IMPACT OF 5E TEACHING CYCLE ON ATTITUDE, RETENTION AND PERFORMANCE IN GENETICS AMONG PRE-NCE STUDENTS WITH VARIED ABILITIES, NORTH-WEST ZONE, NIGERIA

BY

Sukola Tambaya IBRAHIM

DEPARTMENT OF SCIENCE EDUCATION
FACULTY OF EDUCATION,
AHMADU BELLO UNIVERSITY,
ZARIA

DECEMBER, 2015

IMPACT OF 5E TEACHIING CYCLE ON ATTITUDE, RETENTION AND PERFORMANCE IN GENETICS AMONG PRE-NCE STUDENTS WITH VARIED ABILITIES, NORTH-WEST ZONE, NIGERIA

BY

Sukola Tambaya IBRAHIM
BSc (ED) Biology (1999), ABU, Zaria
M. ED Science Education (2008), ABU, Zaria
Ph.D/EDUC/14403/2010-2011. ABU, Zaria

A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA. IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY (Ph.D) IN SCIENCE EDUCATION

DEPARTMENT OF SCIENCE EDUCATION
FACULTY OF EDUCATION,
AHMADU BELLO UNIVERSITY,
ZARIA

DECEMBER, 2015

DECLARATION

I declare that, this thesis entitled "Impact of 5E Teaching Cycle on Attitude, Retention and Performance in Genetics among Pre-NCE Biology Students with Varied Abilities, North-West Zone, Nigeria" has been carried out by me in the Department of Science Education, Faculty of Education, Ahmadu Bello University Zaria. The information derived from literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another Degree or Diploma at any University.

_____ _____

Sukola, Tambaya IBRAHIM **Date**

CERTIFICATION

This thesis titled "Impact of 5E Teaching Cycle on Attitude, Retention and Performance in Genetics among Pre-NCE Biology Students with Varied Abilities, North-West Zone, Nigeria" by Sukola, Tambaya IBRAHIM meets the regulations governing the award of the degree of Doctor of Philosophy in Science Education (Ph.D) of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

_____ _____

Dr. T.E Lawal **Date**
Chairman, Supervisory Committee

_____ _____

Prof. I.A. Usman **Date**
Member, Supervisory Committee

_____ _____

Dr. S.S. Bichi **Date**
Member Supervisory Committee

_____ _____

Dr. M. Musa **Date**
Head of Science Education Department

_____ _____

Prof. K. Bala **Date**
Dean, School of Postgraduate Studies

DEDICATION

This work is dedicated to my parents, Mallam Ibrahim Tambaya and Gimbiya Waziri, my wife, Alisa Magaji and my children, Bamaiyi, Blessing(Albarka) and Mainasara.

ACKNOWLEDGEMENTS

First and foremost, I sincerely express my special appreciation and thanks to the Almighty God, King of Kings, Lord of lords, mighty and everlasting God for His abundant love, mercy and grace Who has granted me the strength, wisdom, opportunity, life and health to undertake and finish this work successfully. My profound gratitude also goes to my major supervisor Dr T. E. Lawal, who painstakingly went through the write up several times, providing valuable motherly suggestions and constructive criticism. Mama may the good Lord continue to bless and protect you in all your endeavour. My gratitude and appreciation to the ever humble Prof. I.A.Usman and Dr. S.S. Bichi, my second and third supervisors for their guidance, suggestions, support and encouragement in their supervisory roles towards making this thesis a reality. May Almighty God bless and protect you continuously.

I graciously appreciate the academic and exemplary roles played by Professor A. K. Adamu, and Professor (Mrs.) E.F. Adeniyi for accepting to validate the instrument for this study. Thanks and God bless you. My gratitude also goes to Prof. A.A. M. Shaibu, Prof. J.S. Mari, Dr S. B. Olorukooba, Dr M. M. Atadoga, Dr. M.A. Lakpini, Dr J.O. Olajide, Dr. F. K. Lawal, Dr. B. Abdulkarim , Mr. M. K. Falalu and other academic and non academic staff of Science Education Department for their contributions. I also appreciate the University authority especially, the Vice Chancellor, Dean of Postgraduate School Prof. Kabir Bala for the opportunity to develop myself academically. May God reward you all.

My gratitude goes to the management of Federal University, Dutsinma for permitting me to undertake this course of study coupled with the financial support given.

May the university continue to grow and attain its set vision and mission. I also acknowledge with gratitude the sacrifice and inconveniences borne by my family members: Wife, Alisa Magaji, the Children: Bamaiyi, Blessing and Mainasara during the course of this programme, May God continue blessing and protecting you (Amen). I also wish to acknowledge and appreciate the roles played by the stenographers, computer/Data analyst, my class course mates and other well wishers, May God bless you all.

ABBREVIATIONS

FGN	-	Federal Government of Nigeria
WAEC	-	West African Examinations Council
NCE	-	Nigeria Certificate in Education
NCCE	-	National Commission for Colleges of Education
COE	-	College of Education
SSCE	-	Senior Secondary Certificate Examination
COL	-	Commonwealth of Learning
STAN	-	Science Teachers Association of Nigeria
NERDC	-	Nigeria Educational Research and Developing Council
NTRC	-	National Teachers Registration Council
FCE	-	Federal College of Education
SCE	-	State College of Education
ANOVA	-	Analysis of Variance
GAPT	-	Genetic Academic Performance Test
SAGQ	-	Student Attitude to Genetics Questionnaire
PPMCC	-	Person Product Moment Correlation Coefficient
TTA	-	Target Tasks Approach
5E	-	E1: Engagement, E2: Exploration, E3: Explanation, E4: Elaboration and E5: Evaluation

OPERATIONAL DEFINITIONS OF TERMS

Academic Performance: Scores that students obtained after been subjected to tests or examinations at the end of a program or instruction.

Attitudes: Showing favorable or unfavorable response of something, somebody, place, ideas or a method.

Retention: The ability to store information for a period of time after a given instruction.

Pre- NCE: This is a program of study before the regular NCE program because of certain deficiencies.

Lecture Method: Verbal means of presenting information to students dominated by the teacher.

Inquiry method: An interactive method that allows students to ask questions during teaching and equally find out things by themselves through mingling with materials.

Varied abilities This is the grouping of students into different ability groups (high, average and low) based on their performance in a given test.

5E Teaching Cycle It is an instructional model for designing series of lessons which are conceptually linked and developmentally sequenced by Bybee, Taylor, Gardner, Powell, Scotter, Westbrook and Landes (2006).5E teaching cycle is based on the logic of prior knowledge, interchangeably used as 5E learning cycle.

TABLE OF CONTENTS

Content **Pg**

Cover Page - - - - - - - - - i

Title Page - - - - - - - - - ii

Declaration Page - - - - - - - - iii

Certification Page - - - - - - - - iv

Dedication - - - - - - - - - v

Acknowledgements - - - - - - - - vi

Abbreviation - - - - - - - - - viii

Operational Definition of Terms - - - - - - ix

Table of Contents - - - - - - - - x

List of Tables - - - - - - - - - xiv

List of Figures - - - - - - - - - xv

List of Appendices - - - - - - - - xvi

Abstract - - - - - - - - - xvii

CHAPTER ONE: THE PROBLEM

1.1 Introduction - - - - - - - - 1

1.1.1 Theoretical Framework - - - - - - - 13

1.2 Statement of the Problem - - - - - - 15

1.3 Objectives of the Study - - - - - - - 16

1.4 Research Questions - - - - - - - 16

1.5 Null Hypotheses - - - - - - - 17

1.6 Significance of the Study - - - - - - 17

1.7 Scope of the Study - - - - - - - 19

1.8 Basic Assumptions - - - - - - - 20

CHAPTER TWO: REVIEW OF RELATED LITERATURE

2.1 Introduction - - - - - - - - 21

2.2 Historical Perspectives of Science and Biology - - - 21

2.3 Teaching of Biology at Pre-NCE Level - - - - 23

2.4 Academic Performance in Science and Biology - - - 25

2.5 5E Teaching Cycle and Academic Performance in Science - - 29

2.5.1 5E Teaching Cycle and Academic Performance in Biology - - 46

2.5.2 Genetic Concept and Academic Performance in Biology - - 52

2.6. Concept of Ability Levels and Academic Performance in Science - 53

2.7. Attitude and Academic Performance in Biology - - - 57

2.7.1 Retention Ability Levels and Academic Performance in Biology - 61

2.7.2 Gender and Academic Performance in Biology - - - 63

2.8 Overview of Similar Studies - - - - - - 65

2.9 Implication of Literature Reviewed on the Present Study - - 72

CHAPTER THREE: METHODOLOGY

3.1 Introduction - - - - - - - - 74

3.2 Research Design - - - - - - - 74

3.3 Population of the Study - - - - - - 77

3.4 Sample and Sampling Technique- - - - - - 78

3.5 Selection of Concepts to be Taught - - - - - 79

3.6 Instrumentation - - - - - - - - 79

3.6.1 Validation of the Instrument - - - - - - 82

3.6.2 Pilot Testing - - - - - - - - 83

3.6.3 Reliability of the Instrument - - - - - - - 83

3.6.4 Item Analysis - - - - - - - - 84

3.7 5E Teaching Cycle Package - - - - - - - 86

3.8 Administration of the Treatment - - - - - - 88

3.8.1 Treatment of the Experimental Group - - - - 89

3.8.2 Teaching the Control Group - - - - - - - 92

3.9 Data Collection Procedure - - - - - - - 93

3.10 Procedure for Data Analysis - - - - - - - 93

3.10.1 Hypothesis Testing - - - - - - - - 93

CHAPTER FOUR: ANALYSIS, RESULTS AND DISCUSSION

4.1 Introduction - - - - - - - - 95

4.2 Analysis and Results Presentation - - - - - - 95

4.3 Summary of Major Findings - - - - - - - 106

4.4 Discussion of the Results - - - - - - - 107

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Introduction - - - - - - - - 111

5.2 Summary - - - - - - - - 111

5.3 Conclusion - - - - - - - - 113

5.4 Contributions to Knowledge - - - - - - - 114

5.5 Recommendations - - - - - - - - 115

5.6 Limitations of the Study - - - - - - - 117

5.7 Suggestions for Further Studies - - - - - 117

References - - - - - - - - 119
Appendices - - - - - - - - 137

LIST OF TABLES

Table		Pg
1.1	Students' SSCE Results in Biology (2005 – 2014) - - - -	3
3.1	Population of the Study - - - - - -	77
3.2	Sample of the Study - - - - - - -	78
3.3	Item specification based on Bloom Taxonomy of Cognitive Level -	81
4.1a:	Mean and Standard Deviation of Experimental and Control Groups.	95
4.1b:	Analysis of Covariance (ANCOVA) of the Mean Scores of Experimental and Control Group. - - - - -	96
4.1c:	Post Hoc Tests (LSD) Multiple Comparison Pair wise Between Experimental and Control Groups - - -	97
4.2a:	Mean & Standard Deviation of Male and Female of Varied Abilities in the Experimental Group. - - - -	98
4.2b:	Analysis of Covariance (ANCOVA) of Male and female Experimental Group- - - - - - - -	99
4.3a:	Mean and Standard Deviation of Retention Ability of Experimental Group and Control Group - - -	100
4.3b:	Analysis of Covariance (ANCOVA) of Experimental and Control Groups - - - - -	101
4.3c:	Post Hoc Tests of Analysis of Covariance (ANCOVA) of Experimental and Control Group - - - -	102
4.4a:	Mean and Standard Deviation of the Retention Ability of Male and Female of Experimental Group - - -	103
4.4b:	Analysis of Covariance of the Retention Ability of Male and Female of the Experimental Group - -	103
4.5a:	Descriptive Statistics (Means ranks) Results of Attitude Change of Experimental Group - - - - -	104
4.5b:	Kruskal Walis Analysis in the Attitude Change of Experimental Group-	105

LIST OF FIGURES

Figure		Pg
1.1:	Bybees 5E Teaching Cycle - - - - - -	6
2.1:	Instruction and Nurturing Effects on 5E Teaching Cycle Training Model - - - - - -	30
2.2:	Instructional and Nurturing Effects in Biological Science Inquiry Model - - - - - -	31
3.1:	Research Design - - - - - - -	76
3.2:	Flow Chart of 5E Teaching Cycle - - - - -	86
3.3:	Flow Chart of Bybee's et al (2006) Model - - - -	91

