). The lesson plans of Hands-on Learning Strategy were guided by the following steps:

Step 1: Identification of prior knowledge: The teacher introduces the lesson by guiding the students to identify various ecological concepts and make connection from new to known.

Step 2: Exploration: The teacher guides the students using Hands-on Learning Strategy to explain the specific objectives of the lesson through mind-on and hands-on activities which the students will carry out.

Step 3: Discussion: The teacher guides the students to discuss what they have learned in exploration steps through written report in a group.

Step 4: Application: The teacher guides the students to expand on their knowledge connect it to similar concepts applied to other situation which can lead to new knowledge

Step 5: Evaluation: The teacher guides the students to access their knowledge, skill and abilities through answering questions and provides opportunities for teacher to evaluate students' progress toward achieving the educational objectives. (The flow-chart is presented in Figure 3.2)

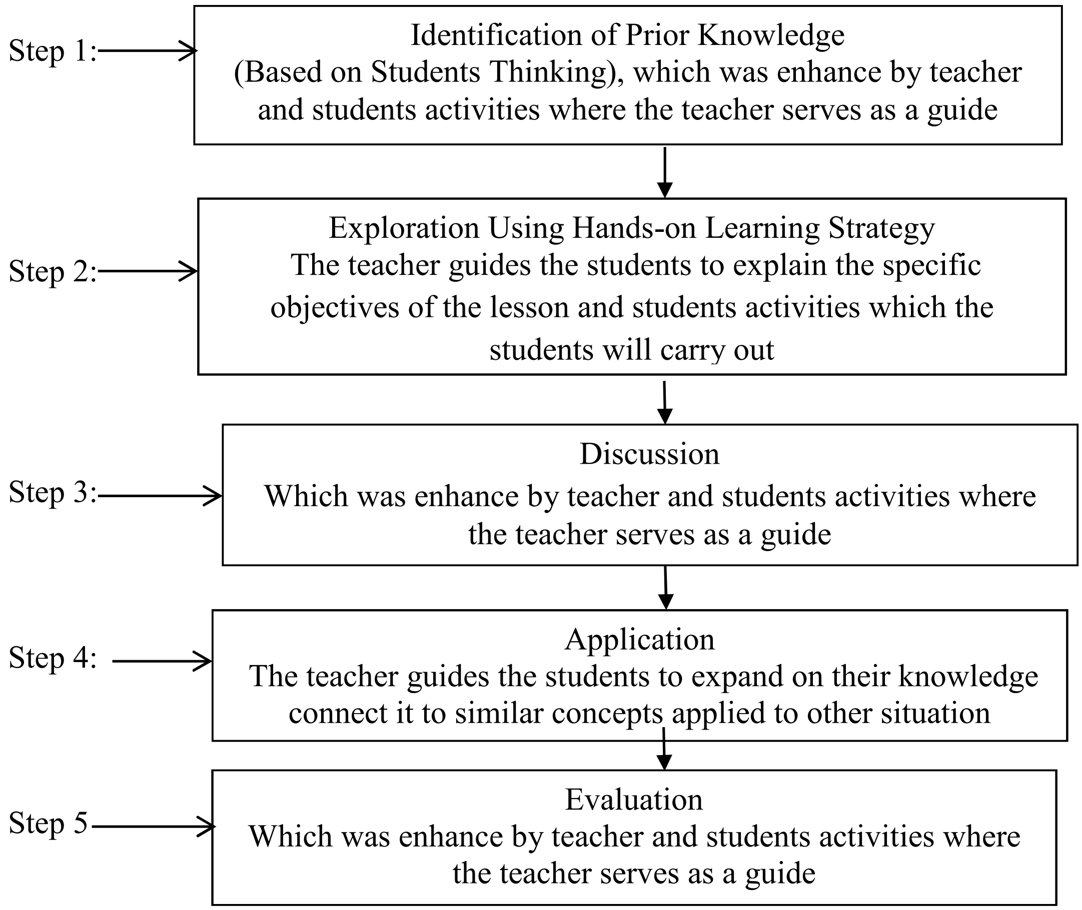


Fig.3.2: Flow-Chart of Hands-on Learning Strategy Model.
Source: Adapted from Shuaibu (2017).

Before the commencement of the treatment, the subjects in both groups (experimental and control) were pretested on ecology in term of academic performance in order to determine group equivalence. Subjects in the experimental group were taught the concept of ecology by the researcher in order to ensure effective utilization of the adapted Hands-on Learning Strategy model and to ensure that the teaching procedure was in conformity with the direction of the model. This comprised practical activity, problem solving and discussions. The subjects were allowed to explore the concept in question through practical activities and problem solving and small group discussions. In the exploration session, they was asked focusing questions based on the specific objectives of the lesson using Hands-on Learning Strategy meant to lead them to observe and discuss their experiences. This is with a view to stimulate the subjects to articulate the inconsistencies and discrepancies between the phenomenon under consideration and their own previously held ideas. The teaching was lasted for six weeks consisting of 6-double periods of 80 minutes each. Thus, the subjects will be taught ecology terminologies, components of ecosystem, population studies by sampling method, ecological factors, functioning ecosystem, trophic level and energy transformation.

The control group was taught the same concepts by the researcher using the lecture methods for the same duration. The notes of the lesson plans prepared by the researcher were strictly adhered to in the teaching of the subjects in the control group. The concepts were discussed and explained verbally using talk and chalk method; students wrote notes where necessary and ask questions on the area(s) where they find difficult to understand any concept. The detail of the lesson plans for the control group is presented in Appendix G.

3.8 Data Collection Procedure

The procedure for administration of research instrument and data was described as follows:

The test is design to investigate the critical thinking ability of SSII biology students before treatment and impact of Hands-on Minds-on after treatment. The pretest was administered to the subjects before the commencement of the teaching. Teaching lasted for six weeks; one and half hours every week base on the lesson note. The experimental group was taught using Hands-on Learning Strategy (HLS). After a period of teaching, both the experimental and control groups were post-tested with both ECPT and ECCTQ. The responses were scored using the marking scheme (See appendix B). Each correct score was marked one point and for incorrect responses zero. After collate and record based on research question and Hypotheses formulated.

The pre-test was administered before the intervention to identify learners' pre-existing knowledge on the concepts of ecology. After the intervention, the same questions in the pre-test were used as a post-test except that the item numbering in the post test was different from pre-test to avoid recognition of items. Post-test was used to explore learners' concepts associated with ecology in order to determine how their understanding had changed due to the Hands-on intervention. The tests covered most aspects of ecology.

This study was conducted over a period of six weeks to alter learners' performance. The independent variable was the intervention using hands-on learning strategy, and the dependent variable was learners' understanding (performance) measured by pre-test and post-test scores. The EG was taught using the Hands-on learning strategy/approach, while the CG was taught using the traditional approach (lecture method). Educator facilitated learners' activities in the EG through implementation of the Hands-on learning strategy/approach. In the CG, where the traditional approach was utilized, the textbook method; whole class discussion and lectures was employed for instructional purposes.

3.9 Procedure for Data Analysis

The results and responses of the subjects obtained from the two instruments were scored using the marking guide for each instrument respectively, and the data collected was analyzed by re-stating the research questions and null hypotheses, while appropriate statistical tools were used for testing the stated hypotheses at $P \leq 0.05$ level of significance to retain or reject the null hypotheses.

The data were re-encoded in several ways. The first analysis consolidated results from research questions and hypotheses: correct answer had value 1, incorrect answer value 0. To identify performance, each question was evaluated separately and showed as a percentage (see Figure).

Answers of explanation part were re-encoded so that it is possible to distinguish the correct interpretation of scientifically incorrect.

Research Questions

The following research questions were formulated for answering as follows:

1. What is the effect of hands-on learning strategy on mean academic performance of Senior Secondary II Students in ecology?
2. What is the effect of hands-on learning strategy on critical thinking skills of SSII students in ecology exposed to hands-on learning strategy and those exposed to lecture method?
3. What is the effect of gender on hands-on learning strategy of teaching ecology among senior secondary school students?
4. What is the effect of hands-on learning strategy on the mean Critical thinking scores of Male and female students in ecology concepts exposed to hands-on learning strategy?

Research Hypotheses

The following research hypotheses have been formulated for testing at $P \leq 0.05$

H_{01}: There is no significant difference between the mean academic performance score of students in ecology exposed to hands-on learning strategy and those exposed to lecture method.

This hypothesis was tested using Independent t-test statistics.

Ho_2: There is no significant difference between the mean critical thinking skills scores of students in ecology exposed to hands-on learning strategy and those exposed to lecture method.

This hypothesis was tested using Non parametric test of Man Whitney (U-test).

H_{03}: There is no significant difference between the mean academic performance scores of male and female students taught ecology when exposed to hands-on learning strategy.

This hypothesis was tested using Independent t-test statistics.

H_{04}: There is no significant difference between the mean Critical thinking skills scores of male and female students exposed to hands-on learning strategy of teaching ecology.

This hypothesis was tested using Man Whitney (U-test).

CHAPTER FOUR

DATA ANALYSIS, RESULTS AND DISCUSSION

4.1 Introduction

The aim of this study is to investigate the effects of hand-on learning strategy on critical thinking and performance in Ecology concepts among Secondary School biology students in Zaria Education Zone Kaduna state Nigeria. This chapter is presented in the following sub-headings:

4.1.1 Analysis of bio data variables in frequencies and percentages

4. 2 Data Analysis and Presentation of Results

4.3 Summary of Major Findings

4.4 Discussion of Results

4.1.1 Analysis of bio-data variables in distribution of respondents by their gender and study groups was done with the frequencies and percentages**.**

Gender

	Frequency	**Percent**
Male	198	75.3
Female	65	24.7
Total	263	100.0

Table 4.2.1 shows a total of 198 of the students in this study representing 75.3 0% are male students and the rest 65 or 24.7% are female students.

Table 4.1.2 Frequency Result of Experimental and Control Groups exposed to Hands-on Learning and Lecture Method respectively

Groups

	Frequency	**Percent**
Exp.	130	49.4
Cont.	133	50.6
Total	263	100.0

Table 4.1.3 shows a total of 130 representing 49.4% of the total samples students were the experimental group exposed to the hands-on learning strategy while the rest 133 or 50.6% were the control group exposed to the lecture method.

4.2 Data Analysis and Result Presentation

Two instruments; Ecology Concepts Performance Test (ECPT) and Ecology Concepts Critical Thinking Questionnaire (ECCTQ) were used to collect two instruments: Ecology Concepts Performance Test and Ecology Concepts Critical Thinking Questionnaire scores for analysis. In this study, four research questions were answered with the descriptive Mean statistics and Mean Rank Non Parametric test while four research null hypotheses were tested with the independent t-test and Non-Parametric U-test of Man Whitney. The research questions were presented as follows:

4.2.1 Answering the Research Questions

Research Question One: What is the effect of hands-on learning strategy on academic performance of SSII students in ecology concepts exposed to hands-on learning strategy and those exposed to lecture method?

To answer this question, pretest and post test scores of both the experimental and control groups were used so as to determine the effect of the hands-on learning strategy on performance

Table 4.2.1: Descriptive statistics on difference between the mean perception levels of academic performance scores of students in ecology concepts exposed to hands-on learning strategy and those exposed to lecture method

Descriptive Statistics

Dependent Variable: performance

Groups	Tests	N	Mean	Std. Deviation
Exp	pre test	130	14.0462	6.88652
	post test	130	33.0615	3.43884
	Total	260	23.5538	10.96612
Cont	pre test	133	12.6391	3.21535
	post test	133	16.9248	2.83545
	Total	266	14.7820	3.70993
Total	pre test	263	13.3346	5.39032
	post test	263	24.9011	8.67246
	Total	526	19.1179	9.24901

Table 4.2.1 shows the outcome of the descriptive mean statistics, huge differences exist in the mean performance scores of students taught ecology using hands-on learning strategy and those exposed to lecture method.