LIST OF APPENDICES

Appendix		Pg
1:	Genetics Academic Performance Test - - - -	137
2:	Marking Scheme of Genetic Academic Performance Test (GAPT) -	142
3:	Students' Attitude to Genetics Questionnaire (SAGQ) - -	143
4:	Letter to Validators of the Instruments - - - -	145
5:	Lesson Notes for the Experimental Group Exposed to 5E Teaching Cycle - - - - - - - -	146
6:	Lesson Plan for Control Group Exposed to Lecture Method - -	175
7:	Facility Index and Discriminating Index for GAPT - - -	187
8:	Scores of Pilot Testing - - - - - -	188
9:	Scores of Experimental Group - - - - -	189
10:	Scores of Control Group - - - - - -	191
11:	Family Picture - - - - - - - -	193
12:	Group of Children of the Same Age Standing - - -	194
13:	Picture Showing Major Types of Finger Prints. - - -	195
14:	An Introductory Letter to Access Research Data. - - - -	196

ABSTRACT

The study investigated the "Impact of 5E Teaching Cycle on Attitude, Retention and Performance in Genetics among Pre-NCE Biology Students with Varied Abilities, North-West Zone, Nigeria". The population was 2,231 pre-NCE Biology students made up of 1,168 males and 1,063 females. Simple random sampling technique by balloting method was used to select two schools out of the eleven coeducational colleges of education that served as population of the study. Federal College of Education Zaria served as experimental group while Federal College of Education Katsina served as the control group. Fifty five (55) Pre-NCE Biology students (38 males and 17 females) were selected from each college for the study as guided by Central Limit Theory which proposed that thirty or more subjects are considered as large sample for experimental research of this nature. Quasi-experimental and Control group Design involving pretest, posttest and post-posttest was used for the study. A total of one hundred and ten (110) students were used for the study. Equal numbers of subjects were selected for each group in order to have a fair representation of the subjects in the study. Pretest was administered on the subjects, before they were exposed to the treatment, 5E learning cycle to determine that they are not different significantly in their ability level. The experimental and control group subjects were assigned to sub-groups according to their ability levels by stratifying sampling technique after the pretest. The ability grouping was carried out by categorizing the subjects into high average and low ability group where students who scored 60-100 range of scores comprised high ability, those that scored 40-59 were categorized as average ability and those with 0-39 comprised low ability subjects. The experimental groups were exposed to 5E teaching cycle while the control group was exposed to lecture method. The posttest was given to determine the effects of exposure to 5E learning cycle which was for experimental and control groups. The Post-posttest was administered after two weeks from the administration of the Post-test in order to determine the retention ability of the subjects in the study. Two instruments, namely Genetics Academic Performance Test (GAPT) with reliability coefficient of 0.79 and Students Attitude Genetics Questionnaire (SAGQ) with reliability of 0.82 were used for data collection. Five research questions and five hypotheses guided the study. One of the research questions was: What is the difference in the mean achievement scores of pre-NCE students of varied abilities taught with 5E teaching cycle and those taught with lecture method?. One of the hypotheses include: There is no significant difference in the mean achievement scores of pre-NCE students of varied abilities taught with 5E teaching cycle and those taught with lecture method. These were tested using Mean scores, Two-way Analysis of Variance (ANOVA) and Kruscal Wallis test statistics at $P \leq 0.05$ level of significance. The findings of the study showed that pre-NCE Biology students exposed to 5E teaching cycle in the teaching and learning of genetics concepts in all the ability levels had higher mean performance scores and also retain more than those in the control group exposed to lecture method of instruction. On the issue of gender differences, the study revealed that male and female in all ability groups exposed to 5E teaching cycle performed equally well and had also no difference in their retention abilities. The attitude of the experimental groups improved significantly in all the three ability levels. Recommendations were made based on the findings source of which is: The teaching of Biology especially genetics should be conducted using 5E teaching cycle as it make

students learn meaningfully, enhances better retention of knowledge and develop positive attitude towards the subject. It should therefore be incorporated into the main stream of pedagogy in the teaching of Biology at pre-NCE level of colleges of education.

CHAPTER ONE

THE PROBLEM

1.1 Introduction

Science and technical education are the foundations for sustainable national development by protecting human societies from ignorance, illiteracy, disease and poverty. For any nation to experience economic development there must be strong, stimulating growth in the teaching and learning of science (Nwagbo & Ovute, 2011). Science has been defined as a systemic enterprise of gathering knowledge about the world, organizing and condensing that knowledge into testable laws and theories (Hornby, 2010). According to Rao (2007), science is the system of knowing the universe through data collected by observation and controlled experimentation. Pearson Education (2003) also defined science as knowledge about the world, especially based on examining, testing and proving facts as well as particular parts of science such as Physics, Chemistry and Biology. This researcher views science as a systematic study of nature through experimentation.

In Nigeria, several studies such as that of Lakpini (2006), Usman (2007), Adeyemi (2008), Akinbobola and Folashade (2009), Lawal, Obeka and Mohammed (2011), and Ibrahim (2013) were carried out to improve the teaching and learning of science. Despite various efforts to improve the teaching and learning of science in Nigeria by different researchers, Ajagun (2001), Adedura and Tayo (2007), observed that Nigerian educational system is still confronted with poor academic performance. This has been the major concern of parents, teachers, science educators, educationists, examination bodies and the general public (Oludipe, 2012).

The incidence of poor performance in science is attributed to so many factors such as poor teaching methods and improper use of instructional materials (Jibrin & Nuru 2007), large class size (Bassey, 2002), constant use of lecture method (Lakpini, 2006), non-availability of well-trained teachers (Emabe, 2006), poor vocabulary and word association (Anamuah, Otuka & Ngman-wara, 2006), students' poor understanding of basic concepts in science (Lakpini 2006), teaching science in foreign language such as English, rather than learners' native language, inability to interpret correctly science words encountered in science textbooks and in everyday use of English Language and learning science through a second language (Mohammed, 2009) ,students misconception in science (Lawal, 2009) and difficulty of science courses as a result of constant use of lecture method (Gyuse,2009). Since one of the factors causing poor performance in science is the use of lecture method during teaching and learning, there is the need for using a method that will improve students' performance.

Science as a course has many branches such as Biology, Chemistry Physics, Agricultural Science and Geography. Biology is one of the science subjects that occupy an important position in the senior secondary school curriculum, which when acquired and applied in any society can bring rapid national sustainable development. Biology is especially designed to equip students with skills and attitudes of caring about themselves, the organisms and the environment. Biology as a subject is required for everyday life on matters of personnel and community health as stated in the National Policy on Education (FRN, 2013). Ibrahim, (2013) also stated that Biology is central to many Science related disciplines such as Medicine, Pharmacy, Agriculture, Nursing, and Biochemistry and so on. No student can study these disciplines without Biology. Basson (2012) defined Biology as the study of living organisms. Also, Hornby (2011) defined Biology as the

scientific study of life and structure of plants and animals. Despite the importance of Biology as a subject, empirical studies have shown that students still perform poorly in the subject, especially in the area of Genetics (Lakpini 2006, Lawal 2009 and WAEC, 2010) as seen in Table1.1.

Table 1.1: Students' SSCE Results in Biology (2005 – 2014)

Year	Total No of Cands that Sat	No of Cands with C6 and Above	% of Cands with C6 and Above	Percentage fail
2005	105155798.04	375850	35.74	64.26
2006	113713197.86	559854	49.23	50.77
2007	123816398.11	4132211	33.37	66.63
2008	125996598.05	427644	33.94	66.06
2009	134020698.21	383112	28.58	71.42
2010	130041898.11	645633	49.64	50.36
2011	150519998.20	579432	38.49	61.51
2012	164615097.53	587044	35.66	64.34
2013	169818800.00	564138	33.22	66.78
2014	169243500.00	529425	31.28	68.72

Source: West Africa Examination Council Office, Lagos (2014)

Table1.1 showed that, almost 60 percent of students that sat for the examination from 2005-2014 could not have the minimum requirements that qualified them to get admission into Universities or Colleges of Education therefore, they have to undergo pre-NCE program at Colleges of Education, pre-ND program at Polytechnics or pre-degree program in Universities.

One of the reasons discovered for the poor performances was the constant use of lecture method which is teacher-centered encouraging rote learning or memorization (Adeyemi, 2008; Usman, 2008; Lawal, 2009) and not encouraging formal reasoning of the students (Bello, 2012).

To teach Biology effectively, the teacher needs to employ methods that will enable the students to learn more, retain more and apply what is learned by engaging in

significant and appealing activities, and 5E teaching cycle may be good in this aspect. 5E teaching cycle is interchangeably called 5E learning cycle, 5E teaching model and inquiry-based teaching approach. The researcher adopted both within the literature cited in this study. According to O' Brien (2013) 5E teaching cycle is an instructional model for designing a series of experientially rich lessons that are conceptually linked and developmentally sequenced to support the ongoing, progressive refinement in student understanding as it develops over time. Bybee, (2009) sees 5E teaching cycle as an instructional model based on the constructivist approach to learning which says that learners build or construct new ideas on top of their old ideas. The 5E teaching cycle allows students and teachers to experience common activities, to use and build on prior knowledge and experience, to construct meaning and to continually assess their understanding of a concept. According to National research council NRC (2000) ,5E teaching cycle is an inquiry-based Teaching approach, constructivist- oriented strategy where students are involve in experimenting, questioning, and investigating credited to Roger Bybee who developed the 5E model (Bybee, Taylor, Gardner, Scotter, Powell, Westbrook, and Landes (2006). The 5 E-learning cycle model sequences learning experiences so that students have the opportunity to construct their understanding of a concept during the teaching and learning process (Bybee,2002). The model leads students through five phases of learning that are easily described using words that begin with the letter E: Engagement, Exploration, Explanation, Elaboration and Evaluation as seen in Figure1.

In the engagement phase the teacher captures students' interest and makes them curious about the topic and concepts to be learnt. This phase provides an opportunity for the teacher to find out what students already know or think they know about the topic and

concepts to be developed (Bybee, 2002). In the exploration phase students interact with materials and ideas through classroom and small group discussions (Llewellyn, 2005). This helps the students to acquire a common set of experiences so that they can compare results and ideas with their classmates. In the explanation phase students are provided an opportunity to connect their prior experiences with current learning and to make conceptual sense of the main ideas. This phase also provides the opportunity for the introduction of formal language, scientific terms and content information that might make students' prior experiences easier to describe. In the elaboration phase students' are provided with the opportunity to apply introduced concepts to new experiences (Llewellyn, 2005). This phase helps students to make conceptual connections between new and prior experiences, connect ideas and deepen their understanding of concepts and processes. The evaluation phase that is centrally placed in the model and takes place virtually in every phase of the 5E teaching cycle model provides a summative assessment of what students know (Bybee, 2002).

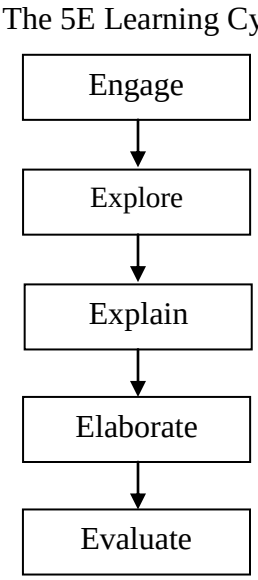


Figure 1.1 Flow Chart of Bybee et al (2006) Model

5E teaching cycle requires the students to do more than just report on a topic but, go beyond the simple memorization of facts and regurgitation of information to the realm of creating new and deeper understanding (O' Brien (2013). Its efficacy in enhancing student's performance in Biology when compared with that of the conventional lecture method is the thrust of the study.

There are many studies on 5E teaching cycle in different science disciplines in both Nigeria and other countries. Many researchers indicated the effectiveness of instruction based on 5E learning cycle model (Campbell, 2000;Coulson,2002; Boddy et al., 2003;Whilder & Shuttleworth, 2004; Akar, 2005; Ates, 2005 Garcia, 2005; Balcı, Çakıroglu and Tekkaya,2005; Ozsevgec, 2006;Ceylan, 2008; Pulat, 2008, Bunkure, 2012, Shitu 2013,and Njoroge, Changeiwo and Ndirangu (2014)). In these studies, students instructed by instruction based on 5E learning cycle model in different subjects' outperformed students instructed with instruction based on traditional methods. In other words, the results revealed that students who were instructed by instruction based on 5E teaching cycle model gain better acquisition of concepts with respect to different subject

areas compared to students who were instructed by instruction based on traditional methods. For example, Hiccan (2008) reported that 5E learning cycle had a statistically significant effect on conceptual and procedural knowledge. Baser (2008) reported that students who studied with the activities of 5E model learnt better than the students who studied with traditional teaching methods and Ozdal, Unlu, Catak and Sari (2006) found that students understood Pi and could apply it to new situation when taught using the sequences of 5E. When they compared the result of the present study with another study conducted in science, they also found that the 5E learning cycle had a positive effect on achievement (e.g. Lee, 2003, Demircioglu, Ozmen & Demircioglu 2004; Balci, 2005; Saygin, Atilboz and Salman, 2006; Ozsevgec, Cepni & Bayri, 2007; Yildirim, Er Nas, Senel & Ayas, 2007 and Cardak, Dikmenli & Saritas 2008;). For example, the study of Lee (2003) found that the students were found to acquire knowledge about plants in daily life easier and to understand the concepts better when taught with 5E teaching cycle. Other researchers like Varnado (2011), Poderoso (2013) & Greenmiller (2014) found no differences in terms of academic performance when students were taught with inquiry-based approach using 5E teaching cycle.

It is one of the purposes of this study to find out whether Pre-NCE Biology students of varied abilities will achieve better when they are exposed to 5E teaching cycle. Other studies were carried out in other subject areas without involving them, their ability levels and not also in the North-West Zone Nigeria. Also, studies carried out in Biology (Akar, 2005; Balci, 2005; Garcia ,2005; Balcı, Çakıroglu and Tekkaya,2006; Cakiroglu,2006; Kaynar ,2007; Ndioho ,2007; Cardak, Dikmenli and Saritas ,2008 ;and Özlem & Jale (2010) showed that students taught different Biology concepts, in different countries and levels of education apart from pre-NCE, performed better when taught

using 5E teaching cycle than those taught with lecture method. This study therefore, investigates how 5E teaching cycle will affect pre-NCE Biology students of varied abilities academic performance, retention and attitude in North-West Zone of Nigeria since other research were done elsewhere without involving them.

Academic performance is also another aspect of this study. Obeka, Bichi, and Yusuf (2012) defined academic performance as the display of knowledge attained or skill developed in school subjects designed by test and examination scores or marks assigned by subject teacher. In another definition, Lawal (2009) considered academic performance as overall measure of academic achievement of students in a given test after a period of instruction and teaching, usually weighted as a score. Many studies were carried out on academic performance in Biology and other science subjects. For example, Ibrahim (2008) who investigated the effects of levels of teacher-student verbal interaction on academic performance of Senior Secondary School Biology students found that students taught Biology using high level of teacher-student verbal interaction performed significantly better than those in the medium and low level of interaction in some Biology concepts. In another research by Lawal (2009), students exposed to conceptual change strategy performed better than those taught with traditional strategy. Ketim and Olowo (2013) in a study on the academic performance of direct and pre-NCE students in Federal Colleges of Education (special Oyo) found that students that entered Federal Colleges of Education through Pre-NCE and Direct entry did not differ in their performance. Despite much research to improve academic performance in Biology, empirical studies such as those of Lakpini (2006), Lawal (2008) and Usman (2010), still revealed poor academic performance in the subject and this is the major aim of this study to find out if exposure

of pre-NCE Biology students to 5E teaching cycle will positively affect their academic performance in Biology.

Retention ability is also a very important factor in learning science in general and Biology in particular. Hornby (2010) defined retention as the ability to remember things. Lakpini (2006) defined retention as the ability of the memory to store information which can be recalled after interval of weeks when exposed to a series of instructions and trainings. Studies carried out by Lakpini (2006), Anaso (2008), Lawal (2009), Nemati (2009),Bitrus (2012) and (Bunkure 2012) revealed that students exposed to conceptual change, discovery, constructivist, process approach instructional strategy retained scientific concepts better than those taught using lecture method. This is because 5E teaching cycle strategy facilitates better understanding of Biology concepts and deeper understanding of the concepts leads to better academic achievement and retention. It is also another aim of this study to find out if Pre-NCE Biology students exposed to 5E teaching cycle would have better retention than those taught with lecture method.

Improving students' attitudes toward school subjects is one of desirable outcome in education (Pulat, 2008). This is because student attitude to a subject influences their academic performance in that subject. Attitude has been defined in several ways and often been used interchangeably with the terms such as interest, value, motivation, and opinion. In attitude literature, quite specific definition of attitude specified as "a general and enduring positive and negative feeling about some person, object, or issue" (Ceylan, 2008). Shitu (2014) refers to attitude as an effective response that involves relatively stable positive or negative feelings. In the same vain Lawal (2009) sees attitude as the learner's state of mind that influences personal actions of the individual. A study carried out by Bunkure (2012) found out that constructivist instructional strategy improved

students' attitude to Biology and their understanding. This change of attitude was attributed to how teachers presented the lesson in an interesting manner, and thereby making students actively participate in the lesson. A study by Lakpini (2006) revealed that students of high and average abilities had more positive attitudes to conceptual change instructional strategy than their counterparts taught using lecture method. Poderosa (2013) in a study also determined that students who participated in inquiry-based, hands-on learning showed a more positive attitude about science than students that participated in the traditional learning environment. This study showed that the traditionally instructed control group had slightly lower interest in science than the 5E teaching cycle treatment group.

Many researchers indicated the effectiveness of 5E learning cycle based instruction on students' attitude toward science (Garcia, 2005). Bybee et al. (2006) indicated that learning cycle based instruction consistently results in more positive attitudes about science. Students' attitude toward genetics as a school subject is an important component that affects students' achievements. Therefore, teachers should be aware of students' attitudes towards genetics as a school subject and seek to improve students' attitudes. Ceylan (2008) study also improved students attitudes when taught with 5E learning cycle model. In the contrary studies of (Ozsevgec, 2006, Ersahan, 2007; Kaynar, 2007; Keskin, 2008; Pulat 2008) found no statistically significant effect of 5E learning cycle on attitudes toward the various subjects studied. It is in order to find out if 5E teaching cycle will affect the attitudes of pre-NCE students of varied abilities towards Genetics at both State and Federal Colleges of Education in North-West, Zone that this study was undertaken.

Ability grouping of students is also an important factor in enhancing the teaching and learning of science. Ahmed (2010) defined ability grouping as the placement of children in one classroom into groups, based on their abilities. Bitrus (2012) maintained that there are two types of ability groupings. These consist of between- class and within - class ability groupings. Between-class ability grouping is a school-level practice; it refers to forming a classroom so that students of similar ability are placed together. Lakpini (2006) categorized students' abilities into three levels being low, medium and high achievers. Students with ability level of 0-49% are called Low ability students; those students with ability level of 50 – 59% are referred to as average ability students. Also, students of ability levels of 60 and above are categorized as high ability students. This categorization will be adopted by the researcher in the present study.

Studies by Anaso (2006), Lakpini (2006), Ahmed (2010), Bitrus (2012) and Bunkure (2012) all revealed that students of high ability levels achieved higher than the medium and low ability achievers in the experimental group when compared with their counter part in the control group. Idris (2012) found out that students of varied ability level did not differ in their academic performance when taught Mathematics using concept mapping teaching strategy. Literature reviewed showed that, no study had been carried out on 5E teaching cycle using pre-NCE students of varied ability level. This study therefore, will investigate whether or not 5E teaching cycle could enhance pre-NCE students' of varied abilities academic performance in North-West, Nigeria.

There have been a number of studies of gender on academic performance in science. Bichi (2002) defined gender as amount of musculanity or ferminity in an individual. Researches on gender and academic performance such as that of Usman (2008), Ibrahim (2012), Olorukooba, Lawal and Jiya (2012) and Umar (2013), observed

that boys achieved better than girls, but studies by Bichi (2002), Adedayo 2004, Atadoga (2005), Lawal (2009) , Bunkure (2012) and Dahiru (2013) pointed out that girls achieved better than boys. Ceylan (2008) investigated the effect of 5E learning cycle on gender in students' understanding of state of matter and solubility concepts. The results revealed that there was no significant mean difference between male and female students in understanding state of matter and solubility concepts. In other words, male and female students showed similarities with respect to understanding of state of matter and solubility concepts at the end of the study. Hiccan (2008), also found no gender difference with respect to understanding of mathematic concepts when taught with 5E learning cycle. The study on gender-related difference and academic performance is not conclusive. This study among other things is also set to find out if there are significant differences between male and female when exposed to 5E teaching cycle.

The subjects of this study are mainly Pre-NCE students. Pre-NCE students are students that graduated from secondary school, but did not have enough credits in SSCE/NECO Examination to be admitted into NCE one, but were given one year programme to meet up (NCCE, 2009). According to Ketim and Olowo (2013), the idea of pre-NCE started even before National Commission of Colleges for Education (NCCE) was conceived. In the programme, some Colleges of Education (COE) admitted students who were deficient in some subjects into a remedial Science or Arts Class for one academic year, while those who passed final SSCE examinations were admitted into NCE programme proper. The action was meant to produce teachers in some specific areas of needs. The coming of NCCE tagged the practice as pre-NCE. So many researches were done using Secondary School without involving pre-NCE Biology students despite their peculiar problem of not having enough credits to take them to NCE

one. This research covered pre-NCE students in North-West Zone of Nigeria to find out if their performance in Genetics can be greatly enhanced.

Genetics is another subject of interest in this research work. Genetics is a branch of Biology, which is referred to as the science of genes, heredity and variation in living organisms. The knowledge of Genetics is very vital in all human endeavors. Through the knowledge of Genetics human life has improved effectively, ranging from improved variety of plant and animal species through selective breeding, inbreeding, out breeding, sex determination and prevention of heritable diseases in the family. Bailey (2013) defined Genetics as the study of heredity or inheritance. Genetics helps to explain how traits are passed from parents to their offspring. A report from West African Examination Council (2013), said that students still perform poorly in the area of Genetics and only few candidates attempt questions on Genetics because it is difficult (Umeh, 2006). According to Araz (2007), Genetics has a lot of abstract concepts, terminologies that are hard to understand, to learn and to remember. Lakpini (2006) reveals that when students are taught genetic concept using constructivist teaching strategies they achieved better than those taught with lecture method. A study by Lawal (2005) on genetic concept showed that students taught using concept mapping strategy performed better than those taught with lecture method. Part of the aim of this study is to investigate the impact of 5E teaching cycle on pre-NCE Biology students of varied abilities attitude, retention and academic performance in some genetic concepts.

1.1.1 Theoretical Framework

A number of science education researchers like Okebukola (2002), Lakpini (2006), Lawal (2009), Akuezuilo & Chinweoke (2009) and Igbojinwaekwu (2012) had been concerned with developing ways of facilitating students' conceptual development.

These researches stressed the important of knowledge construction by students. There are three theoretical frameworks that guide this study. First is the Theory of Constructivism developed by John Dewey in the 1920s and 1930s, which proposed that learning occurs through experience. Constructivism is a philosophy about learning that proposes that, learners build their own understanding of new ideas during teaching and learning. Much had been researched and written by many eminent leaders in the fields of learning theory and cognition. Scholars such as Jean Piaget, Eleanor Duck-worth, George Hein, and Howard Gardener have explored these ideas in-depth. According to constructivist views, students express their current thinking when they interact with objects, organisms, substances which equip them to develop range of experiences on which to base their thinking. The Biological Science Curriculum Study (BSCS), a team whose principal investigator was Roger Bybee developed an instructional model for constructivism, called the "Five Es". Each of the E's describes a phase of learning and each phase begins with the letter "E" which are: Engage, Explore, Explain, Elaborate and Evaluate.

Secondly is the Theory of Ego Development, first proposed by Erik Erikson in the 1950s and 1960s, which stated among other things that a child's environment is crucial to his growth and third is Vygotsky's Socio Cultural Theory (1986), which stated that children are drawn into cognitive activities when active participation in the learning is required. The present study therefore, adopted Bybee's 5E teaching Cycle in teaching Genetics and its impact on students' attitude, retention and academic performance, in North-West zone.