Results of the descriptive statistics showed that among the experimental group their pretest and posttest scores were 14.0462 and 33.0615 respectively. Among the control group their pretest and posttest performance mean scores are 12.6391 and 16.9248 respectively. This implies that differences existed at the post test levels of both experimental and control groups when compared with the performances at pretest levels. This confirms that there is positive effect of hands-on learning strategy on students' academic performances.

Research Question Two: What is the effect of hands-on learning strategy on critical thinking skills of SSII students in ecology concepts exposed to hands-on learning strategy and those exposed to lecture method?

To answer this question, the Mean Ranking test using pretest and post test scores of both the experimental and control groups were used so as to determine the effect of the hands-on learning strategy on critical thinking skills

Table 4.2.2: Mean-Rank Non Parametric tests on difference between the mean perception levels of critical thinking skills of students in ecology concepts exposed to hands-on learning strategy and those exposed to lecture method.

Ranks

Variable	Group tests	N	Mean-Rank
Critical Thinking Scores	Experimental pretest	130	52.13
	Experimental posttest	130	70.13
	Control pretest	133	51.36
	control post test	133	52.88
	Total	526	

Table 4.2.2 shows the results of the Mean-Rank Non-parametric test that difference exists between the mean critical thinking skills of students in ecology concepts exposed to hands-on learning strategy and those exposed to lecture method. Their computed mean-rank critical thinking pretest and post test scores are 52.13 and 70.13 respectively, while in the control group their computed Mean-Rank critical thinking scores are 51.36 and 52.88 respectively. This shows that the critical thinking was higher at the experimental Posttest when compared with the rest of the three groupings. This implies that the hands-on learning strategy has effect on the Mean-Rank critical thinking skills of the students.

Research Question Three: What is the effect of hands-on learning strategy on the mean academic performance of male and female students in ecology concepts exposed to hands-on learning strategy?

To answer this question, the pretest and posttest scores of both the male and female experimental group were used so as to determine the effect of the hands-on learning strategy on male and female students' performance.

Table 4.2.3: Descriptive statistics on difference between the mean academic performance of Male and female students in ecology exposed to hands-on learning strategy

Descriptive Statistics

Dependent Variable: performance

Tests	Gender	N	Mean	Std. Deviation
pre test	Male	95	14.3263	7.46971
	Female	95	13.2857	3.41287
	Total	190	23.5000	10.86948
post test	Male	35	32.6737	4.98569
	Female	35	34.1143	3.33230
	Total	70	23.7000	11.30262
Total	Male	130	14.0462	6.88652
	Female	130	33.0615	3.43884
	Total	260	23.5538	10.96612

Table 4.2.3 shows the outcome of the Mean descriptive statistics that there is no difference in the mean performance scores of male and female students taught ecology using hands-on learning strategy. Results of the descriptive statistics showed that among the male students their pretest and posttest scores were 14.326 and 32.673 respectively. And in the same vein among the female students their pretest and post test scores were 13.286 and 34.114 respectively. This implies that at the pretest levels both male and female had almost the same level of performance. And at the post test level both male and female had slightly increased same level of performance. This confirms that there is positive effect of hands-on learning strategy on both male and female students' academic performance.

Research Question Four: What is the effect of hands-on learning strategy on the mean Critical thinking scores of Male and female students in ecology exposed to hands-on learning strategy?

To answer this question, the Mean Rank non-parametric test using pretest and post test scores of both the experimental Male and female were used so as to determine the effect of the hands-on learning strategy on critical thinking skills.

Table 4.2.4: Mean-Rank Non Parametric tests on difference between the mean perception levels of critical thinking skills of male and female students in ecology exposed to hands-on learning strategy.

Ranks

Variable	**Gender groups**	**N**	**Mean-Rank**
Critical Thinking Scores	Male Pretest	95	26.33
	Female pretest	35	26.63
	male Post test	95	36.55
	Female Post test	35	33.66
	Total	260	

Table 4.2.4 shows results of the Mean-Rank test Non-parametric test that there is no significant difference between the mean critical thinking skills of Male and female students in ecology exposed to hands-on learning strategy. Their computed mean-rank critical thinking skills show that among the males their pretest and posttest critical thinking mean-ranks are 26.33 and 36.55 respectively. In the same vein, among the females their pretest and posttest critical thinking mean-ranks are 26.63 and 33.66 respectively. This shows that the critical thinking of both male and female were the same at the pretest level. And at the post test level both male and female critical thinking skills have increased to the same levels. This implies that the hands-on learning strategy has positive effect on the Mean-Rank critical thinking skills of both male and female the students.

4.3 Testing of Null Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance:

Null Hypothesis One (Ho_1): There is no significant difference between the mean academic performance scores of students in ecology exposed to hands-on learning strategy and those exposed to lecture method. This null hypothesis was tested using t-test analysis at $\propto$=0.05, as shown in table 4.3.1.

Table 4.3.1: T- test Analysis on Academic Performance of students for Experimental and Control Groups

Group	N	Mean	SD	Mean diff	df	T	t	P	R
Experimental Group	130	33.06	3.43	16.14	261	41.56	1.96	0.001	S
Control Group	133	16.92	2.84						

The result of the independent t-test statistics in table 4.3.1 showed that there is significant difference in the mean performance scores of students taught ecology using hands-on learning strategy and those exposed to lecture method. Reasons being that the calculated p-value of 0.001 was less than the $p<0.05$ alpha level of significance and the computed t-value observed was 1.96 at df 261, T = 41.56. Their mean academic performances were 33.06 and 16.93 for students in ecology exposed to hands-on learning strategy and those exposed to lecture method respectively. Therefore, the null hypothesis which stated that there is no significant difference between the mean academic performance scores of students in ecology exposed to hands-on learning strategy and those exposed to lecture method, was hereby rejected.

Null Hypothesis Two (Ho_2): The null hypothesis states that there is no significant difference between the perception level of critical thinking scores of students taught ecology using hands-on learning strategy and those exposed to lecture method. This null hypothesis was tested using Man Whitney (U-test) analysis at $\propto$=0.05, as shown in table 4.3.2.

Table 4.3.2: Man Whitney (U-test) analysis among the perception level of critical thinking scores of students for Experimental and Control Groups

Group	N	Mean Rank	Sum of Rank	U	P	R
Experimental Group	130	190.89	24816.00	9900.00	0.001	S
Control Group	133	74.44	9900.00			

The result in Table 4.3.2 compared the perception level of critical thinking scores of students for Experimental and Control Groups. The result showed that, the experimental and control groups have mean rank value of 190.89 and 74.44 respectively. The Man Whitney (U-test) observed was 9900.00 and p-value observed was 0.001 is less than $p<0.05$ alpha level. This indicated that there was a significant difference between the mean perception level of critical thinking scores of students taught ecology using hands-on learning strategy and those taught using lecture method. Therefore, the null hypothesis which stated that there is no significant difference between the mean perception level of critical thinking scores of students taught ecology using hands-on learning strategy and those exposed to lecture method was rejected.

Null Hypothesis Three (Ho_3): The null hypothesis states that there is no significant difference between mean academic performance scores of male and female students taught ecology using hands-on learning strategy. This null hypothesis was tested using t-test analysis at $\propto$=0.05, as shown in table 4.3.3.

Table 4.3.1: T- test Comparison on Academic Performance of Male and Female Students in Experimental Group

Group	N	Mean	SD	Mean diff	df	T	t	P	R
Male	95	34.67	3.41	0.44	128	1.15	1.96	0.074	NS
Female	35	34.11	3.33						

Result in Table 4.3.3 of the independent t-test statistics showed that there was no significant difference in the mean performance scores of male and female students taught ecology using hands-on learning strategy. Reason being that the calculated p-value of 0.074 is less than the 0.05 alpha level of significance and the t-value observed was 1.96, T=1.15. Therefore, the null hypothesis was accepted and retained.

Null Hypothesis Four (Ho_4): The null hypothesis states that there is no significant difference between the mean perception level of Critical thinking scores of male and female students in ecology taught using hands-on learning strategy. This null hypothesis was tested using Man Whitney (U-test) analysis as shown in table 4.3.4.

Table 4.3.2: Man Whitney (U-test) Statistics between the Perception Level of Critical Thinking Scores of Male and Female Students in ecology exposed to Hands-on Learning Strategy

Group	N	Mean Rank	Sum of Ranks	U	P	R
Male	85	66.32	5637.50	1842.50	0.734	NS
Female	45	63.94	2877.50			

Results in Table 4.3.4 of the Non-parametric test of Man Whitney statistics showed that there was no significant difference between the mean perception level of critical thinking scores of male and female students in ecology exposed to hands-on learning strategy. Reason being that the calculated p-value of 0.734 is greater than the 0.05. Their mean Rank critical thinking scores are 66.32 and 63.94 by male and female respectively. Their Sum of Rank critical thinking scores are 5637.50 and 2877.50 by male and female respectively. Therefore, the null hypothesis was accepted and retained.

4.4 Summary of Major Findings

The major findings from the data analysis and test of hypothesis for the study are summarized below:

1. Hands-on learning strategy had significantly effect on the academic performance of Ecology Students exposed to it more than those taught using lecture method. Evidence from students' responses has indicated that the difference in academic performance between Ecology students in the experimental group and those in control group was statistically significant.
2. Ecology Students taught with Hands-on Learning Strategy (HLS) have improved significantly in critical thinking skills of ecology in the way they responded to the skills tested in Ecology Critical Thinking Skills.
3. The academic performance of male and female students in the ecology when taught using Hands-on Learning Strategy did not differ significantly.
4. The perception level of male and female students in ecology in critical thinking skills did not differ significantly when exposed to Hands-on Learning Strategy.

4.5 Discussion

This study investigated the Effect of Hand-on Learning Strategy on Performance in Biology and Students Perception Level of Critical Thinking involved in Zaria, Nigeria. Four hypotheses were tested for the study.

It was indicated that the use of hands-on learning strategy significantly influenced critical thinking of students who were exposed to it. The critical thinking of students taught biology with Hands-on Learning Strategy was significantly higher than those taught with lecture method. In Hands-on Learning Strategy, students share common goal and have different perspectives on the best way of attaining the goals, this sharing of different points of view in the attempt to achieve a common goal results in critical thinking and problem solving. Hands-on learning strategy is increasingly, becoming a popular method of teaching in view of its intuitive benefits and advantages of allowing students do and experience what is being taught, thus enabling them to develop critical thinking and understanding of the basic concept of what is being learnt (Jacob, Sababa & Filgona, 2016).

The academic performance of students exposed to hands-on learning strategy and those exposed to lecture method were compared. The outcome of the comparison indicated that the use of hands-on learning strategy significantly improved the academic performance of students taught biology with it. Their performance was indicated to be significantly higher than those taught biology with lecture method. This implies that hands-on learning strategy (HLS) has multifaceted benefits over lecture method. That is, the results of this study revealed that hands-on learning strategy increased students' performance in biology more than the traditional instruction/lecture method did.

This result is not surprising considering the fact that it agrees with many studies that indicated hands-on learning strategy if regularly incorporated classroom instruction, can enhance students' cognitive performance (Ozlem and Jale, 2011; Scharfenbery and Bogner, 2010, Thompson and Soyibo, 2002; Turpin, 2000, Bristown, 2000, Stohr-Hunt, 1996, Freedman, 1997). The study of Ezlem (2011) and Stohr-Hunt (1996) investigated effects of hands-on learning activity enriched instruction on students' achievement and attitudes towards science and effect of science achievement that the students who performed hands-on activities had significant higher scores of science achievement that the students who performed hands-on science infrequently. Likely, Bristow (2000) reported that science concepts should be learned better when using hands-on teaching methods versus a traditional method. According to Cetin (2003), students can be more active learner when they are instructed by hands-on activities in science classrooms, especially if they can apply what they have learnt in school to their daily life situations. Similar result was reported by McConnell, Steer, and Owens (2003). In general, conducting hands-on activities in science classes; for example, in field, class activities (such as hands-on in ecology) or laboratory settings, is widely recommended by educational authorities like the National Research Council (2000).