1.2 Statement of the Problem

Secondary school students have been learning Biology through predominant use of lecture method, discussion, practical, field trip, discovery method (Ibrahim, 2008). Despite that, several studies revealed that they have been performing poorly at the end of their final SSCE (Lawal, 2010). It is also established from the literatures of Lakpini (2006) and Lawal (2010) that one of the problems facing students of Biology is the constant use of lecture method.

Previous studies like those of Lawal (2005), Umeh, (2006), Rotbin, Marbach-Ad, Stavy, (2006), Araz (2007) and (Lawal 2010) showed that, students have difficulties, misconceptions and confusion in Genetics . This makes students hate the topic and the situation leads to poor performance of students in Biology, especially at Senior Secondary school level (WAEC 2012). It is also assumed that students are at the same ability level during teaching and learning in the classroom. The low-ability students who need more attention are often neglected (Bitrus, 2012). There is therefore the need for Biology teachers to give proper attention to students of different ability levels especially low ability students so as to improve their performance, hence, one of the aims of this study is to investigate the impact of 5E teaching cycle on pre- NCE students' academic performance, retention and attitudes among different ability levels in North-West Zone of Nigeria. Since 2000, there has been an abundance of published researches that discuss the need to enact reform in science education, and there has also been an abundance of published researches regarding the benefits of inquiry-based practices in science education; however, there is a scanty of literature available on the use of 5E teaching cycle to improve students' performance in biology. The problem of this study therefore is: What is the impact of 5E teaching cycle on academic performance, retention and

attitude towards Biology concepts among Pre-NCE students of varied abilities in the North-West, Zone?"

1.3 Objectives of the Study

The objectives of this study are to:

1) determine the impact of 5E teaching cycle on pre-NCE students of varied abilities academic performance in Biology;
2) examine gender-related impact of 5E teaching cycle on the academic performance of pre-NCE students of varied abilities;
3) find out if pre-NCE students of varied abilities retain Genetic concepts when taught using 5E teaching cycle;
4) determine the retention abilities of male and female pre-NCE students taught with 5E teaching cycle;
5) investigate the attitudinal change of pre-NCE students of varied abilities towards Genetics when taught with 5E teaching cycle;

1.4 Research Questions

The following research questions are formulated for answering:

1) What is the difference in the mean performance scores of pre-NCE students of varied abilities taught with 5E teaching cycle and those taught with lecture method?
2) What is the difference in the mean performance scores of male and female pre-NCE students of varied abilities taught with 5E teaching cycle?
3) How do pre-NCE students of varied abilities retain genetic concepts when taught with 5E teaching cycle and those taught with lecture method?

4) Do male and female pre-NCE Biology students retain genetic concepts when taught using 5E teaching cycle?
5) What is the difference in the attitude change of pre-NCE students of varied abilities taught Genetics with 5E teaching cycle?

1.5 Null Hypotheses

Based on the objectives and research questions stated above, the following null hypotheses are formulated for testing at $P \leq 0.05$:

Ho_1: There is no significant difference in the mean performance scores of pre-NCE students of varied abilities taught with 5E teaching cycle and those taught with lecture method.

Ho_2: There is no significant difference in the mean performance scores of male and female pre-NCE students of varied abilities taught with 5E teaching cycle.

Ho3: There is no significant difference in the retention ability of pre-NCE students of varied abilities taught with 5E teaching cycle and those taught with lecture method.

Ho_4: There is no significant difference in the retention ability of male and female pre-NCE students of varied abilities taught with 5E teaching cycle.

Ho_5: There is no significant difference in the attitude change of pre-NCE students of varied abilities taught Genetics with 5E teaching cycle.

1.6 Significance of the Study

The findings of this study will hopefully uplift the standard of Biology education in the following ways:

- **Teachers:** Sensitize Biology teachers on how to use 5E teaching cycle in teaching Biology through seminar, workshop and series of lectures;

- Assist Biology teachers to appreciate the relationship of 5E teaching cycle and academic performance in Biology education and to improve on Biology instructions at pre-NCE level;
- **Institutions:** The institutions of higher learning such as Colleges of Education will make use of this research work on 5E teaching cycle to teach their students, so that they become effective to be able to equip effective teachers who will in turn help their students.
- **Professional bodies:** Professional bodies, associations, such as Science Teachers Association of Nigeria (STAN), Nigeria Educational Research and Development Council (NERDC) as well as educational agencies concerned with outcomes of research in instructional innovations will find this study helpful. This will make them organize workshops and conferences on how to use of 5E teaching cycle.
- **Students:** Academic performance has been the concern of educational endeavour. A study involving academic performance will be of interest to teachers, students, parents, ministry of education and other stakeholders in education such as Science Teachers' Association of Nigeria (STAN).
- National Commission for Colleges of Education (NCCE) will have information on how pre-NCE program can be redesigned to incorporate 5E teaching cycle during teaching and learning.
- **Curriculum planners:** Curriculum planners, developers and authors who plan, develop syllabi and recommend effective methods of instruction incorporating the learning with 5E teaching cycle.

- **Textbook publishers:** Textbook publishers will also incorporate materials on 5E teaching cycle so as to advance the frontiers of knowledge.
- Varied ability is another topical issue in educational studies; a study in this area is likely to help teachers tackle the issue of individual difference in the classroom, most especially on ability levels.
- **Researchers**: This study will also help researchers, since it is a foundation for further studies on 5E teaching cycle and adds new information to the existing literature.

1.7 Scope of the Study

The population of the study comprised all pre-NCE biology students of coeducational Colleges of Education in the North-West zone of Nigeria. The colleges were divided into: Federal Colleges of Education (FCE) and State Colleges of Education (SCE) in the North-West zone. The samples used for this study were two coeducational colleges of education randomly selected from the eleven Colleges of Education in the North-West zone, Nigeria. These colleges were Federal College of Education: Zaria, and Katsina. Also, Genetics was chosen for this study because the concepts are central to the understanding of a number of aspects of Biology in general that prove to be difficult for the students to understand (Lakpini 2006, WAEC, 2013). The Genetics topics chosen are as follows:

1. Morphological variation in the physical appearances of individuals;
2. Psychological variation and application of variation;
3. Causes of variation;
4. Chromosomes, the basis of heredity;

5. Transmission and expression of characteristics of organisms (monohybrid inheritance);
6. Mendels Dihybrid inheritance.

These topics were chosen because apart from being difficult to understand, they contain a lot of abstract concepts (WAEC Chief Examiners Report, 2014).

1.8 Basic Assumptions

The study has the following basic assumptions:

1. The Colleges selected for the study are true representatives of all Colleges of Education in North-West zone.
2. Teachers do not take in to consideration the ability levels of the students in teaching Biology to pre-NCE students.
3. The selected topics in Genetics are appropriate to the level of the subject used for the study.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

This chapter reviews relevant literature and they are presented in the following sub-headings:

- Historical Perspective of Science;
- Teaching of Biology at Pre-NCE Level;
- Academic Performance in Science and Biology;
- 5E Teaching Cycle and Academic Performance in Science;
- 5E Teaching Cycle and Academic Performance in Biology;
- Genetics Concept and Academic Performance in Biology;
- Different Ability Levels and Academic Performance in Science;
- Attitude and Academic Performance in Biology;
- Retention Ability Levels and Academic Performance in Biology;
- Gender and Academic Performance in Biology;
- Overview of Similar Studies;
- Implications of the Literature Reviewed on the Present Study.

2.2 Historical Perspective of Science and Biology

It is pertinent to define and give the historical background of science and Biology before discussing in detail the effects that 5E teaching cycle which is inquiry-based teaching approach has on academic performance, attitude and retention of different ability group of students in Biology. The origin and beginning of science could be as old as the beginning of human race arising from the need of man to solve various problems that threatened his survival (Itamah, 2007).

Science is defined by Njoku (2004) as the rational and systematic study of the environment through experimentation and observation, with a view to understanding the environment in order to manipulate and control it for the betterment of human race. Therefore, science seeks to explain how the universe operates and encompasses Biology, Chemistry, Physics, Social, and applied sciences. Abdullahi (2007) stressed that, one of the aims of teaching science is to enable students understand, retain and use knowledge obtained to solve problems through laboratory work, field work, class work. Abdullahi (2007) further added that most teachers unfortunately do not have the capacity to actualize these ideas due to problems faced with prevailing large number of students which often result in disruption of class work, cheating and physical aggression.

Science is regarded as instrument par excellence for solving so many socio-economic problems and has helped to meet the minimum needs of human society in terms of food, shelter, clothing, water energy, employment, basic education, transportation, communication and healthcare (Okebukola, 2002 and Akinsola, Lawal & Oyedokun, 2007). Science is the foundation upon which the bulk of present technological breakthrough is built. A distinctive feature of the present millennium of human history has undoubtedly been the birth of modern science and its subsequent exponential growth (Corbit, 2002 and Druger, 2002). Through the application of science, man ensures longevity of his existence and the prestige and political power of any nation reside in its level of scientific development.

The study of science exposes students to both theoretical and practical knowledge about the environment and this knowledge can be used to manipulate and explore the resources of nature for human development (Njoku, 2004). This

study therefore will be carried out to investigate the impacts of 5E teaching cycle on academic performance, retention and attitudes of Pre-NCE students of different ability levels in the North-West zone.

2.3 Teaching of Biology at Pre-NCE Level

Biology is the scientific study of life. A brief history of Biology traces the study of the living world from ancient to modern times. Although, the concept of Biology was a single coherent field, it emerged from the traditions of medicine and natural/history back to ancient Egyptian and Greco-Roman World (Bason, 2012). The main goal of Biology is to improve our understanding of living organism from microscopic bacteria to giant Red-wood trees to human beings. Biology research affects many aspects of lives. Examples, many of the products we use, the food we eat and the medicine we take have been improved through application of Biology. Silvia and Michael (2010) defined Biology as the scientific study of life. Basson (2012) sees Biology as the study of living organisms. It is concerned with the characteristics as the study of living organisms. It is concerned with the characteristics, classification and behavior of organisms, how species come into existence and the interaction they have with one another and with the environment.

Biology as a branch of science has many branches which are: Zoology, study of animals; Botany, study of plants; microbiology and virology, the study of bacteria and viruses; anatomy and morphology, the study of structure and general form of plants and animals; physiology, the study of how living organisms function; cytology study of cells; Ecology, study of behavior of organisms in relation to their environment; biochemistry, the study of the structure and properties of molecules found in the cells; and Genetics, which is the study of how characteristics are

transmitted from an organism to its off springs and many other areas of Biology. According to the National Policy on Education (FRN, 2013), Biology belongs to the core subjects that must be offered by students at the Senior School Certificate Examination. The West African Examinations Council (WAEC) is one of the examination bodies that are responsible for the conduct of Senior School Certificate Examination (SSCE). In its 2004-2008 regulations, Biology was among the science subjects that must be passed for the award of the Certificate. In Nigerian Universities, for a candidate to gain admission to study courses like Medicine, Pharmacy, Biochemistry, Agricultural science, to mention a few, he/she must possess a credit pass in Biology in the SSCE. The importance of Biology as a science subject in the Nigerian school system cannot be overemphasized. It is required for everyday life on matters of personal, community health and agriculture. It is also a core subject as stated in the National Policy of Education (FRN, 2013). The objectives of the Biology curriculum as provided in the National Policy include:-

- Adequate laboratory and field skills in Biology;
- Meaningful and relevant knowledge;
- Ability to apply scientific knowledge to everyday life on matters of personal and community health and agriculture;
- Reasonable and functional scientific attitudes.

In spite of the importance of Biology in the school system, the problem of poor performance of students in the Senior Secondary School Certificate Examination (SSCE) conducted by West African Examination Council (WAEC) and similar examination bodies in Nigeria have registered over the years.

Lawal (2010) noted that poor academic performance in secondary schools prevents students from proceeding to universities, polytechnics and colleges of

education, despite the unique role Biology plays in all spheres of life. For instance, Ihejireke (2010) in analyses of ten secondary schools which participated in Senior Secondary School Certificate Examination in Kano still revealed poor performance in Biology from 2005-2009.

The result indicated that, out of ten sampled schools, the highest pass rate was forty seven per cent. 47% recorded from school 4 and thirty seven per cent (37%) from school 5. Within this period, many research studies have been carried out in the areas of teaching and learning of Biology. Some of these investigations bordered on strategies for Biology instructions (Lawal, 2004, Lakpini, 2006; Anaso, 2008; Usman, 2008, Lawal, 2010; and Students Psycho-Social Factors of Achievement (Vamadevapa, 2002). Therefore, researchers argued that what influences academic performance is the method of presentation and level of knowledge in Biology retained by learners. To improve students' academic performance in science and Biology an activity method such as inquiry method need to be used. The general poor academic performance of students in Biology is what is currently motivating this researcher to undertake a study on the impacts of 5E teaching cycle on attitude, retention and academic performance of pre-NCE Biology students of varied abilities in North-West zone of Nigeria. The aim is to find solutions which will go a long way in helping to improve academic performance of students who write Biology in the Senior School Certificate Examination (SSCE).

2.4 Academic Performance in Science and Biology

Academic performance applies to what an individual can do within a specific criterion domain (Anaso, 2008). It is assessed by outcomes and improvement in performance resulting from education. Academic performance according to Lawal (2009) is the overall measure of academic achievement of students in a given test after a period

of instruction and teaching usually weighted by score. Obeka, Bichi and Yusuf (2012) have further defined academic performance as the display of knowledge attained or skills developed in school subjects designed by test and examinations score or marks assigned by subject teachers. Nnachi (2002) on the other hand, noted that science academic performance is a quantitative indication of the positive result of behaviour accruing from the study of science. In this study, the researcher considers academic performance as the level of each student's educational attainment as determined by comparing his average score with others of the same age or peer group. Several studies were conducted in academic performance in science. For example, Jibrin and Zayum (2012) carried out a study on the effects of peer-tutoring instructional method on the academic performance in Biology among secondary school students in Zaria metropolis, and found that students taught Biology using peer instructional method performed higher than those taught using expository method.

Another study by Obeka, Bichi and Yusuf (2012) on the Effects of Integrating Instructional Models with Lecture Method on Academic Performance of Senior Secondary School Students of various Class-Sizes in Environmental Concepts of Zaria Educational Zone, revealed that students taught environmental concepts using integrating instructional models with lecture method performed significantly better in all the three different class sizes when compared to those taught using lecture methods only in all the three different class sizes. In the same vein, studies carried out by Usman (2010) on the effects of indoor and outdoor laboratory instructional methods on academic performance of junior secondary school integrated science students in Zaria Local Government Area of Kaduna State, revealed that students exposed to outdoor laboratory activity performed better than those exposed to indoor laboratory activities. In other studies carried out by

Lawal, Obeka and Mohammed (2012) in Wase supervisory zone of Wase Local Government Area of Plateau State on the effect of using conventional and improvised instructional materials on primary five pupils academic performance in basic science concepts, it was revealed that students taught using conventional and improvised materials performed better than the control group taught using conventional teaching method only.

Dahiru (2013) carried out a study on the effects of using Gagne's learning hierarchy in chemistry students academic performance and anxiety level in balancing chemical equations in secondary schools in Katsina metropolis in Nigeria, revealed that students taught using Gagne's learning hierarchy performed better in balancing chemical equations than those taught using lecture methods. Studies carried out by Bunkure (2012) on the effect of constructivist instructional strategy on the academic performance, retention and attitude of SS II physics students of varied ability levels in Kano State, showed that students taught physics using constructivist instructional strategy performed better than those taught physics using lecture method.

Several studies (such as Lakpini, 2006; Usman, 2007; Adeyemi, 2008; Akinbobola & Folashade, 2009; Lawal, Obeka & Mohammed, 2011; and Ibrahim, 2013) had been carried out all over the world on academic performance and all were carried out in different science disciplines, using different teaching methods. None of these studies examine the use of inquiry method on academic performance of pre-NCE Biology students. This study therefore is being carried out to find out the impact of 5E teaching cycle on academic performance of pre-NCE students in North-West zone of Nigeria.

According to the National Policy on Education (FRN, 2013), Biology belongs to the core subjects that must be offered by students at the Senior School Certificate

Examination. The West African Examinations Council (WAEC), is one of the examination bodies that are responsible for the conduct of Senior School Certificate Examination (SSCE), in which its 2004-2008 regulations listed Biology among the science subjects that must be passed for the award of the certificate. In Nigerian universities, for a candidate to gain admission to study courses like Medicine, Pharmacy, Biochemistry, Agricultural science, to mention a few, a candidate must possess a credit pass in Biology, in the SSCE. The importance of Biology as a science subject in the Nigerian school system cannot be overemphasized. Many researches were done in Biology; Katcha (2005) for example investigated the effect of vee-diagram instructional strategy on senior secondary school academic performance in an attitude change to Biology. He found that students taught Biology concepts using vee-diagram instructional strategy performed better in Niger State than students taught with lecture method. In studies by Bello (2012) on effects of learning cycle teaching strategy on students acquisition of formal reasoning ability and academic performance in Genetics in Senior Secondary School II Biology students, it was found that students taught using learning cycle teaching strategy performed better than those taught with lecture method and their reasoning ability improved. Jibrin and Zayum (2012) carried out studies on the effect of peer-tutoring instructional method on the academic performance in Biology among secondary school students in Zaria metropolis and found that students taught Biology using peer instructional method performed better than those taught using expository method.

Studies conducted on the effect of conceptual change instructional strategy on the academic performance, retention and attitudes of secondary Biology students with varied abilities in Sabon Gari Zaria by Lakpini (2006), showed that students exposed to

conceptual change instructional strategy performed better in all the ability levels than their counterparts exposed to traditional instruction only. It is one of the aims of this study to find out the impact of 5E teaching cycle on academic performance of pre-NCE Biology students in North-West zone of Nigeria.

2.5 5E Teaching Cycle and Academic Performance in Science

Teaching science courses in Nigerian schools has been a challenge for a long time. Despite the fact that all students attend science classes, many do not acquire and improve upon the required science knowledge. Therefore, they may be unable to recognize the functions and significance of science in the society. Nwagbo (2001) also noted that teachers shy away from the more effective activity oriented teaching methods in preference for methods that are easy and most times inadequate and inappropriate. Therefore, quality improvement of our teacher education programme is one of the indispensable needs (Patric, 2000). To change this trend, several learning techniques have been designed to ensure that students appreciate and understand the relevance of science in the society.

5E teaching cycle is an Inquiry-based, constructivist-oriented teaching approach which attempts to improve the teaching of science by actively engaging learners in authentic and practical investigations that enable them to develop more realistic ideas about scientific study, as well as offer a more motivating and learner-centered environment. The importance of 5E teaching cycle in the science process cannot be overemphasized and thus, the National Research Council (NRC 2000) created the standards around a central theme ‘science standards for all students’. This theme emphasizes the importance of inquiring in the science process, allowing students to describe objects and events, ask questions, construct explanation, test those explanations

against current scientific knowledge and communicate their ideas to others (Opara, 2011). In teaching science with 5E teaching cycle, the assumptions of the diverse populace are considered, critical and logical thinking skills are fostered. In 5E teaching model processes, teachers act as catalysts, rather than as dispensers of information. They offer students problems, issues and questions and then provide encouragement for inquiry into the nature of the problems and guidance for seeking solutions. They help students find or pose problems, investigate, and clarify positions and concision.5E teaching model promotes strategies of inquiry and the value and attitude that are essential to an inquiring mind including process skills (observing, collecting and organizing data, identifying and controlling variables formulating and testing hypothesis and explanation, inferring), active, autonomous learning, verbal expressiveness, tolerance of ambiguity, persistence, logical thinking (Fig. 2.1).

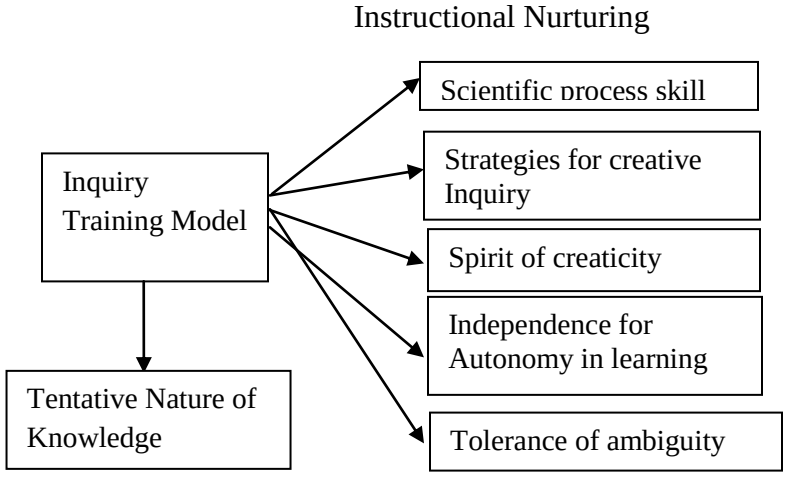


Fig 2.1: Instruction and Nurturing Effects of Inquiry Training Model

Inquiry Training model (summary chat)

- **PHASE ONE:**

  Confronting with the problem

  Explain inquiry procedure present discrepant event.

- **PHASE TWO:**

  Data gathering-verification

  Verify the nature of objects and conditions,

  Verify the occurrence of the problem situation

- **PHASE THREE:**

  Data gathering-Experimentation

  Isolation relevant variables

  Hypothesis (and test) casual relationships

- **PHASE FOUR:**

  Organizing, formulating and explanation

  Formulate rules or explanation.

- **PHASE FIVE:**

  Analysis of the inquiry process

  Analysis inquiry strategy and develop more effective ones

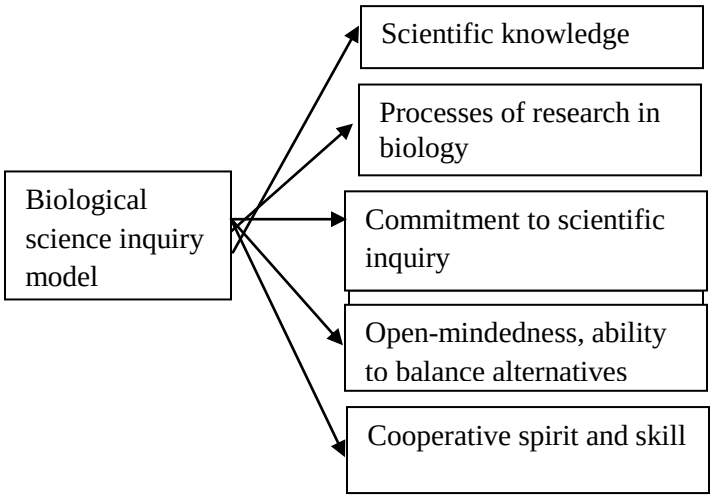


Fig 2.2 Instructional and Nurturing Effects in Biological Science Inquiry Model

Biological science inquiry Model (summary chart)

- **PHASE ONE:**

  Area of investigation is posed to student

- **PHASE TWO:**

  Students structure the problem

- **PHASE THREE:**

  Students identify the problem in the investigation

- **PHASE FOUR:**

  Students speculate on ways to clear up the difficulty

There were too many studies in science and other related disciplines home and abroad about 5E teaching cycle all over the world. In Nigeria these studies were limited. Research on 5E teaching cycle was generally carried out in science lesson using secondary school students without involving pre-NCE students. Some of the studies carried out that support 5E teaching cycle on academic performance are as follows. Campbell (2000) investigated the fifth grade students' understanding of force and motion concepts through the use of the 5E learning cycle. Students participated in investigations about force and motion concepts weekly for a period of 14 weeks. Findings showed that students' knowledge about force and motion concepts increased although their knowledge as demonstrated on paper was insufficient. It seemed that the students were of the same opinion that learning science through text book was not the best way for them. Study performed by Demircioglu, Ozmen and Demircioglu (2004) was based on the 5E, which was instructional model for the constructivist view of learning, about the topic "Factors Affecting the Solubility Equilibrium" in lycee-2 chemistry curriculum. It was noticed that experimental group students were more successful than the other group. Because in the experimental group, the activities used were based on 5E learning method.

Moreover, the students' opinions were taken into consideration. Ates (2005 investigated the effectiveness of learning cycle method on direct current circuits concepts at university level using 120 freshmen students from four intact classes. Two of these groups were randomly assigned as experimental group taught by using 5E learning cycle based instruction, other two groups were randomly assigned as control group instructed by using traditional instruction. Electric circuits' concept test was administered as pretest before the instruction to both groups and as posttest after the instruction to both groups. The results revealed that when the students' pretest scores on electric circuits' concept test were used as covariate, significant difference was found between experimental groups and the control groups with respect to student's posttest scores on electric circuits' concept test, favoring experimental group which constituted learning cycle instructional method.