Teaching students using hands-on learning strategy enables student to acquire not only scientific knowledge but also critical thinking skills. The present study also found that hands-on learning strategy enhanced critical thinking among biology students as the result indicated that there is significant difference in the mean performance scores of students taught ecology using hands-on learning strategy and those taught same concept using lecture method. Among the experimental group their pretest and posttest scores were 12.43 and 32.83 respectively. Among the control group their pretest and posttest performance mean scores are 12.80 and 17.00 respectively. This implies that significant differences exist in the post test level of the experimental group when compared with the performance at pretest levels of both groups and pretest of control group. In their study ((Jacob, Sababa & Filgona, 2016) concluded that Hands-on learning strategy is increasingly, becoming a popular method of teaching in view of its intuitive benefits and advantages of allowing students do and experience what is being taught, thus enabling them to develop critical thinking and understanding of the basic concept of what is being learnt. Similarly, this finding agrees with the results obtained by Oluwatosin and Josiah (2016) and Martine (2011) and Mishira and Yadav (2013) who found that students achieved higher when exposed to hands-on activities than their counterparts that were exposed to traditional method in integrated science and elementary science respectively.

A hypothesis stating that there is no significant difference in the mean performance scores of male and female students taught ecology concepts using hands-on learning strategy was investigated in the study. The third finding indicated that there is no significant difference between the performance of male and female students after exposure to ecology concepts using hands-on learning strategy. Therefore, this hypothesis stood every ground to be retained and is hereby not rejected. This implies that hands-on learning strategy is gender friendly. Irrespective of gender, both male and female students equally benefited from the use of this strategy. Hands-on learning environment can quite often simulate a student to learn as much as possible. Thus, the finding of this study corroborates that of Jacob (2016) and Haliru (2015) in Geography, who found no significant gender difference in the academic performance of students when exposed to treatment (Hands-on learning strategy). But in conflict with Yakubu and Yusuf (2013) who revealed that girls do better than boys in Geography which is also a science subject.

There is no significant difference between the mean critical thinking skills of male and female students in ecology concepts exposed to hands-on learning strategy. This can be attributed to the awareness of the importance of the subject by both sexes in the society and that one hardly survives without it. Their computed mean rank critical thinking skills shows that among the males their pretest and posttest critical thinking mean Ranks are 26.33 and 36.55 respectively. In the same vein, among the females their pretest and posttest critical thinking mean Ranks are 26.63 and 33.66 respectively. This shows that the critical thinking of both male and female were not significantly different at the pretest level. And at the post test level both male and female critical thinking skills have increased to the higher levels. This implies that the hands-on learning strategy has significant positive effect on the Mean Rank critical thinking skills of both male and female the students. The test of mean critical thinking skills scores of male and female students exposed to hands-on learning strategy were also compared, which agrees with the findings of Jacob, Sababa and Joel (2016), Munir and Mumtaz (2013) that there exists no significant difference between the posttest achievement score of male and female students of experimental groups using hands-on learning strategy. Hence, this means that hands-on activities are equally effective to raise the performance score in science irrespective of the gender of the students. These findings are similar to the studies of Pine, Aschbacher, Roth, Jones, Mcphee, Martin, Phelps, Kyle and Foley (2006) and Harvey and Wareham (1984). However, Randler and Hulde (2007) and Burkam, Lee and Smerdon (1997) found that female students benefitted more as a result of experiencing hands-on activities; that it may be due to the fact that in their study, activities were related to biology and according to Lee and Smerdon (1996) female students perform better than male students in biology. Some other studies have also evidenced that performance of female students in science is better than their male counterparts (Martin, Mullis & Foy, 2008; Qualter & Abu-Hola, 2000; and Murphy, 1994). But according to Steinkamp & Maehr (1984) sex differences in performance/achievement in science do exist but smaller than it is assumed, generally they tend to favour males.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter summarizes the investigation on the Effect of Hands-on Learning Strategy on Performance in Biology and Students Perception Level of Critical Thinking involved in Zaria, Nigeria.

The chapter is presented under the following headings:

5.2 Summary

5.2.1 Summary of Findings

5.3 Conclusion

5.4 Contributions of Knowledge

5.5 Recommendations

5.6 Limitation of the Study

5.7 Suggestions for Further Studies

5.2 Summary

This study investigated the effects of Hands-on Learning Strategy on Critical Thinking and performance in Ecology concepts among Secondary School students, in Zaria Educational Zone, Kaduna, Nigeria. The research was presented in five chapters. Chapter one presented the problem of this study which was prompted by poor/low level of critical thinking skills and poor academic performance of Secondary School Biology students. The study was guided by four research objectives, four research questions and four null hypotheses corresponding to the research objectives were also stated. While other aspects of the chapter are significant of the study, scope of the study and basic assumptions. The study was limited to only SSS II students of public Secondary Schools offering Biology in Zaria Educational Zone of Kaduna State.

Chapter two of this study reviewed literatures that were relevant in areas such as Teaching of Biology at Secondary Schools Levels, Methods of Teaching Science, Concept of Hands-on Learning Strategy (HLS), Hands-on Learning Strategy and Academic Performance in Sciences, Concept of Critical Thinking (CT), Studies on Critical Thinking and Academic Performance in Sciences, Educator's Role in Developing Critical Thinking Skills, Critical Thinking and its Usage in this study, Relationship between Critical and Creative Thinking, Hands-on Learning/Active Learning for Enhancing Critical Thinking and Performance, Hands-on Learning on Academic Performance and Gender, Overview of Similar Studies, Implications of the Literature Reviewed for the Present Study as well as overview of related studies and implications of literature reviewed for the present study.

The chapter three of this study presented the methodology employed in carrying out this study which includes Research Design, Population of the Study, Sample and Sampling Techniques, Instrumentation, Validity of the Instruments, Pilot test, Reliability of the Instruments, Administration of Treatment as well as Data Collection Procedure and Procedure for Data Analysis.

Chapter four of the study presented the results and discussions of the findings. Four hypotheses were tested along the research objectives and questions. From the analysis of the data and test of the study's hypotheses, the following major findings were outlined: there was significant difference in the academic performance of students taught ecology using hands-on learning strategy and those taught same concept using lecture method, Significant difference existed between the mean critical thinking skills of students in ecology concepts exposed to hands-on learning strategy and those exposed to lecture method, there was no significant differences in the mean performance scores of Male and female students taught ecology with hands-on learning strategy and lecture method and there was no significant difference between the mean critical thinking skills of Male and female students in ecology concepts exposed to hands-on learning strategy and lecture method.

Chapter five summarizes the investigation on the Effect of Hands-on Learning Strategy on Performance in Biology and Students Perception Level of Critical Thinking involved in Zaria, Nigeria. The chapter looked at the following sub-headings: summary of major findings, conclusion, contribution to knowledge, recommendations, limitations of the study and suggestions for further studies.

5.2.1 Summary of Findings

1. Significant difference exists in the mean performance scores of students taught ecology using hands-on learning strategy and those taught same concept using lecture method among the experimental group their pretest and post test scores.
2. Significant difference exist between the mean critical thinking skills of students in ecology concepts exposed to hands on learning strategy and those exposed to lecture method.
3. There is no significant difference in the mean performance scores of Male and female students taught ecology using hands-on learning strategy.
4. There is no significant difference between the mean critical thinking skills of Male and female students in ecology concepts exposed to hands-on learning strategy.

5.3 Conclusions

In the light of the preceding discussions and findings, the following conclusions can be drawn:

1. Hands-on Learning appears to have a strong record of successes in increasing students' critical thinking to learn and enhancing higher academic performance;
2. Students taught ecology concepts by hands-on approach in the present study performed significantly better/higher than those taught by the conventional/lecture method;
3. The strategy (hands-on learning) was also found to be gender-friendly as the results from the test of the third and fourth hypotheses indicated that male and female students taught ecology concepts do not differ significantly in their critical thinking and performance; and,
4. Critical Thinking was an effective means of enhancing students' performance of ecology concept using hands-on learning because the skills has helped in interpreting, analyzing, evaluating and presenting data in a logical and sequence manner.

5.4 Contributions to Knowledge

The results of the findings of this study have made the following contributions to knowledge; concern of this study was to explore the effect of hands-on learning strategy on critical thinking and performance in Ecology concept among Secondary School Students. The findings of the study have the following significant contributions to knowledge;

1. Hands-on Learning Strategy improved Senior Secondary School Students' Performance in Ecology;
2. Hands-on Learning Strategy enhanced Senior Secondary Students' Critical Thinking in learning of Ecology;
3. Hands-on Learning Strategy (HLS) was gender-friendly in the learning of ecology among Senior Secondary School Students.

4. Hands-on Learning strategy can be used to address the present trend of poor academic performance of senior secondary school students in ecology concept examinations of biology as reported in previous studies.
5. Biology teachers at senior secondary level can explore the enormous benefits tied to Hands-on Learning strategy in promoting effective teaching and learning of ecology concept within the classroom and outside the classroom.

5.5 Recommendations

Based on findings of this study, the following recommendations are made:

1. The use of hands-on learning strategy improved the academic performance of students in the present study. Therefore, Biology teachers should endvour to use hands-on learning strategy as an alternative strategy or incorporate this instructional technique with other teaching methods in order to improve the teaching and learning of ecology concepts in senior secondary schools.
2. School should purchase a variety of ecological instruments for use in practical Biology periods. Hence, there is the urgent need for Government serving as custodian of public secondary schools to build/renovate good Biology laboratories, furnished with relevant instructional materials for conducting practical sessions in ecology concepts/biology through hands-on learning strategy.
3. The teaching of ecology concepts should be practically oriented. Students should be involved in the teaching and learning process through exposure to ecological concepts and fieldwork. Thus, learners should be encouraged to make models and differentiate terms of some ecological features.

4. Both male and female Senior Secondary School students should be taught Biology with Hand-on learning instruction as both acquire critical thinking skills when used.
5. Teachers of Biology should be sponsored by government/private school owners to attend regular courses, workshops, seminars and in-house training on the use of Hand-on learning instruction for the maximum students' acquisition of critical thinking skills.

5.6 Limitation of the Study

This study was limited to the following:

1. The students were not conversant with the hands-on learning strategy; as such, the researcher took some time and gave the learners (subjects) orientation regarding the strategy to embark on. Thus, this resulted to time constraint for the study.

5.7 Suggestions for further studies

This study determined the effects of hands-on learning strategy on critical thinking and performance in ecology among senior secondary students in Zaria.

1. The relationship between critical thinking skills and academic performance of students who were exposed to hands-on learning strategy in secondary schools could be determined since it was not covered in this study.
2. Similar researches can be constructed for different science topics, and different levels of education with larger sample size.
3. This study could be expanded to other secondary school as well as primary and higher institutions in the remaining/other Education Zones of the State.

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APPENDIX A

ECOLOGY CONCEPTS PERFORMANCE TEST (ECPT)

SECTION A: Bio-data

Gender: Male [ ] Female [ ]

SECTION B: Instruction; Answer all Questions from Section A and B

Time Allowed: 45 minutes

- Write your name, identification number and tick the gender in the space provided.
- Read each question carefully.
- Go to your answer sheet and shade the correct letters A-D.
- Shade only one alphabet on each question.

1. The study of organism and the environment of an abandoned farmland is the ecology of
    A. A community
    B. A population
    C. A habitat
    D. An ecosystem
2. The complex relationship between the members of a community and between community as a whole and its physical environment is
    A. Ecosystem
    B. Habitat
    C. Environment
    D. Niche
3. Secchi disc is used in the determination of
    A. Rainfall
    B. Tides
    C. Waves
    D. Turbidity
4. If three 30cm lengths of glass tubing are tightly packed with clay, sand and loamy soils respectively, and then stood in a beaker of water for one week, the level of water will be
    A. Lowest in the tube with clay
    B. The same in all the tubes
    C. Highest in the tube with sandy soil
    D. Lowest in the tube with sandy soil

5. A few grams of dried soil were first heated until red hot and then further heated until no more smoke was released. This experiment was to determine the:
   A. Amount of water in soil
   B. Percentage of water in soil
   C. Present of humus in soil
   D. Resistance of laterite to heat
6. Soil is said to be fertile if
   A. It is black
   B. It can supply usable nutrients to plants
   C. The oxygen content is very high
   D. Artificial manure is added to it
7. A population is defined as the collection of:
   A. Similar organisms that are found in the same habitat
   B. Similar organisms that breed in the same habitat
   C. Similar organisms that interbreed freely in the same habitat
   D. Similar organism that eat the same feed
8. 28g of soil sample was heated to constant weight of 24g. When further heated to red hot and cooled, it weighted 18g. What is the percentage of humus in the soil?
   A. 21.4
   B. 55.6
   C. 75.0
   D. 25.0
9. An anemometer is an instrument for measuring
   A. Relative humidity
   B. Altitude
   C. Wind speed
   D. Turbidity
10. Which of the following groups of factor is completely abiotic?
    A. Salinity, tide, plankton, turbidity
    B. Temperature, pH, soil, insect
    C. Wind, altitude, humidity, light
    D. Conifers, pH, rainfall
11. If a hand full of sand is shaken with water and left to settle, the soil particles will settle from light to heavy particles as follows
    A. Humus, clay, silt, sand, stone
    B. Humus, silt, clay, sand, stone
    C. Humus, clay, silt, sand, stone
    D. clay, Humus, silt, sand, stone

12. Which of the following has the greatest influence on the distribution of animals in the marine and fresh water habitat?
    A. pH
    B. salinity
    C. water current
    D. turbidity
13. The word 'ecology' is a branch of biology concerned with the study of
    A. Interrelationships between living organisms and their external environment.
    B. The study of living organisms
    C. The study of snails and snakes
    D. The capillary movement of water in plants
14. In ecology, the total surrounding of an organism is called its:
    A. Surrounding
    B. Environment
    C. Temperature
    D. None of the above
15. The study of an individual organism or a single species of an organism and its environment is known as
    A. Biosphere
    B. Synecology
    C. Autecology
    D. All of the above
16. The study of interrelationships between groups of organisms living together in an area is called
    A. Gynecology
    B. Autecology
    C. Synecology
    D. Topocology
17. The main kinds of habitats are
    A. Arboreal and ground habitat
    B. nderground and Arboreal habitats
    C. Aquatic and terrestrial habitats
    D. Salt and fresh water habitats
18. The factors which influence living organisms in their habitats and control their survival and distribution are called
    A. Habitat factors
    B. Ecological factors
    C. A and B only
    D. Physical factors

19. Abiotic factors are referred to the following except:
    A. Physical factors
    B. Biotic factors
    C. Climatic factors
    D. Edaphic factors
20. An example of topographic factors is:
    A. Temperature
    B. Rainfall
    C. Elevation
    D. Soil texture
21. The ecological unit that composed of organisms and their physical environments is
    A. Niche
    B. Population
    C. Ecosystem
    D. Community
22. Organisms which breakdown the compounds of dead organisms are called
    A. Phagotrophs
    B. Parasites
    C. Saprophytes
    D. Producers
23. Which of these must be present in an ecosystem if the ecosystem is to be maintained
    A. Producers and carnivores
    B. Producers and decomposers
    C. Carnivores and decomposers
    D. Herbivores and carnivores
24. The relationship between fungi and algae in lichens is known as
    A. Mutualism
    B. Parasitism
    C. Commensalism
    D. Saprophytism
25. All ecosystems have three basic components. Which one of the following is not necessarily found in the entire ecosystem?
    A. "producers" plants
    B. Animal "consumers"
    C. Decomposers
    D. Parasites and communalists
26. A sequence of species related to another predator and prey is a/an
    A. Trophic level
    B. Ecosystem
    C. Food chain
    D. Climax

27. An association between two organisms in which both benefit is known as:
    E. Parasitism
    F. Symbiosis
    G. Commensalism
    H. Predation
28. Which of the following is not a structural adaptation of desert plants for water conservation
    A. Tiny leaves
    B. Sunken stomata leaves
    C. Stems and leaves with heavy cuticle
    D. Broad leaves with numerous stomata
29. In cold climates or at high altitudes, some small mammals fall asleep in some specially prepared nests or burrows. This process is known as:
    A. Hibernation
    B. Masturbation
    C. Conservation
    D. Contraction
30. Fewer number of trees is a characteristic of the savannah zones of Nigeria because
    A. There is too much sunlight
    B. They are usually exposed to grazing animals
    C. There is limited amount of rainfall
    D. The driest savannah consists of almost entirely of grasses
31. The number of individuals in a habitat in relation to the unit space available to each organism is referred to as the
    A. Birth rate
    B. Density
    C. Mortality
    D. Frequency
32. In a complex feeding relationships in a community, where the organisms benefit from each other is referred to as:
    E. Symbiosis
    F. Omnivores
    G. Heterotrophs
    H. Autotrophs
33. Predators are beneficial in pest control because they:
    A. Are natural enemies of small mammals
    B. Feed on pests of crops
    C. Devour farm animals
    D. Compete for food with pests

34. Which of the following limiting resources is competed for by organisms in the desert?
    A. Light
    B. Temperature
    C. Oxygen
    D. Water
35. Water guinea grass, grasshopper, toad , snake, hawk (Producer) (Primary consumer) (Secondary consumer) (Tertiary consumer)
    The above example of a food chain belongs to
    A. Terrestrial habitat
    B. Aquatic habitat
    C. Ecosystem
    D. Food web
36. A complex relationship among organisms in the same environment with two or more interrelated food chains is an example of a
    A. Food web
    B. Pyramid of numbers
    C. Pyramid of biomass
    D. Simplified food chain
37. An interaction between two species in which one species attacks and kill the other is known as
    A. Inter-specific competition
    B. Intra-specific competition
    C. Predation
    D. A only
38. Without the sun, no green plants could exist. And without green plants no animal life could exist. The green plants are called
    A. Primary consumers
    B. Secondary producers
    C. Tertiary consumers
    D. Primary producers
39. Changes in energy flow between organisms in a habitat can be represented by a
    A. Pyramid of biomass
    B. Pyramid of numbers
    C. Pyramid of energy
    D. Food chain
40. Which of the following groups consists of heterotrophs?
    A. Mucor, Chlamydomonas and Euglena
    B. Spirogyra, Mucor and Mushroom
    C. Man, Mucor and Mushroom
    D. Chlamydomonas, man and maize

APPENDIX B

MARKING SCHEME OF ECOLOGY CONCEPTS PERFORMANCE TEST (ECPT)

1	D	11	A	21	C	31	B
2	A	12	A	22	C	32	C
3	D	13	A	23	B	33	B
4	D	14	B	24	B	34	D
5	C	15	C	25	D	35	A
6	B	16	C	26	A	36	A
7	A	17	C	27	B	37	C
8	A	18	B	28	C	38	D
9	C	19	B	29	A	39	C
10	C	20	C	30	C	40	C

Total = 1 mark X 40 = 40 marks

APPENDIX C

ANSWER SHEET FOR ECOLOGY CONCEPTS PERFORMANCE TEST (ECPT)

SECTION A: Bio-data

Admission Number: ……………………………………………………………….

Gender Male [ ] Female [ ]

SECTION B: Instruction

Please shade the correct option appropriately.

1	=A=	=B=	=C=	=D=	21	=A=	=B=	=C=	=D=
2	=A=	=B=	=C=	=D=	22	=A=	=B=	=C=	=D=
3	=A=	=B=	=C=	=D=	23	=A=	=B=	=C=	=D=
4	=A=	=B=	=C=	=D=	24	=A=	=B=	=C=	=D=
5	=A=	=B=	=C=	=D=	25	=A=	=B=	=C=	=D=
6	=A=	=B=	=C=	=D=	26	=A=	=B=	=C=	=D=
7	=A=	=B=	=C=	=D=	27	=A=	=B=	=C=	=D=
8	=A=	=B=	=C=	=D=	28	=A=	=B=	=C=	=D=
9	=A=	=B=	=C=	=D=	29	=A=	=B=	=C=	=D=
10	=A=	=B=	=C=	=D=	30	=A=	=B=	=C=	=D=
11	=A=	=B=	=C=	=D=	31	=A=	=B=	=C=	=D=
12	=A=	=B=	=C=	=D=	32	=A=	=B=	=C=	=D=
13	=A=	=B=	=C=	=D=	33	=A=	=B=	=C=	=D=
14	=A=	=B=	=C=	=D=	34	=A=	=B=	=C=	=D=
15	=A=	=B=	=C=	=D=	35	=A=	=B=	=C=	=D=
16	=A=	=B=	=C=	=D=	36	=A=	=B=	=C=	=D=
17	=A=	=B=	=C=	=D=	37	=A=	=B=	=C=	=D=
18	=A=	=B=	=C=	=D=	38	=A=	=B=	=C=	=D=
19	=A=	=B=	=C=	=D=	39	=A=	=B=	=C=	=D=
20	=A=	=B=	=C=	=D=	40	=A=	=B=	=C=	=D=

APPENDIX D

ATTEMPT ALL THE FOLLOWING QUESTIONS

ECOLOGY CONCEPTS CRITICAL THINKING QUESTIONNAIRE (ECCTQ)

Dear Respondent,

The bearer of this research instrument is a student of Master of Education in the Department of Science Education, Faculty of Education, Ahmadu Bello University, Zaria. The items presented are designed to determine the degree of your Critical Thinking in Ecology Concept of Senior Secondary School Biology. You are therefore requested to rate yourself on the questionnaire items. You are guaranteed an outmost confidentiality as the information provided are used strictly for this research only.

Please take note of the following keys:

SA - - - - - Strongly Agreed

A - - - - - Agreed

D - - - - - Disagreed

S.D - - - - - Strongly Disagreed

U.D - - - - - Undecided

Thanks!

IBRAHIM ABDULSALAM

SECTION A: Bio-data

Admission Number: ……………………………………………………………….

Gender: Male [ ] Female [ ]

SECTION B: Instruction; Attempt all the following questions

Please tick (√) the appropriate column that suits your interest.

S/NO	ITEMS	SA	A	D	SD	UD
1	My teacher asks questions that require me to remember certain facts about ecological concept.					
2	My teacher asks questions that help me to predict what comes next when studying ecology concept.					
3	My teacher asks questions that check I understand how to do something in terms of classifying organisms around me based on ecology concept.					
4	My teacher asks questions that challenge me to think in new ways regarding the learning of ecology concept.					
5	My teacher asks questions that require me to give my opinion on methods of population studies in ecology concept.					
6	My teacher asks questions that require me to justify my opinion based on the knowledge of component of an ecosystem in ecology concept.					
7	My teacher asks questions that help me to reflect on my learning and in connection with ecology.					
8	My teacher asks questions that help me relate what I already know to what I am learning now.					
9	My teacher asks questions that help me relate my understanding to the real world.					
10	My teacher asks questions that help me to use my learning in other topics and subjects.					
11	My teacher provides enough time for me to think and answer questions in ecology and other topics/subjects.					
12	My teacher provides opportunities for me to ask questions on ecology concepts.					
13	My teacher provides different ways for me to respond to a question (written, verbal, visual and physical).					
14	My teacher asks questions that we can discuss and share how we might go about completing a task in ecology concepts.					
15	My teacher asks questions so we can discuss different ideas and theories in relation to ecology concepts.					
16	My teacher asks questions that we can debate and justify our ideas about ecology and related topics.					
17	My teacher asks a range of question types so we can all participate in the teaching and learning of ecology.					