Ozsevgec (2006) investigated the effect of 5E learning cycle on 5th grade students' achievement and attitudes toward science and technology course. It was found that there was a statistically significant mean difference in the favour of 5E learning cycle group. In the same vein, Ozdal, Unlu, Catak and Sari (2006) undertook the mathematics' design project in 2003-2004s for the Malaysia Ministry in their studies in the name of RtB Educational Solutions. In the project, a teaching courseware which could be used by mathematics teachers was prepared as being suitable for 5E learning cycle. This courseware was prepared for grade 7 about the teaching of Pi. In the work, the teaching of Pi was applied by introducing the sequences of 5E. After this application, it was seen that the students understood Pi and applied it to new situations. The aim of the study conducted by Ozsevgec, Cepni and Bayri (2007) was to discover the effectiveness of the 5E model on 5th grade students' constant conceptual changes. The researcher developed

the 5E learning activities based on the 'Force and Motion' unit's objectives. It was noticed that although there were not differences between the initial conceptual level of the experiment and control group students before 5E learning cycle, after the application, treatment group students were better at having conceptual changes than the students in the control group. However, the difference was remarkable between the pre-test and post-test scores.

Yildirim, Er Nas, Senel and Ayas (2007) expressed the aim of their study to discover 7th grade students' misunderstandings about dissolution and melting and solution them via activities designed based on the 5E learning cycle. At the beginning of the study, a concept test was implemented as a pre-test. According to the results of the test, an activity was developed based on the 5E learning cycle. The teacher implemented the activity regularly in the period of the lesson. After two weeks passing, pre-test was implemented as post-test. Finally, three students played role in the semi-structure interviews that was conducted. At last, it was pointed out that the activity designed according to the teaching model affected students in a positive way in remediation of students' misunderstandings about dissolution and melting. Orgill and Thomas (2007) suggested that analogies could be useful tools in each phase of the 5E learning cycle and pointed out that science classes would provide from performing the lesson with the challenging concepts that were related to everyday experiences. They gave examples of what the students and teachers could do while using analogies in each phase.

Pabuccu (2008) examined the effects of 5E learning cycle on eleventh-grade high school students' attitudes toward chemistry. The instruction developed the similar attitudes toward science as a school subject. Study carried out by Ceylan (2008) investigated the effectiveness of 5E learning cycle on 10th grade students' understanding

of state of matter and solubility concepts and attitudes toward chemistry as a school subject. In the experimental group, students were taught with respect to the sequence of 5E learning cycle model through the use of activities such as demonstrations, video animations, laboratory activities, and discussions. In the control group, traditionally designed chemistry instruction was implemented through teacher explanations and use of textbook. The results showed that 5E learning cycle improved students' attitudes as a school subject. This constructivist 5E learning cycle helps the students with their attitudes toward the subjects by seeing their conceptual differences, evaluating their misconceptions, improving their conceptual learning, scientific process skills, improving their exploration and mental thinking skills and lastly increasing the permanence of learning.

Pulat (2009) investigated the impact of 5E learning cycle on sixth grade students' mathematics achievement on and attitudes toward mathematics. The study was carried out in a public school in one of the towns of the Central Anatolia Region with 28 sixth-grade elementary school students. One group pretest-posttest design was used. Mathematics Achievement Test and Mathematics Attitude Scale were administered to collect the necessary data. The instructional was applied by the researcher five hours per week in a 15-week. The data were analyzed by using one-way repeated measures analysis of variance and a paired-samples t-test. According to the results of the study it was found that there was a statistically significant change in mathematics achievement of sixth grade students who participated in the instruction based on 5E learning cycle over three time periods (pre-intervention, post-intervention, and follow-up). There was only no statistically significant mean difference between post-intervention and follow-up mathematics achievement. Furthermore, there was a statistically significant decrease in

mean scores of attitudes toward mathematics from prior intervention to after intervention. Açışlı, Altun and Yalçın (2011) evaluated the efficiency of student guiding materials on student achievement, using the 5E learning model. The materials were developed by the researcher, based on the "Movement and Force" unit's objectives. Quasi experimental research design included 60 students (30 experimental, 30 control group). Control group students were given experiment booklets, which were prepared for each experiment in accordance with the 5E learning model. To determine whether any differences exist between the two groups' academic achievements, Achievement Tests on Movement and Force Issues were applied to the groups, both at the beginning and at the end of the semester as pre- and post-tests. Pre- and post-test results were compared, using a t-test in SPSS packet program. Results showed a meaningful difference between groups in favor of the experimental group (t_{58}=5.06; p=.00 < .05).

Turgut and Gurbuz (2011) investigated eighth grade students' misconceptions related to heat and temperature, compared the effectiveness of 5E model and traditional instruction on eighth grade students' understanding of heat and temperature concepts and their attitudes towards science and technology in order to determine whether consisting of conceptual change to be retentive. The subjects of the study were 37 eighth grade students at a primary school in Erzurum, who were in two different classes and taught by the same teacher at 2009-2010 educational years. One of the classes was randomly selected as experimental group in which students were thought by means of activities which were prepared according to the 5E model, and the other was determined as the control group in which students were thought by traditional methods (teacher-centered, based on straight narrative and question-answer method). The data were obtained through the use of three-phase Heat and Temperature Misconception Test (HTMT) and the

Attitude Scale towards Science and Technology (ASST). The study results were analyzed by SPSS. To analyze data, independent and paired sample t-test, and percentage and mean scores were conducted. Results of Heat and Temperature Concept Success Test revealed that 5E model is more successful on remediation of misconceptions and effective in providing a permanent conceptual change than the traditionally designed instructions. However, there was no statistically significant difference between the experimental and control group in terms of students' attitude towards science and technology.

Bunkure (2012) investigated the effects of constructivist instructional strategy using 5E teaching model on the academic achievement, retention and attitude to physics among Science Secondary School Student's of varied ability levels in Kano State. Pretest posttest experimental design was used for the study. A simple random sampling technique was used to select 4 schools out of 7 Science Secondary Schools in Kano State. 160 out of 1559 SS II physics students were used for the study. Physics Achievement Test (PAT) and Physics Attitude Questionnaire (PAQ) were used to collect data. The reliability of PAT was calculated using Pearson's Product Moment Correlation Coefficient to be 0.86. Six null hypotheses were tested at $p<.05$ level significance using t-test, one way Analysis of Variance (ANOVA), and Mann Whitney U test statistics. The following major findings were obtained: (i) students exposed to constructivist instructional strategy achieved, retained the learnt concepts and developed more positive attitude to physics than their counterparts exposed to conventional method of teaching. (ii) There was no significant difference in students' achievement with reference to gender. (iii) The strategy is suitable for students' of varied ability levels. On the basis of these findings a number of recommendations were made for the improvement of teaching

physics in secondary schools. One major recommendation is that physics teachers should incorporate 5E constructivist instructional strategy into mainstream of pedagogy in the teaching of physics as it seems to have high potentials for enhancing understanding, achievement and retention on the part of the learners.

Shittu (2013) conducted a study on the effects of guided inquiry strategy on learning outcomes of low achieving secondary school physics students using 5E teaching cycle model. He purposively selected a sample of 91 low achieving students in Kaduna Metropolis. He used quasi-experimental control group design consisting of pretest and post-test. The experimental group where taught by inquiry method while the control group where taught using lecture method. He used t-test to analyze his data. The result showed that low achieving students taught using inquiring method in physics concept achieved significantly higher than those taught using lecture method. Therefore, this study investigated the impact of 5E teaching cycle on academic performance of pre-NCE biology students of different abilities in North-West Zone of Nigeria.

Njoroge, Changeiywo, and Ndirangu, (2014) investigated the Effects of inquiry-based teaching approach using 5E learning cycle on Secondary School Students' performance and motivation in Physics in Nyeri County, Kenya. The study adopted a Quasi-Experimental Research Design. Solomon-Four Non-equivalent Groups Design was involved. Stratified random sampling technique was used to select four boys' and four girls from county secondary schools in Nyeri, County. The four schools in each category were assigned to treatment and control groups by simple random sampling technique. Each group had one boys' and one girls' county secondary school. Each school provided one form two class for the study and a total of 370 students were involved. Students in all the groups were taught the same physics content but the experimental groups were taught

using IBT approach while the control groups were taught through Regular Teaching Methods (RTM) such as lecture method and teacher demonstrations. The experimental group I and the control group II were pre-tested prior to the implementation of the IBT treatment. After four weeks, all the four groups were post-tested using the Students' Physics Achievement Test (SPAT). The instrument had been validated by five experts in education and pilot tested before use to estimate its reliability. The reliability coefficient using K-R21 was 0.87. The acceptable threshold for reliability coefficient is 0.7 and above. The instruments were scored and data was analyzed using t-test, one way ANOVA and ANCOVA at a significance level of coefficient alpha (α) equal to 0.05. The findings of the study showed that Inquiry-Based Teaching (IBT) approach resulted into higher students' scores in achievement in physics. The study recommends that Teacher training institutions, Kenya Institute of Curriculum Development (KICD) and physics teachers should enact IBT approach as the preferred physics teaching approach in Kenyan secondary schools.

Ado (2014) investigated the impact of constructivist teaching strategy using 5E teaching model on attitude, academic performance, retention and attitude towards trigonometry among Senior School Students in Kaduna State u. A quasi – experimental study which used pretest – post – test control group design was adopted. Total population of 20, 154 SS II students admitted during 2012/2013 academic session form the population of the study. Stratified random sampling was used to select 400 students. Six hypotheses and six research questions were formed and investigated using three instruments trigonometric perform test (TPT).T-test and Wilcoson signed – rank were used for data analysis at $P \leq 0.05$.Results shows significant different in the mean scores of experimental and control groups in academic performance, retention ability and

attitude. The results also showed gender differences in academic performance and retention ability of students but no gender difference in attitude when taught with constructivist strategy using 5E teaching model. This was part of the purpose of the study to investigate the impact of 5E teaching cycle on academic performance of pre-NCE biology students of different abilities in North-West Zone of Nigeria.

It was stated by Thompson (2006) that constructivist learning, inquiry based activities involve the use of "manipulative or hands-on materials" "incorporating inquiry, discovery, and problem-solving approaches [and] applying Mathematics and Science concepts to real-world context". Moreover, inquiry based methods for learning, associates the activities in the classroom to distinct careers and involves the original data analysis. Other researches reviewed on inquiry method support 5E teaching cycle, which comprised: Amaral, Leslie and Klentschy (2002) in their study involving fourth and sixth grade students in Latino school district in southern California studied the effect of inquiry-based approach in science and mathematics. The results of the study indicated that inquiry-based approach led to greater proficiency in science and mathematics. The researchers concluded that the hands-on activities allow learners to construct context, to develop positive attitudes toward learning and to engage in authentic conversation with other students. Marx, Blumenfeld, Krajcik, Fishman, Soloway, Geier and Revital (2004) in their study involving sixth, seventh and eighth grade physics students over a three-year period found out that students who took part in the inquiry curriculum made statistically significant gains in academic performance. The researchers concluded that an inquiry approach led to higher gains in knowledge of the content, understanding of the process, and overall academic performance.

Mergendoller, Maxwell & Bellisimo, (2006) compared students academic performance results between high school students that were taught either traditional or inquiry-based strategies to determine which method produced higher students academic performance. The data from his study revealed that there was not a significant difference in performance when using traditional or inquiry-based, hands-on teaching methods, which supports the findings from this study. In 2003, Keegan also conducted a study comparing traditional and inquiry-based classrooms. He compared students that participated in the discovery learning method (an inquiry-based method) to students taught with traditional methods and determined that there was not a significant difference in performance between the two groups based on instructional strategy. This makes the researcher question several literature that support inquiry-based learning where the students are encouraged to be actively involved in their learning by connecting prior experiences with new information (Ozmon & Craver, 2008).

A study conducted by Vanosdall, Klentschy, Hedges and Weisbaum (2007) involving fifth grade students in California State of America showed that the use of Inquiry-Based Teaching Approach (IBT) led to higher academic performance in learning of mixtures and solutions in chemistry than did those taught using the regular teaching methods. Sola and Ojo (2007) studied the effect of inquiry models of teaching. The results of this study showed that inquiry models of teaching were very effective in enhancing students' academic performance and skill development. They reported that students' academic performance scores and analytical skills were either raised or greatly enhanced.

The research collected by Akkus, Gunel, and Hand (2007) established that the quality of the implementation technique does have great impact on students' post-test

scores when they compared the effectiveness of inquiry-based science to traditional teaching practices. Thus, the researcher is led to believed that the inquiry-based, hands-on labs would be significantly higher because of the review from the literature that was grounded in the Constructivist Theory, where Dewey (1929) stressed the importance of using scientific inquiry as an essential part of learning (Nodding, 2007).

In synthesis of two meta-analysis of "inquiry-based teaching" Hattie (2009) found that this approach resulted in improved students performance in a number of areas. Akins, Durham, Smit, and VanDenend (2008) assessed the effectiveness of two instructional models on students achievement using two fourth grade classes. The post-test results demonstrated higher performance by the students in the inquiry-based classroom.

Hattie (2009) in Journal of Instructional Pedagogies further demonstrates through extensive meta-analysis of the impact on student achievement brought about by various instructional and environmental factors, a variety of instructional strategies including but not limited to inquiry-based instruction may be necessary to maximize student achievement. Schiller (2009) underscored the significance of social team-work to the attainment of success of knowledge retention and learning. His study concluded that learners who were participating in a team-based in an inquiry based learning environment had high inclinations to Journal of Instructional Pedagogies. Effectiveness of inquiry-based, attend to the given task of knowledge learning and retained information at the applicable stage of comprehension. His study pertained to mathematics at a high level with students from a university environment but the suggestion contained the applicability to a team-based and inquiry-based environment to K-12 through grade 12 mathematics materials.

Hernandez-Ramos and De La Paz (2009) compiled an analysis which compared inquiry based instruction with teacher directed instruction in a group of over 700 learners in a given middle school and a similar number of learners in a geographically close middle school with similar educator credentials and student demographics. During this study, they found support for higher efficacy for learning that was student-oriented. They found that learners that had inquiry based material presentation achieved better results as contrasted with students in controlled group in both internal motivation and overall material knowledge. Also, they reported the students had increased critical thinking abilities within the content area. As part of an Alberta Initiative for School Improvement (AISI) project, over the course of a three-year study, Friesen (2010) found that engaging students in disciplinary-based inquiry had a significant positive impact on student academic performance on standardized provincial examinations. Designed and implemented by 26 elementary and secondary schools with 12,800 students in a school district in Alberta, Friesen (2010) specifically found that the aggregate performance scores of students in schools designated as high inquiry schools significantly exceeded provincial norms on provincial achievement tests. These findings make a strong argument that disciplinary-based inquiry does not detract from traditional forms of assessment but actually increases academic performance on traditional forms of standardized assessment.

Minner, Levy, and Century (2010) found that students who were involved in guided-inquiry lessons demonstrated greater science achievement than the students involved in traditional lecture classrooms. The literature reviewed so far confirmed the importance of inquiry-based, hands-on instructional methods in every area of teaching, but especially in science courses. The Constructivist Theory supports inquiry-based

learning because students are encouraged to be actively involved in their learning by connecting prior experiences with new information (Ozmon & Craver, 2008).

Ortlieb and Lu (2011) offer further support for the importance of inquiry-based instruction in their study of pre-service teachers. Teachers who are encouraged to employ the inquiry-based teaching model demonstrate greater, more sustained commitment to aiding students' development of critical thinking strategies. The implementation of well-designed, conceptually based instructional units for inquiry supervised by educators with a strong foundation in multiple instructional delivery models is supported by the literature.

Abdi (2014) investigated the effects of inquiry-based learning method on students' academic performance in sciences lesson using quasi-experimental non-equivalent group design. A total of 40 fifth grade students from two different classes were involved in the study. They were selected through purposive sampling method. The group which was assigned as experimental group was instructed through inquiry-based learning method whereas the other group was traditionally instructed. This experimental study lasted eight weeks. To determine the effectiveness of inquiry-based learning method over traditional instruction, an achievement test about sciences which consisted of 30 items was administered as pre-test and post-test to students both in the experimental and control groups. For the statistical analysis, Analysis of Covariance (ANCOVA) was used. The results showed that students who were instructed through inquiry-based learning achieved higher score than the ones which were instructed through the traditional method.

Greenmiller (2014) investigated the effect of inquiry-based, hands-on labs on achievement in middle school science in Georgia, United States. The quasi-experimental

research methodology adopted in this study allowed a comprehensive comparison and analysis of the data collected. The use of the quasi-experimental design made it possible for the researcher to examine the effects on students' achievement when inquiry-based, hands-on labs were implemented into a standards-based Life Science class as the primary instructional approach. The research indicated that there was not a significant difference in student academic performance based on the mean scores on the CRCT for the two groups. There was a significant difference in the mean scores for student interest, with the traditional group outscoring the inquiry-based, hands-on group. Taylor and Bilbrey (2014) investigated the effectiveness of inquiry-based instruction in improving the Mathematics and science achievement of fifth graders in a rural elementary school in South Alabama as measured by standardized achievement scores. Standardized achievement test scores in mathematics and science over a 6-year time period were analyzed in order to compare the group percentile rank of fifth graders in Mathematics and Science when teacher-directed instruction was utilized with the group percentile rank of fifth graders in science and mathematics education, following the application of inquiry based classroom instruction. Taylor and Bilbrey (2014) investigated the effectiveness of inquiry-based instruction in improving the Mathematics and science achievement of fifth graders in a rural elementary school in South Alabama as measured by standardized achievement scores. Standardized achievement test scores in mathematics and science over a 6-year time period were analyzed in order to compare the group percentile rank of fifth graders in Mathematics and Science when teacher-directed instruction was utilized with the group percentile rank of fifth graders in science and mathematics education, following the application of inquiry based classroom instruction. This study investigated the impact of 5E teaching cycle on academic performance of pre-

NCE biology students of different abilities in North-West Zone of Nigeria since other research were done using secondary school students.

2.5.1 5E Teaching Cycle and Academic Performance in Biology

So many researchers such as Lakpini (2006), Ihejirika (2010) and Lawal (2009) observed that the issue of poor academic performance is still prevalent in Nigerian secondary schools. This has been attributed to so many factors among which is difficulty of science courses as a result of constant use of lecture method which is authoritative in nature, teacher centered, unstable, ineffective and unproductive to the teaching and learning of Biology which is activity-oriented (Gyuse2009, Usman 2010, Lakpini 2012 and Ibrahim 2013). Opara (2011) pointed out that, though the place of teaching of Biology is at the top of hierarchy of other science subjects, researches in this area have been relatively scanty. The teaching of Biology generally conforms to the conventional methods and continues to be dominated by the teacher making it as dull and uninspiring as ever before (Kalia, 2005). Ibrahim, (2013) also opined that most Biology teachers prefer the use of lecture method of teaching to an activity-oriented teaching method such as inquiry method. Lawal (2009) also stated that academic performance of Nigerian students in school subjects including Biology at secondary school level has remained poor over the years and this could be as a result of poor mastery of the subject matter which occurs as a result of poor method of teaching. Opara and Oguzor (2011) opined that to perhaps improve the students' academic performance in Biology, a shift will be necessary from what has traditionally been experienced in the Nigeria classrooms toward more inquiry teaching practices, which facilitate teaching for meaningful learning.

5E teaching cycle is a strategy that provides opportunity for students to experience and acquire processes through which they can gather information about

science. It requires high level interaction among the learner, the teacher, area of study, available resources and learning environment. During 5E teaching cycle instruction, students are allowed to describe objects and events, ask questions, construct explanation, test those explanations against current scientific knowledge and communicate their ideas to others. 5E teaching cycle allows students to learn and experience Biology firsthand, by taking on the roles of scientists. During 5E teaching cycle lessons, the students use the inquiry process to develop explanations from their observations (evidence) by integrating what they already know with what they have learned. They learn discrete Biology concepts and skills and how to solve problems using practical approaches. Incorporating 5E teaching cycle into Biology classrooms empowers students. They play an active role in their learning rather than the passive role commonly seen in traditional classrooms. Teachers can foster better experiences with 5E teaching cycle strategy in various ways and ultimately positively affect students' Biology process skills and understanding of Biology. Some of researches carried out on 5E teaching cycle in Biology include:

An instructional learning model based on 5E learning cycle has been used by Biological Sciences Curriculum Study (BSCS) as one of the instructional model to develop new curriculum materials since 1980's (Ceylan, 2008). This model was accepted as BSCS 5Elearning cycle model. It was said that 5E model is rooted its' fundamentals in constructivism and it facilitates conceptual change. Since BSCS 5E learning cycle model is young when compared with the learning cycle, there are fewer published studies that examine the effectiveness of this model. However, the studies stated that BSCS 5E learning cycle model is effective than alternative teaching methods with respect to reaching important learning outcomes in science. Akar (2005) stated that 5E learning cycle model is more effective than alternative approaches with respect to students'

mastery of science subjects. Coulson (2002) conducted a study to explore how varying levels of fidelity to the BSCS 5E learning cycle model affected student learning. The results showed that students who were taught BSCS 5E learning cycle model with medium or high levels of fidelity experienced learning gains that were nearly double than the students who were taught not using 5E learning cycle model or taught with low levels fidelity. It was stated that BSCS 5E learning cycle model have positive impact on scientific reasoning (Boddy,Watson, & Aubusson, 2003), and on interest and attitudes toward science (Akar, 2005;Boddy et. all, 2003).

In another study performed by Lee (2003), in his lesson of plant nutrition which was prepared according to learning cycle during 10 years, provided from 5E learning cycle to make the lesson more real by using real plants as well as pictures and figures. In this way, students were in an interaction with each other with small groups and in the level of all classrooms. Eventually, the students were provided to acquire knowledge about the plants in daily life and also to understand the concepts better.

Study performed by Wilder and Shuttleworth (2004) investigated in the effectiveness of 5E learning cycle in "Cell Inquiry". The participants of the study consisted of high school students in the lesson of Biology-1. In the start of study, students were provided to rethink what they learned and knew and were made to be motivated. In the phase of exploration, the students were faced with everyday-life situations but in the phase of explaining, the teacher led students to explain their own results scientifically. In the sequence of extension, the students were given more problems and different problems, and in the sequence of evaluation, they wanted to see if the students developed a true understanding on the concepts.

Balci (2005) was studied photosynthesis and respiration in plants with 8th grade students. In the first experimental group, the classes were assigned according to the 5E learning cycle and in the second one, the classes were assigned according to the conceptual change text based instruction. As for the control group, the traditional teaching method was applied. Two-tier multiple choice diagnostic test was applied to all test groups as pre-test and post-test. The results show that the students of experimental group were more successful. Moreover, the methods applied in the experimental groups were impressive in eliminating the students' misconceptions.

Saygin, Atilboz and Salman's (2006) studies were carried out by 47 students in classes. In the classes in which constructivist teaching approach was applied, Rodger Bybee's 5E model was used. The tests were applied to students as pre-test and post-test. It was reported that, the students who studied with constructivist teaching approach were more successful than the ones who studied with traditional method in learning the cell subject.

Balcı, Çakıroglu and Tekkaya (2006) carried out a study to investigate the effects of the 5E learning cycle model, conceptual change text, and traditional instructions on8th grade students understanding of photosynthesis and respiration in plants. 101 8thgrade students in three intact classes of the same school were used in this study. There were three groups in this study. Two of the groups were assigned as experimental groups in one of which 5E learning cycle model was used and in the other experimental group conceptual change text instruction was used. The third group was defined as control group in which the traditionally designed instruction was used. The results showed that there was a significant difference between experimental and control groups in favor of experimental groups with respect to students' understanding of photosynthesis and

respiration in plants. On the other hand, there were no statistically significant difference between the students who were instructed 5E learning cycle and students who were instructed by conceptual change texts with respect to students' understanding of photosynthesis and respiration in plants.

In the study carried out by Kaynar (2007) the effectiveness of 5E learning cycle on sixth grade students' understanding of cell concepts, their attitudes toward science and their scientific epistemological beliefs was investigated. The study was carried out with 160 sixth-grade elementary school students. While a statistically significant treatment difference with respect to collective dependent variables; understanding of cell concept and epistemological beliefs was found there was no significant difference on attitudes toward science. The outcomes of the study exhibited that students in the experimental group who were engaged in learning cycle instruction demonstrated significantly better performance over the control group students who were engaged in traditional instruction in students' understanding of cell concepts and epistemological beliefs.