18	My teacher provides opportunities for all students to answer questions on ecology concepts based on the interactions with the environment.					
19	The ecology teacher very often encourages us to apply our insight to new or other situations.					
20	My ecology teacher very often makes me feel engaged in class and learning of ecology.					
21	I appreciate the way my teacher explained the concept of ecology by relating the concepts with the immediate environment.					
22	My ecology teacher very often support us when we try to show good thinking in ecology concepts					
23	My ecology teacher helped me greatly to work through complexities in issues without giving up on ecological concepts					
24	My ecology teacher helped me greatly to make logical connections when studying ecology concepts on the danger of ecological hazards					
25	Critical Thinking has the capacity to develop first-hand skills in ecology classroom interaction					
26	My ecology teacher helped me greatly to identify specific examples to illustrate my reasoning skills in identifying and classifying various organisms in the environment.					
27	My ecology teacher helped me greatly to understand that my prejudices or biases influence my thinking on ecology concepts.					
28	My ecology teacher helped me greatly to know what clear questions are when I learn					
29	My ecology teacher helped me greatly to consider multiple perspectives in my subject matter					
30	I will like my school to introduced Hands-on Learning Strategy in order to develop Critical Thinking skills to enhance classroom activities for teaching ecology					

APPENDIX E

Learning Critical Thinking Inventory (LCTI) for Students

Did not help me at all				Helped me greatly
1	2	3	4	5

The Instructor of the subject/course helped me:

1. _________ Think about my thinking
2. _________ Know what clear questions are when I learn
3. _________ Identify specific examples to illustrate my reasoning
4. _________ Consider multiple perspectives in my subject matter
5. _________ Make logical connections when studying subject matter
6. _________ Understand that my prejudices or biases influence my thinking
7. _________ Work through complexities in issues without giving up

Not at all				Very often
1	2	3	4	5

How often did the instructor:

8. __________ Support us when we try to show good thinking
9. __________ Ask questions that help us think more carefully
10. __________ Encourage us to apply our insight to new or other situations
11. __________ Make me feel engaged in class and learning

Source: Van Zyl, M.A., Bays, C.L., & Gilchrist, C. (2013). Assessing teaching critical thinking with validated critical thinking inventories: The learning critical thinking inventory (LCTI) and the teaching critical thinking inventory (TCTI). Inquiry: Thinking Across The Discipline, 28(3), 40-50.

APPENDIX F

LESSON PLAN FOR EXPERIMENTAL GROUP

LESSON ONE WEEK ONE

Theme: Environmental Biology/ Interaction in Nature

Model of Teaching: Hands-on Learning Strategy

Class: SS2

Duration: 80 Minutes

Subject: Biology

Topic: Ecology

Sub-topic: Basic Ecological Concepts

Average: 16 years

Number of Students: 130

Instructional Materials: 1. Charts illustrating forest reserve and a botanic garden/varieties of organisms

2. Charts illustrating Ecological study of plant and animals.

Behavior Objectives: By the end of the lesson, the students should be able to:

i. Define ecology and identify its branches;

ii. Define and explain the following ecological concepts: autecology, synecology, lithosphere, hydrosphere, biosphere/Ecosphere, atmosphere

iii. What are the main types of habitat?

Previous Knowledge: Students have been familiar with the meaning and concept of biology.

Introduction: The teacher introduces the lesson by leading the students to identify some aspects of life interactions that proves the relevance of biology to man.

Presentation:

Step I: Identification of prior Ideas

Teacher Activities: Teacher asks students the following questions based on their thinking about environmental biology:

ii. What is ecology and ecosystem?

iii. What is autecology and synecology?

Students Activities:

i. Students attempt the teacher's questions above;

ii. Students ask the teacher questions

Step II: Exploration

Students Activities:

Teacher guides the students to observe the lesson's instructional materials

Teacher guides students using hands-on learning strategy to define and explain basic ecological terms (such as: ecology, autecology, synecology, lithosphere, hydrosphere, biosphere/Ecosphere, atmosphere, environment, habitat, community ecological niche) in the following stages:

a. Students observe group of organisms of the same species;

b. Students identify particular places organisms inhabit;

c. Students discuss varieties of plants and the animals living in a habitat that form Community;

d. Students record the habitat and the community together forms a natural unit;

e. Students further study charts showing different types of water bodies and areas of Land (e.g forest).

Students with the guide of the teacher describe the concept of:

i. Ecology as a branch of biology that deals with the study of plants and animals in relation to their environment. Ecology is derived from a Greek word "Oikos" which means home or dwelling place.
ii. Autecology - is concerned with the study of an individual organism or a single species of organism and its environment. Example, the study of a single rat and its environment.
iii. Synecology - is concerned with the study of the interrelationships between groups of organisms or species of organisms living together in an area. Example, the study of different organisms in a river in relation to their aquatic environment.
iv. Biosphere or Ecosphere: this is the zone of the earth occupied by living organisms. It is a layer of life which exists on the earth's surface.
v. Lithosphere: is the solid portion of earth. It is the outermost layer of zone of the earth's crust. It is made up of rocks and mineral materials, and it also represents 30% of the earth's surface.
vi. Hydrosphere: is the liquid/aquatic part of the earth or living world. It covers about 70% of the earth's crust. It holds water various forms - solid ice, liquid (water) and as gases (water vapour).
vii. Atmosphere: the atmosphere is the gaseous of the earth. It is a layer of gases surrounding the earth over 99% of the atmosphere within 30Km of the earth surface.
viii. Students carried out the activities giving by the teacher

ix. Students ask questions

Step III: Discussion

Teacher activities:

The teacher guides the students to discuss ideas from the various activities carried out as follows; to:

i. list similarity between ecology and ecosystem;
ii. state two (2) main branches of ecology
iii. identify difference(s) between autecology and synecology
iv. enumerate the main types of habitat
v. outline the relationship between atmosphere and biosphere

Students Activities:

i. Students participate actively in the discussion by contributing their ideas
ii. Students ask questions

Step IV: Application

Teacher Activities:

The teacher guides students to mention the application of basic terms in ecology as follows:

i. state the importance of ecology to the society
ii. list the significance of ecosystem
iii. identify the roles of autecology and synecology in ecological system

Students Activities:

i. Students mention the application of basic terms in ecology.
ii. Students ask questions

Step V: Evaluation:

Teacher Activities:

The teacher evaluates the lesson by asking the following questions:

i. Define ecology and identify its branches;
ii. Define and explain the following ecological concepts: autecology, synecology, lithosphere, hydrosphere, biosphere/Ecosphere, atmosphere;
i. What are the main types of habitat?

Summary and Conclusion

The teacher highlights the main points of the lesson along with the students.

LESSON PLAN FOR EXPERIMENTAL GROUP

LESSON TWO: WEEK TWO

Theme: Environmental Biology

Model of Teaching: Hands-on Learning Strategy

Class: SS2

Duration: 80 Minutes

Subject: Biology

Topic: Components of Ecosystem

Average: 16 years

Number of Students: 130

Instructional Materials: Sample specimens of organisms, Charts, Photographs and films of different biotic communities in Nigeria and biomes of the World

Behavioral Objectives: By the end of the lesson, the students should be able to:

i. List the components of the ecosystem
ii. Identify the biotic components of the ecosystem and explain them
iii. Describe the abiotic components of the ecosystem

Previous Knowledge: The students have been taught the ecological concepts

Introduction: The teacher introduces the lesson by asking the students to make a list of all they observed in the environment and on the charts, Photographs and films.

Presentation: Based on the students' responses, the teacher presents the lesson in the following steps:

Step 1: Identification of Prior Ideas

Teacher Activities:

The teacher asks students the following questions:

i. What is an ecosystem?
ii. What are the components of ecosystem?

Students Activities:

1. Students response to the questions
2. Students ask questions

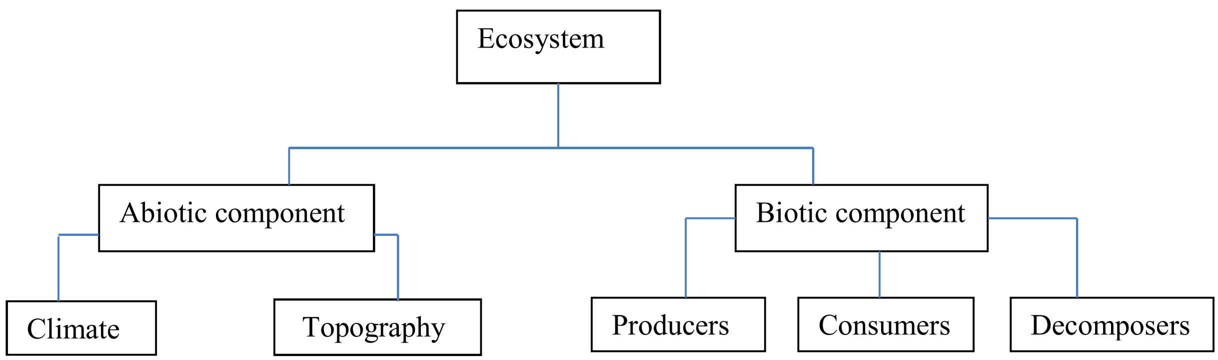
Step 2: Exploration

Students Activities:

i. The teacher guides the students to observe the Charts, Photographs and films of different biotic communities in Nigeria and biomes of the World;

ii. Students collect sample specimens, study the displayed charts by the teacher, and record their observations;

iii. Students with the guide of the teacher define and explain that: ecosystem is made up of abiotic and biotic components. The diagram below illustrates the components of ecosystem.



iv. Students classify the biotic components of the ecosystem into producer, consumer and decomposer;

v. The students with the guide of the teacher describe the biotic components of the ecosystem that:

Producers are green plants which can make their own food through the process of photosynthesis, these plants are autotrophs;

Consumers are animals which feed on plants or on other animals. They are said to be heterotrophs consumers are sub-divided as follows;

Primary consumers are animals which feed directly on plant e.g cattles, grasshopper.

Secondary and tertiary consumers are animals that feed on primary consumers examples hawks, leopards;

Omnivores are animals that feed on both plants and animals e.g man;

Decomposers are organisms which feed on the carcasses of dead producers and consumers and in the process bring about the decay of such carcasses.

Step 3: Discussion

Teacher Activities:

i. The teacher guides the students to discuss ideas from the various activities carried out as follows:
ii. State the similarity between ecosystem and habitat;
iii. Identify the components of ecosystem
iv. Enumerate the types of biotic components

Students Activities:

i. Students participate actively in the discussion by contributing their ideas
ii. Students ask questions

Step IV: Application

Teacher Activities:

The teacher guides students to mention the application of basic terms in ecosystem as follows:

i. Mention the importance of ecosystem to the environment
ii. State the significance of ecosystem in environmental biology
iii. List the roles of decomposers in/to the atmosphere

Students Activities:

i. Students response to the application of basic terms in ecosystem
ii. Students ask questions

Step 5: Evaluation:

Teacher Activities:

The evaluates the lesson by asking the following questions:

i. List the components of the ecosystem
ii. Identify the biotic components of the ecosystem and explain them
iii. Describe the abiotic components of the ecosystem

Summary and Conclusion: The teacher concludes the lesson by highlighting the points of the lesson.

LESSON PLAN FOR EXPERIMENTAL GROUP

LESSON THREE: WEEK THREE

Theme: Environmental Biology

Model of Teaching: Hands-on Learning Strategy

Class: SS2

Duration: 80 Minutes

Subject: Biology

Topic: Population Studies

Average: 16 years

Number of Students: 130

Instructional Materials: Sampling instruments and Ecological instruments; such as Quadrat, Insect net, tape-rule, fish trap, dry and wet thermometer, rain gauge.

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

i. Define and explain population
ii. Define population size, density, dominance and frequency;
iii. List and explain five (5) ecological instruments and their uses
iv. Identify various ecological instruments and describe them

Previous Knowledge: The students are familiar with the branches of ecology with the terms associated to it, such as ecosystem, environment, population, habitat, e.t.c

Introduction: The teacher introduces the lesson by asking the students to mention some of the terms associated with ecology

Presentation: Based on the students' responses, the teacher presents the lesson in the following steps:

Step 1: Identification of Prior Ideas

Teacher Activities: The teacher guides the students on/how to:

i. What is population?
ii. Identify and describe animal survival in the environment by eating plants and other animals.
iii. What are the function of thermometer, rain gauge and secchi disc?
iv. What are the methods used for population studies?

Students Activities:

1. Students response to the questions above
2. Students ask questions

Step 2: Exploration

Students Activities:

i. The teacher guides the students to display some of the population/ecological instruments for study

ii. The teacher guides the students to observe, identify and record the instruments

iii. The students through the guide of the teacher identify the usage of the various measuring instruments to measure the physical factors of the ecosystem such as temperature, rainfall, etc

iv. The students define and explain the term population

v. The students identify and explain the various terms associated with population: population size, density, dominance and frequency.

vi. The students through the guide of the teacher identify the various methods used for population studies

vii. Students ask questions

Step 3: Discussion

Teacher Activities: The teacher leads the students to discuss the various methods used for population Studies

Students Activities:

i. The students participate in identifying the roles of the ecological instruments

ii. Students ask questions

Step IV: Application

Teacher Activities: The teacher guides students to identify the application of basic terms in population studies as follows:

i. the importance of population studies to the environment

ii. the significance of instruments in environmental biology

iii. the roles of ecological factors to the organisms in the atmosphere

iv. Students ask questions

Step V: Evaluation:

Teacher Activities: The teacher evaluates the lesson by asking the following questions:

i. Define and explain the term population

ii. Describe briefly the following terms: (a) Population size; (b) Population density;
(c) Population dominance;

iii. Outline and describe methods of population studies

iv. Identify and explain any five (5) ecological instruments and their uses

Summary and Conclusion: The teacher concludes the lesson by highlighting the points of the lesson.

LESSON PLAN FOR EXPERIMENTAL GROUP

LESSON FOUR: WEEK FOUR

Theme: Environmental Biology

Model of Teaching: Hands-on Learning Strategy

Class: SS2

Duration: 80 Minutes

Subject: Biology

Topic: Ecology

Sub-topic: Functioning Ecosystem

Average: 16 years

Number of Students: 130

Instructional Materials: Samples of Autotrophs and Heterotrophs (plants and animals) for food chain and food web, cardboard paper and marker

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

i. Define food chain;
ii. Define food web; and,
iii. Illustrate the food chain and food web using diagrams.

Previous Knowledge: The students are familiar with the main components of the ecosystem.

Presentation: Based on the students' responses, the teacher presents the lesson in the following steps.

Step 1: Identification of Prior Ideas

Teacher Activities:

The teacher leads the students to:

a) Recognize that food relationship exists among living things;
b) Recognize that chemical energy (in the form of carbohydrate, fats and proteins) and nutrients are transferred among producers, consumers and decomposers;
c) State that trophic level refers the parts of food chain;
d) Correctly define (or describe) food chains and pyramid of energy/numbers; and,
e) Describe the nature of energy transfer or flow in the ecosystem.

Students Activities: The students actively participate and respond to the above activities.

Step 2: Exploration

Students Activities:

i. The teacher guides the students to observe the sample specimens of the various organisms;

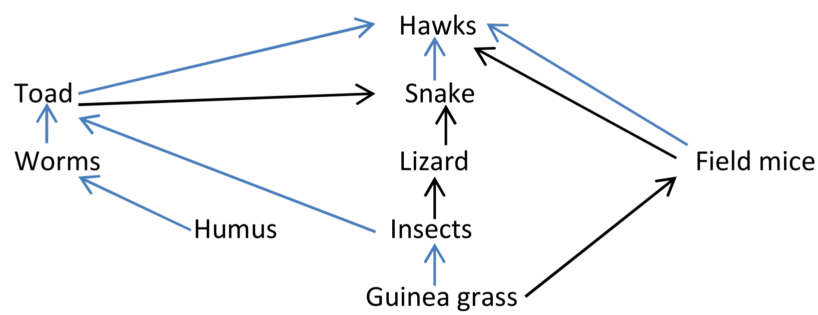
ii. The students define a food web as a complex feeding relationship consisting of interrelated food chains.

iii. The teacher guides the students to illustrate and describe the diagrams of food chain and food web.

Grass → grasshopper → toad → snake → hawk.

A complex feeding relationship consisting of interrelated food chain is called food web.

Example of food web is shown below.



Step 3: Discussion

Teacher Activities: The teacher guides the students to discuss ideas from the various activities they had been carried out by asking them to:

i. To make a chart/ illustration showing relationship among organisms, e.g food chain, food web

ii. Differentiate between food chain and food web?

Students Activities:

i. The students develop and construct a chart showing relationships among organisms (food chain and food web);

ii. The students construct and explain pyramid of energy/number;

iii. The students identify and differentiate between food chain and food web; and,

iv. Students ask questions.

Step IV: Application

Teacher Activities:

The teacher guides students to identify the applications of feeding relationship in an ecosystem as follows:

a) Identify the importance/role of food chain and food web to the environment;

b) Analyze the relationship between autotrophs and heterotrophs in the environment

c) Describe three (3) roles of trophic level in/to in the environment

Students Activities:

i. Students response to the application of feeding relationship

ii. Students ask questions

Evaluation: The teacher evaluates the students by asking the following questions

i. Define food chain and food web;

ii. In a tabular form, identify three (3) differences each between food chain and food web;

iii. Using different organisms, produce/illustrate diagrammatic representation of two (2) examples each of food chain and food web

Summary and Conclusion: The teacher concludes the lesson by revising all that he has taught.

LESSON PLAN FOR EXPERIMENTAL GROUP

LESSON FOUR: WEEK FIVE

Theme: Environmental Biology

Model of Teaching: Hands-on Learning Strategy

Class: SS2

Duration: 80 Minutes

Subject: Biology

Topic: Ecology

Sub-topic: Ecological Factors

Average: 16 years

Number of Students: 130

Instructional Materials: Different types of measuring instruments, such as measuring cylinder, wind vane, thermometer, rain gauge, and meter-rule.

Behavioral Objectives: By the end of the lesson, the students should be able to:

i. Measure three (3) of the ecological factors which they have studied; e.g temperature.
ii. Identify and explain three (3) peculiar factors of ecology, each of aquatic an terrestrial habitats respectively;
iii. Enumerate five (5) ecological factors common to both aquatic and terrestrial habitat
iv. Distinguish with reason(s) between the types of ecological factors; and,
v. Name four ecological factors that are found in your locality/community.

Previous Knowledge: The students are familiar with the main components of the ecosystem.

Presentation: Based on the students' responses, the teacher presents the lesson in the following steps.

Step 1: Identification of Prior Ideas

Teacher Activities:

The teacher begins by asking the students the main components of the ecosystem;

How do animals survive in the habitats/ environment by eating plants and other animals?

The teacher then guides the students to identify two (2) main types of ecological factors; as the biotic and abiotic factors, as well as factors that are common to both.

Students Activities: Students respond to the above questions and ask questions.

Step 2: Exploration

Students Activities:

i. The teacher guides the students to observe the sample specimens of the various organisms in relation to their habitats
ii. The students identify and describe the types of ecological factors.
iii. State and explain two (2) main types of the types of ecological factors;

Step 3: Discussion

Teacher Activities: The teacher guides the students to discuss ideas from the various activities they had been carried out using the following questions:

a. What are abiotic components, and how do they relate with ecological factors?
b. Distinguish with reason(s) between the types of ecological factors; and,
c. State and explain three (3) each of the types of ecological factors

Students Activities:

The students participate in responding to the questions and activities above;
Students ask questions

Step IV: Application

Teacher Activities:

The teacher guides students to identify the applications of the ecological factors in an environment as follows:

a. Measure some of the ecological factors in the environment based on their studies;
b. Analyze and improvise some measuring instruments e.g wind vane;
c. Describe and synthesize the causes of the various factors affecting the population

Students Activities:

i. Students response to the application of feeding relationship
ii. Students ask questions

Evaluation: The teacher evaluates the students by asking the following questions

i. Identify and describe the two (2) types of ecological factors;
ii. State and explain three (3) each of the types of ecological factors; and
iii. Distinguish with reason(s) between the types of ecological factors
iv. Name four ecological factors that are found in your locality/community.

Summary and Conclusion: The teacher concludes the lesson by revising what were taught.

LESSON PLAN FOR EXPERIMENTAL GROUP

LESSON FIVE: WEEK SIX

Theme: Environmental Biology

Model of Teaching: Hands-on Learning Strategy

Class: SS2

Duration: 80 Minutes

Subject: Biology

Topic: Ecology

Sub-topic: Energy Transformation

Average: 16 years

Number of Students: 130

Instructional Materials: Charts and cardboard showing the changes of energy from one form to another.

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

1. State why the tip of the pyramid of energy has the least number of organisms;
2. State the first and second Laws of thermodynamics
3. Describe the following terms: (i) Symbiosis (ii) Parasitism (iii) Commensalism (iv) pollution (vi) Predation (vii) Mortality (viii) Migration (ix) Dispersal (x) Mutualism (xi) Disease.

Previous Knowledge: The pupils have been taught on the biotic and abiotic components of the ecosystem

Introduction: The teacher introduces the lesson by asking the pupils in what ways organisms interacts with each other and the environment.

Presentation: Based on the students' response the teacher presents the lesson in the following steps:

Step 1: Identification of Prior Ideas

Teacher Activities:

The teacher leads the students to:

a) Use the knowledge of energy losses in the ecosystem to explain the pyramidal shape of feeding relationships;

b) Identify different types of association (such as symbiosis, parasitism, commensalism) which exist during the transfer of energy, including the adaptation and competitive activities;
c) State that only a small percentage of the radiant energy actually gets to plants; and,
d) State the first and second laws of thermodynamics and use them to explain ecological events such as pyramid of energy, food chain energy flow;

Students Activities: The students actively participate and respond to the above activities.

Step 2: Exploration

Students Activities:

i) The teacher guides the students to observe and identify the chart and cardboard displayed showing the flow of energy in an ecosystem/environment.

ii) The students identify and describe activities that involve the change and transfer of energy inform of food, from one organism to another; either in linear or complex feeding relationship

Step 3: Discussion

Teacher Activities: The teacher guides the students to discuss ideas from the various activities they had been carried out by leading them to:

i. Recall and synthesize instances which are explained by laws of thermodynamics;
ii. Students discuss energy loss as a limiting factor in primary production (i.e production of autotrophy.

Students Activities:

i. Students recall and synthesize instances which are explained by laws of thermodynamics;
ii. Discuss energy loss as a limiting factor in primary production (i.e production of autotrophy.

Step IV: Application

Teacher Activities:

The teacher guides students to identify the applications of energy transformation as follows:

a. Use the knowledge of energy losses in the ecosystem to explain the pyramidal shape of feeding relationships;
b. Identify and analyze the measures of primary production; e.g the amount and rate of of energy fixation;

c. Analyze the feeding relationship between autotrophs and heterotrophs in the environment
d. Describe and synthesize the types of association, as well as adaptation, competition and pollution.

Students Activities:

a. Students response to the application of feeding relationship
b. Students ask questions

Evaluation: The teacher evaluates the lesson by asking the following questions:

1. Describe why the tip of the pyramid of energy has the least number of organisms;
2. State and analyze the first and second Laws of thermodynamics
3. Describe the following terms: (i) Symbiosis(ii) Parasitism (iii)Commensalism (iv)pollution (vi) Predation; (vii) Mortality; (viii) Migration; (ix) Dispersal; (x) Mutualism (xi) Disease.

Summary and Conclusion: The teacher concludes the lesson by revising all that he has taught.

APPENDIX G

LESSON PLAN FOR CONTROL GROUP

LESSON ONE: WEEK ONE

Theme: Environmental Biology

Model of Teaching: Lecture Method

Class: SS2

Duration: 80 Minutes

Subject: Biology

Topic: Ecology

Sub-topic: Basic Ecological Concepts

Average: 16 years

Number of Students: 133

Instructional Materials: Charts illustrating Ecological, Essential Biology Textbook the study of plant and animals.

Behavior Objectives: At the end of the lesson, the students should be able to:

i. Define ecology

ii. Explain in their own words the following ecological concepts: a. Autecology; b. Synecology; ii. Lithosphere; d. Hydrosphere; e. Biosphere/Ecosphere; f. Atmosphere

Previous Knowledge: Students have been taught the meaning and concept of biology

Introduction: The teacher asks the students either they have heard of the word ecology before.

Presentation: Based on the student's responses the teacher present the lesson in the following steps:

Step I: The concept of "ecology": a branch of biology that deals with the study of plants and animals in relation to their environment. Ecology is derived from a Greek word "Oikos" which means home or dwelling place.

Step II: In other words, ecology can be defined /described based on its origin as:

i. a field of study which deals the relationships of living organisms with one another and with the environment in which they live. **ii.** an environmental biology; **iii.** classified ecology into two main branches namely, Autecology and Synecology.

Step III: The teacher leads the students in defining basic ecological concepts; thus,

i. Autecology: is concerned with the study of an individual organism or a single species of organism and its environment. Example, the study of a single rat and its environment.

ii. Synecology: is concerned with the study of the interrelationships between groups of organisms or species of organisms living together in an area. Example, the study of different organisms in a river in relation to their aquatic environment.

iii. Biosphere or Ecosphere: this is the zone of the earth occupied by living organisms. It is a layer of life which exists on the earth's surface.

iv. Lithosphere: is the solid portion of earth. It is the outermost layer of zone of the earth's crust. It is made up of rocks and mineral materials, and it also represents 30% of the earth's surface.

v. Hydrosphere: is the liquid/aquatic part of the earth or living world. It covers about 70% of the earth's crust. It holds water various forms - solid ice, liquid(water) and as gases(water vapour).

vi. Atmosphere: the atmosphere is the gaseous of the earth. It is a layer of gases surrounding the earth over 99% of the atmosphere within 30Km of the earth surface.

Evaluation: The teacher evaluates the lesson by asking the following questions:

1. What is ecology?
2. Discuss the following terms: a. Biosphere; b. Lithosphere; c. Hydrosphere; d. Autecology;

Summary and Conclusion: The teacher highlights the main points of the lesson along with the students.

LESSON PLAN FOR CONTROL GROUP

LESSON TWO: WEEK TWO

Theme: Environmental Biology

Model of Teaching: Lecture Method

Class: SS2

Duration: 80 Minutes

Subject: Biology

Topic: Component of Ecosystem

Average: 16 years

Number of Students: 133

Instructional Materials: Charts, Photographs and films of different biotic communities in Nigeria and biomes of the World

Behavioral Objectives: By the end of the lesson, the students should be able to:

i. List the components of the ecosystem;

ii. List the biotic components of the ecosystem;

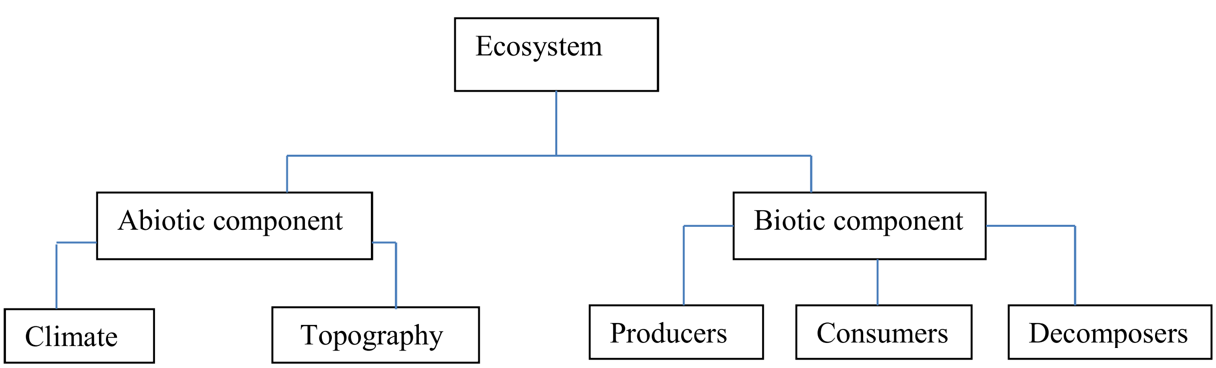
iii. Describe the biotic components of the ecosystem;

Previous Knowledge: The students have been taught the ecological concepts

Introduction: The teacher introduces the lesson by asking the students to make a list of all they observed in the environment.

Presentation: Based on the students' responses the teacher presents the lesson in the following steps:

Step 1: The ecosystem is made up of abiotic and biotic components. The diagram below illustrates the components of ecosystem.



Step 2: The biotic components of the ecosystem areas follow:

1. Producers
2. Consumers
3. Decomposers

Step 3: The teacher further describes the biotic components of the ecosystem that;

Producers are green plants which can make their own food through the process of photosynthesis, these plants are autotrophs;

Consumers are animals which feed on plants or on other animals. They are said to be heterotrophs consumers are sub-divided as follows:

Primary consumers are animals which feed directly on plant e.g cattles, grasshopper.

Secondary and **tertiary** consumers are animals that feed on primary consumers examples hawks, leopards

Omnivores are animals that feed on both plants and animals e.g man

Decomposers are organisms which feed on the carcasses of dead producers and consumers and in the process bring about the decay of such carcasses.

Evaluation: The teacher evaluates the lesson by asking the following questions:

1. List the two (2) major components of the ecosystem
2. Describe briefly the following terms:
   i. Producers
   ii. consumers
   iii. decomposers

Summary and Conclusion: The teacher concludes the lesson by highlighting the points of the lesson.

LESSON PLAN FOR CONTROL GROUP

LESSON THREE: WEEK THREE

Theme: Environmental Biology

Model of Teaching: Lecture Method

Class: SS2

Duration: 80 Minutes

Subject: Biology

Topic: Ecology

Sub-topic: Basic Ecological Concepts

Average: 16 years

Number of Students: 133

Behavioral Objectives: By the end of the lesson, the students should be able to:

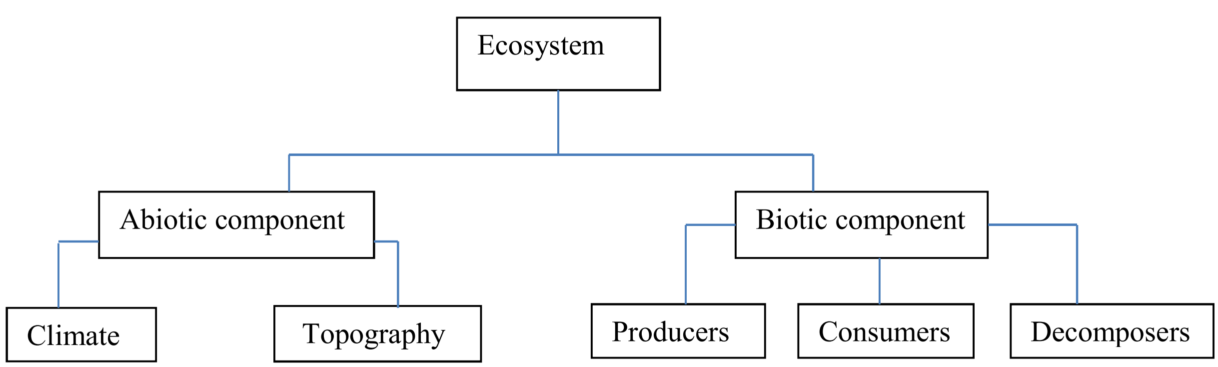
i. List the components of the ecosystem
ii. List the biotic components of the ecosystem
iii. Describe the biotic components of the ecosystem

Previous Knowledge: The students have been taught the ecological concepts

Introduction: The teacher introduces the lesson by asking the students to make a list of all the things they observed in the environment.

Presentation: Based on the students' responses the teacher presents the lesson in the following steps:

Step 1: The ecosystem is made up of abiotic and biotic components. The diagram below illustrates the components of ecosystem.



Step 2: The biotic components of the ecosystem comprise of:

i. Producers

ii. Consumers

iii. Decomposers

Step 3: The teacher then goes forward to describe the biotic components of the ecosystem.

-The producers are green plants which can make their own food through the process of photosynthesis, these plants are autotrophs.

-Consumers are animals which feed on plants or on other animals. They are said to be heterotrophs consumers are sub-divided as follows

Primary consumers are animals which feed directly on plant e.g cattles, grasshopper.

Secondary and tertiary consumers are animals that feed on primary consumers examples hawks, leopards

Omnivores are animals that feed on both plants and animals e.g man

Decomposers are organisms which feed on the carcasses of dead producers and consumers and in the process bring about the decay of such carcasses.

Evaluation: The teacher evaluates the lesson by asking the following questions:

1. List the two (2) major components of the ecosystem
2. Describe briefly the following terms:

i. Producers

ii. Consumers

iii. Decomposers

Summary and Conclusion: The teacher concludes the lesson by highlighting the points of the lesson.

LESSON PLAN FOR CONTROL GROUP

LESSON FOUR: WEEK FOUR

Theme: Environmental Biology

Model of Teaching: Lecture Method

Class: SS2

Duration: 80 Minutes

Subject: Biology

Topic: Ecology

Sub-topic: Functioning Ecosystem

Average: 16 years

Number of Students: 133

Instructional Materials: Charts illustrating Food Chain/Food web

Behavioral Objectives: By the end of the lesson, the students should be able to:

i. Define food chain
ii. Define food web
iii. Illustrate the food chain and food web using diagrams.

Previous Knowledge: The students are familiar with the main components of the ecosystem.

Presentation: Based on the students' responses, the teacher presents the lesson in the following steps.

Step 1: The teacher begins by asking the students on how animals get their food.

Animals survive in the environment by eating plants and other animals.

The teacher then defines food chain as the linear feeding relationship among organisms, in which one organism feed on the one before it in the sequence.

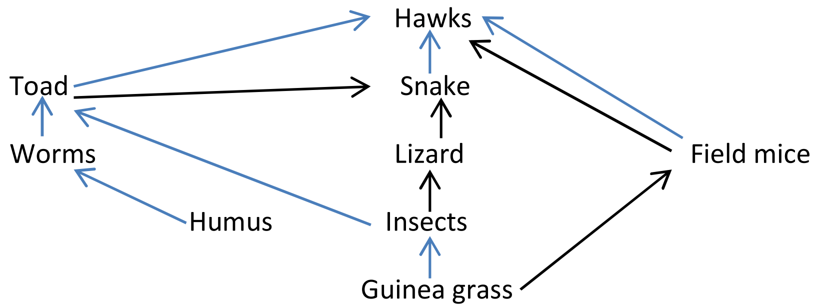
Step 2: The teacher then goes forward to define a food as a complex feed relationship consisting of interrelated food chains.

Step 3: The teacher then goes forward to illustrate the diagrams of food chain and food web.

Grass → grasshopper → toad → snake → hawk

A complex feeding relationship consisting of interrelated food chain is called food web.

Example of food web is shown below.



Evaluation: The teacher evaluates the students by asking the following questions:

i. Define food web and a food web

ii. Draw a diagrammatic presentation of a food chain and a food web.

Summary and Conclusion: The teacher concludes the lesson by revising all that he has taught.

LESSON PLAN FOR CONTROL GROUP

LESSON FOUR: WEEK FIVE

Theme: Environmental Biology

Model of Teaching: Hands-on Learning Strategy

Class: SS2

Duration: 80 Minutes

Subject: Biology

Topic: Ecology

Sub-topic: Ecological Factors

Average: 16 years

Number of Students: 133

Instructional Materials: Samples of Autotrophs and Heterotrophs for Food Chain/web. Various types of measuring instruments, such as measuring cylinder, wind vane, thermometer, rain gauge, and meter-rule.

Behavioral Objectives: By the end of the lesson, the students should be able to:

i. Measure three (3) of the ecological factors which they have studied; e.g temperature.
ii. Identify and explain three (3) peculiar factors of ecology, each of aquatic an terrestrial habitats respectively;
iii. Enumerate five (5) ecological factors common to both aquatic and terrestrial habitat
iv. Distinguish with reason(s) between the types of ecological factors; and,
v. Name four ecological factors that are found in your locality/community.

Previous Knowledge: The students are familiar with the main components of the ecosystem.

Introduction: The teacher introduces the lesson by asking the pupils in what ways organisms interacts with each other and the environment.

Presentation: Based on the student's responses, the teacher presents the lesson in the following steps:

Step 1: The teacher leads the students to define ecological factors as those factors that affect living things in their habitats, by influencing the distribution of plants and animals and their mode of life in different habitats. These include: temperature, light, rainfall, pressure, turbidity, wind, relative humidity, PH, water depth, etc.

Step 2: The teacher identifies that the ecological factors are broadly classified into two (2) categories; namely: (i) biotic (ii) abiotic ecological factors.

Step 3: The teacher describes ecological factors common to both aquatic and terrestrial habitats; to include: oxygen, light intensity, temperature, wind, pressure, PH, etc,

Step 4: The teacher further describes the following terms as general factors and associations that are observed in a population as well as ecological factors.

Competition: Involves interactions among two organisms of the same species or different species in which one outgrows the other and survives while the other cannot nor survives.

Association: These are close relationships between organisms of different species some of these associations are harmful, beneficial and some are neutral.

Tolerance: The ability of an organism to withstand or cope with all or some of the unfavorable environmental factors in the habitat.

Adaptation: Those features of an organism including modification of structures, functioning and behavior which fit them for life in their particular habitats and improve their chances of survival.

Pollution: The release of harmful substances into the environment.

Competition: Involves interactions among two organisms of the same species or different species in which one outgrows the other and survives while the other cannot nor survives.

Commensalisms: Commensalisms is an association between two organisms living together in which only one (the commensal) benefits from the association while the other neither benefited nor is harmed.

Predation: Predation is a type of association between two organisms in which the predator kills the other called the prey and feeds directly on it.

Parasitism: This is a close association between two organisms in which called the parasite, lies in or on and feeds at the expense of the other organism called the host. The parasites benefits from the association while the host usually suffers harm or dies.

Pathogens: These are microorganisms which can cause diseases in plants and animals leading to their reduction through death.

Mortality: Mortality is the death rate of organisms (plants or animals) in an environment. Mortality generally reduces the population of organisms in any habitat.

Dispersal: Dispersal is the spreading of new individuals from their parents to new habitats so as to start a new life in the new environment. Such spreading habitats may affect the lives of other organisms in the new area.

Evaluation: The teacher evaluates the students by asking the following questions:

i. Measure three (3) of the ecological factors which they have studied; e.g temperature.
ii. Identify and explain three (3) peculiar factors of ecology, each of aquatic an terrestrial habitats respectively;
iii. Enumerate five (5) ecological factors common to both aquatic and terrestrial habitat
iv. Distinguish with reason(s) between the types of ecological factors; and,
v. Name four ecological factors that are found in your locality/community.

Summary and Conclusion: To summarize the lesson by highlighting the main points of the lesson

LESSON PLAN FOR CONTROL GROUP

LESSON FIVE: WEEK SIX

Theme: Environmental Biology

Model of Teaching: Lecture Method

Class: SS2

Duration: 80 Minutes

Subject: Biology

Topic: Ecology

Sub-topic: Energy transformation

Average: 16 years

Number of Students: 133

Instructional Materials: Charts and cardboard showing the changes of energy from one form to another.

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

1. State why the tip of the pyramid of energy has the least number of organisms;
2. State the first and second Laws of thermodynamics
3. Describe the Describe the application of both laws to ecological phenomena

Previous Knowledge: The students have been taught on the biotic and abiotic components of the ecosystem

Introduction: The teacher introduces the lesson by asking the students in what ways organisms interacts with each other and the environment.

Presentation: Based on the students' response the teacher presents the lesson in the following steps:

Step 1: The teacher guides the students to:

a) Identify different types of association (such as symbiosis, parasitism, commensalism) which exist during the transfer of energy, including the adaptation and competitive activities;
b) State that only a small percentage of the radiant energy actually gets to plants; and,
c) State the first and second laws of thermodynamics and use them to explain ecological events such as pyramid of energy, food chain energy flow;

Step 2: The teacher guides the students to state first and second laws of thermodynamics respectively. Hence, the first law of thermodynamics states that "energy cannot be created nor destroyed, but may be transformed (changed) from one for to/into another". While the second law states that "energy transformations which occur in doing work is never completely (100%) efficient, and that some energy must escape as heat energy"

Step 3: The teacher further describes the application of both laws to ecological phenomena, such as pyramid of energy, food chain, energy flow.

Evaluation: The teacher evaluates the students by asking the following questions:

4. State why the tip of the pyramid of energy has the least number of organisms;
5. State the first and second Laws of thermodynamics;

f) Describe the application of both laws to ecological phenomena

Summary and Conclusion: To summarize the lesson by highlighting the main points of the lesson.

APPENDIX H

LETTER FOR VALIDATION OF INSTRUMENTS

Department of Science Education,
Faculty of Education,
Ahmadu Bello University, Zaria
1st May, 2018.

Validated
19/05/18

Prof. I.A. Usman,
Department of Science Education,
Faculty of Education,
Ahmadu Bello University, Zaria

Sir,

VALIDATION OF RESEARCH INSTRUMENT

I have developed a research instrument designed to generate data for my M.Ed Dissertation on Teaching of ecology in our Senior Secondary School.

The instrument titled, Ecology Concepts Performance Test (ECPT) consists of 40 multiple choice items adapted from WAEC and NECO past questions. It is to be used as both pre-test and post-test. Research Objectives, Questions and Null Hypotheses of the study from chapter one is attached here with for your reference.

As an experienced biology lecturer, inputs from you would certainly improve the quality of the instrument. I would like you to please examine the items with respect to the following:

i. Do the items relate to ecology concepts expected of secondary students?
ii. Are the items readable, appropriate and of standard?
iii. What general criticism and suggestions can you give for the improvement of the instrument?

I very much thank you and appreciate your assistant please.

Yours sincerely,

Ibrahim, Abdulsalam

Department of Science Education,
Faculty of Education,
Ahmadu Bello University, Zaria
1st May, 2018

Prof. W.S. Japhet,
Department of Biology,
Faculty of Life Sciences,
Ahmadu Bello University, Zaria

Validated
[signature] 22/5/2018
Prof. W.S. Japhet
Dept. Of Botany
ABU Zaria

Ma,

VALIDATION OF RESEARCH INSTRUMENT

I have developed a research instrument design to generate data for my M.Ed Dissertation on Teaching of Ecology in Senior Secondary School.

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I very much thank you and appreciate your assistant please.

Yours sincerely,

Ibrahim, Abdulsalam

SECTION A: Bio-data

Admission Number: ....

Gender: Male [ ] Female [ ]

SECTION B: Instruction; Attempt all the following questions

Please tick (√) the appropriate column that suits your interest.

S/NO	ITEMS	SA	A	D	SD
1	My teacher asks questions that require me to remember certain facts about ecological concept.				
2	My teacher asks questions that help me to predict what comes next when studying ecology concept.				
3	My teacher asks questions that check that I understand how to do something in terms of classifying organisms around me based on ecology concept.				
4	My teacher asks questions that challenge me to think in new ways regarding the learning of ecology concept.				
5	My teacher asks questions that require me to give my opinion on methods of population studies in ecology concept.				
6	My teacher asks questions that require me to justify my opinion based on the knowledge of component of an ecosystem in ecology concept.				
7	My teacher asks questions that help me to reflect on my learning and in connection with ecology.				
8	My teacher asks questions that help me relate what I already know to what I am learning now.				
9	My teacher asks questions that help me relate my understanding to the real world.				
10	My teacher asks questions that help me to use my learning in other topics and subjects.				
11	My teacher provides enough time for me to think to answer questions in ecology and other topics/subjects.				
12	My teacher provides opportunities for me to ask questions.				
13	My teacher provides different ways for me to respond to a question (written, verbal, visual and physical).				
14	My teacher asks questions so we can discuss and share how we might go about completing a task in ecology concepts.				
15	My teacher asks questions so we can discuss different ideas and theories in relation to ecology concepts.				
16	My teacher asks questions so we can debate and justify our ideas about ecology and related topics.				
17	My teacher asks a range of question types so we can all participate in the teaching and learning of ecology.				

SECTION A: Bio-data

Admission Number: ....

Gender: Male [ ] Female [ ]

SECTION B: Instruction; Attempt all the following questions

Please tick (√) the appropriate column that suits your interest.

S/NO	ITEMS	SA	A	D	SD	UD
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16	My teacher asks questions so we can debate and justify our ideas about ecology and related topics.					
17	My teacher asks a range of question types so we can all participate in the teaching and learning of ecology.					

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18	My teacher provides opportunities for all students to answer questions on ecology concepts based on the interactions with the environment.					
19	The ecology teacher very often encourages us to apply our insight to new or other situations.					
20	My ecology teacher very often makes me feel engaged in class and learning of ecology.					
21	I appreciate the way my teacher explained the concept of ecology by relating the concepts with the immediate environment.					
22	My ecology teacher very often support us when we try to show good thinking in ecology concepts					
23	My ecology teacher helped me greatly to work through complexities in issues without giving up on ecological concepts					
24	My ecology teacher helped me greatly to make logical connections when studying ecology concepts on the danger of ecological hazards					
25	Critical Thinking has the capacity to develop firsthand skills in ecology classroom interaction					
26	My ecology teacher helped me greatly to identify specific examples to illustrate my reasoning skills in identifying and classifying various organisms in the environment.					
27	My ecology teacher helped me greatly to understand that my prejudices or biases influence my thinking on ecology concepts.					
28	My ecology teacher helped me greatly to know what clear questions are when I learn					
29	My ecology teacher helped me greatly to consider multiple perspectives in my subject matter					
30	I will like my school to introduced Hands-on Learning Strategy in order to develop Critical Thinking skills to enhance classroom activities for teaching ecology					

1/6/18

APPENDIX I

OUTPUT FOR THE ANALYSIS

Hypothesis One:

T-Test

Group Statistics

	groups	N	Mean	Std. Deviation	Std. Error Mean
performance	Exp	130	33.0615	3.43884	.30161
	Cont	133	16.9248	2.83545	.24586

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Performance	Equal variances assumed	5.456	.020	41.560	261	.000	16.13673	.38827	15.37218	16.90127
	Equal variances not assumed			41.470	249.667	.000	16.13673	.38912	15.37035	16.90311

Hypothesis Two:

Mann-Whitney Test

Ranks

	groups	N	Mean Rank	Sum of Ranks
critical scores	Exp	130	190.89	24816.00
	Cont	133	74.44	9900.00
	Total	263		

Test Statistics[a]

	critical scores
Mann-Whitney U	989.000
Wilcoxon W	9900.000
Z	-12.417
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: groups