Another study of the effectiveness of 5E learning cycle on 8th grade students' achievement on photosynthesis and respiration in plants was investigated by Cakiroglu (2006). Students' knowledge on photosynthesis and respiration in plants was determined by a test developed by Haslam and Treagust. This test was applied to 67 eight-grade students in two classes of the same elementary school as pre-test and post-test while the experimental group students (n=33) learned the lesson by 5E learning cycle instruction, control group students (n=34) learned the lesson by traditional instruction. The significant difference was found between the experimental and control groups in favor of 5E learning cycle instruction.

Ndioho (2007) investigated the effect of constructivist instructional model on Senior Secondary student's achievement in biology using 5E learning cycle. The study adopted a quasi experimental design of non – equivalent control group involving two groups. Four schools were chosen for the study. Four schools were chosen for the study in which two co-educational boy's and one girl's school. From each school 30 students were selected. One group was assigned the experimental group while the other the control group. Experimental group were taught genetics using constructivist instructional approach, the control group was taught using lecture method. Genetics Achievement Test was used to post-test both groups. The result showed that constructivist instructional approach was significantly more effective in increasing students academic performance than lecture method in Kano state. Cardak, Dikmenli and Saritas (2008) investigated the effect of 5E learning cycle on sixth grade students' achievement during the circulatory system unit. While the experimental group and the control group were the same at first, after implementation, there was an important difference in favor of the experimental group.

Özlem and Jale (2010) investigated the effectiveness of 5E learning cycle instruction on 11th grade students' human circulatory system achievement. In this study, The Human Circulatory System Achievement Test was used to assess students' achievement on human circulatory system. Two teachers and four classes and total of 60 11th grade students were participated in this study. One class of each teacher was assigned as experimental group and treated with 5E learning cycle instruction and other class was assigned as control group and treated with traditional instruction. The Human Circulatory System Achievement Test was applied twice as pre-test and after treatment period as a post-test to both experimental and control groups to measure students'

achievement. ANOVA results revealed that 5E learning cycle instruction improved students' achievement in human circulatory system compared to traditional instruction.

All the above researches were conducted on 5E teaching cycle in Biology at different places, using different topics without touching the aspect of genetics using pre-NCE Biology students. This study was therefore carried out in Nigeria, in area of genetics by investigating how 5E teaching cycle model affected the attitude, retention and academic performance of Pre-NCE Biology students of varied abilities in North-West Zone.

2.5.2 Genetic Concept and Academic Performance in Biology

Genetics is one of the areas of Biology that has great impact on human life. Genetics is the study of genes, heredity and variation in living organisms. The father of Genetics is Gregor Mendel (1822-1884), an Australian Monk-Scientist. Mendel studied 'trait inheritance' patterns in the way trait was handed down from parent to their offspring.

The knowledge of Genetics according to Ambuno, Egunyomi & Osakwe (2008) improved varieties of species of plants and animals through selective breeding, inbreeding, out breeding, counseling parents on the risks of diseases on themselves and their offspring, if there is a record of genetic diseases in the family. The knowledge has also helped in determination of both sex and determination of paternity of the child in case of any dispute. Research finding has shown that a number of topics in Biology among which are Genetics, contain some concepts or terminologies which are difficult to learn by students (Umeh, 2006 & Lawal 2010). It is also observed by Okafor & Okeke (2006) that when concepts in genetics are not understood by students, they tend to avoid

attempting such questions in Senior Secondary School Certificate Examination (SSCE). Those who attempt them have performed badly and this accounts for poor performance in Genetics and similar difficult concepts in Biology. A study conducted by Lakpini (2006) showed that when students were taught genetic concepts using constructivist teaching strategies, they achieved better than those taught with lecture method. A study by Lawal (2005) on genetic concepts showed that students taught using concept mapping strategy performed better than those taught with lecture method. It is another aim of this study to investigate the impact of 5E teaching cycle on pre-NCE students of varied abilities academic performance, retention and attitude in some genetic concepts.

2.6 Concept of Ability Levels and Academic Performance in Science

Ability grouping has been an extremely controversial practice (Ansalone, 2006 & Rubin, 2006) as evidenced by the fact that it "has been the subject of more research studies than almost any other educational practice (George and Alexander, 2003)". Ability grouping is based on educators' judgment of students' abilities (Bunkure, 2012). When assigning students to tasks, educators examine prior test scores or other achievement measures they have administered or that have been provided by educators from other grades or schools. Students are then grouped with others who have been judged to be at a similar ability level for instructional purposes.

Vee (2013) defined ability grouping as the arrangement of students by teachers based on ability and proficiency level. This is done by placing the highest achieving students in one cluster, the average achieving students in one cluster and the lowest in another. Lakpini (2006) defined ability grouping as placing a student in a group based on his level of mental power to perform an act. In her studies, Lapkini categorized students into three, based on their abilities:

High ability group = who scored 60% and above;

Average ability group = who scored 50% to 69%;

Low ability group = who scored 0 to 49%.

Proponents of ability grouping (including many parents and teachers) maintain that teachers can move specifically targeted instruction to meet the needs of students when they are grouped by ability. Opponents maintain that intended gains for students in all tracks too often fail to materialize, that students are too often grouped so that their ability tracks correlate with income, social class, and race, and that identification of students with "low ability groups" brings about stigmatizing result".

Hollifield (1987) has categorized ability grouping into between-class and within-class ability grouping. Between-class grouping refers to a school practice of forming classrooms that contain students of similar ability, while within-class grouping refers to a teachers' practice of forming groups of students of similar ability within an individual class.

In theory, ability grouping increases students' academic performance by reducing the disparity in student ability levels and this increases the likelihood that teachers can provide instruction that is neither too easy nor too difficult for most students. Ability grouping allows the teacher to increase the pace and raise the level of instruction of high ability students and also provide more individual attention, repetition and review for low ability students. The high ability students' benefit from competing with one another, and the low achievers benefit from not having to compete with their more able peers. According to Slavins (1986), one of the main arguments against ability grouping is that the practice creates classes or groups of low achievers who are deprived of the example and stimulation provided by high achievers. Labeling students according to ability and

assigning them to low-achievement groups may also communicate self-fulfillment and low expectations. Further, groups with low performance often receive a lower quality of instruction than other groups. Slavins sees as the most compelling argument against ability grouping its creation of academic elites, a practice which goes against democratic ideals. Ansalone and Biafora (2004) found that teachers continue to support ability grouping (tracking) as a result of their managerial concerns about the complexities of teaching students with diverse learning needs. Tracking may make the teachers' work easier, even if it is not the most effective way to serve students. This finding is interesting, considering that another study by Yonazawa and Jones (2006) found that students regarded tracking policies as unjust and inequitable. In response to the negative outcomes of tracking, many schools have begun to implement "detracking" measures (i.e. concentrated efforts to move from ability grouping or tracking to heterogeneous grouping while maintaining appropriately high standards for all students involved). Watanabe (2006) found that teachers must learn how to appropriately initiate dialogue about tracking and detracking. As any experienced teacher can tell you, 'tracking' and de' tracking are not the equivalent of 'forward' and 'reverse' on a car (Rubin and Noguera, 2004, p.94). Teachers implementing heterogeneous grouping as an alternative to tracking must also be careful not to perpetuate inequalities within their "de-tracked" classrooms and, thereby, "re-track" their students within the midst of the apparently heterogeneous group. Because de-tracking is inherently difficult, some will argue that an alternative solution is to maintain tracking but focus on the assurance of quality of instruction provided to students in lower tracks.

Ridgeway (2004) reported the outcome of her research using interactive-lecture strategy and lecture-and-note method. She used two classes of students: One class

comprised students, whom she termed, gifted (high or brilliant) and the other class comprised the not-so-gifted, which she termed the basic (low ability). The gifted students were taught using the usual lecture-and-note methodology while the basic class was taught using the interactive-lecture strategy. The two groups were taught three units on evolution, and they were given the same test at the end of treatment. According to her, the test had difficult multiple-choice questions and several short answer and essay questions that required students to apply their knowledge. At the end of the test, the basic class (low ability) had a higher-class average than the gifted class. It was also found that the basic class students' essays were compared with those written by the gifted students and the very best essay of all was written by one of the students in the basic class. The study revealed that the academic performance of low ability students can be improved using an improved teaching strategy.

Eze (2002) studied the effect of Target Task Approach (TTA) on students' achievement in Senior Certificate physical chemistry found that student's ability level is a significant factor in their academic performance in physical chemistry. These results are contrary to the findings of Ridgeway (2004) who found that low ability students had a higher-class average than the gifted class. In another study on ability levels and academic performance, Lakpini (2006) found that students of varied ability level exposed to conceptual change instructional strategy performed significantly better than those exposed to traditional method. The high ability level in the environmental group performed better than the high ability group in the control. The average ability in the experimental group performed significantly better than that of the average ability level in the control groups. Also, students of low ability level in the experimental group performed better than low ability level in the control group.

Anaso (2008) worked on the Effects of Class Size on the Academic performance and Retention of different Ability Groups among Chemistry Students at Secondary School Level in Zaria Educational Zone, revealed that the high-ability students in all the three class-size groupings showed significant differences in their academic achievement. (i.e. high ability students in the small class size achieved significantly better than their counterparts in other class size groupings). A study also carried out by Bunkure (2012) on effect of Constructivist Instructional Strategy on Physics students academic performance in Kano State Secondary Schools of different ability levels, showed results of students of different ability levels (i.e. high average and low) performing significantly better when exposed to Constructivist Instructional Strategy than those exposed to lecture method. Since other studies on different ability levels were carried out in other subjects using different method rather than inquiry method, this study is then undertaken to address this issue. Ajewole and Okebukola (1998) and Lakpini (2006) concept of ability level will be adopted in this study.

2.7 Attitude and Academic Performance in Biology

Many science educators such as Lakpini (2006), Lawal (2009), Yara (2009) and Manko (2010) have attributed great importance to affective domain characterized by a variety of constructs such as attitude, preferences and interest (Sjobery, 2002). Attitude has been defined by many authors; Bunkure (2012) defined attitude as an opinion, or way of thinking or the behaviour reflecting the way of thinking. Yara (2009) views attitude as an individual way of thinking, acting and behaving. Osborne (2003) defined attitude as feelings, beliefs and values an individual holds about an object that may be the enterprise of science on society or scientists. In another definition, Lawal (2009) sees attitude as the learner's state- of- mind that influences personal actions of the individual.

According to Yara (2009), attitude has serious implication for teaching and learning processes in science. That is, it has both the potential to facilitate or inhibit learning. Attitudes are formed as a result of some kind of learning experience which affects the outcomes in teaching and learning of science. Bunkure (2012) posited that attitudes are important in influencing students' acceptance or rejection of situations. He went on to say that the kind of attitude a child has, affects his school work and learning. If a child has positive attitude about teachers and school work, he will experience some success and will work more effectively. Various researches carried out in different parts of the world have identified so many factors influencing students' attitudes towards sciences. For example, Yara (2009) identified gender, personality, environmental factor and curriculum variables as factors influencing students' attitude to science. The quality of teaching of science is a significant determinant of attitude towards science (Sjoberg, 2002). Okebukola (2002), opined that the way students perceive science is another significant factor affecting their attitude towards science.

However several studies established that students have negative attitudes towards science and science-related subjects. And that some even preconditioned their minds on their incapability to learn science and have the belief of it been difficulty (Peni, 2008). He went on to stress that certain science concepts are perceived difficult by most students and in turn, affects their achievement. There are extensive literatures on attitudes towards achievement in science. Nnachi (2002) stated that attitude seems to account for some significant percentage of the differences in academic performance in science. Okebukola (2002) also stressed that students' attitudes to science have significantly direct effect on academic performance in science. Therefore, higher academic performance in science is linked to positive attitudes towards science learning. Katcha (2005) investigated the

effect of vee-diagram instructional strategy on senior secondary school academic achievement in an attitude change to Biology. He found out that students taught Biology concept using vee-diagram instructional strategy performed better in Niger State than students taught using lecture method and they also showed a positive attitude towards Biology.

In a study carried out by Lakpini (2006) on the effect of a conceptual change instructional strategy on academic achievement, retention and attitudes of secondary school Biology students with varied ability levels in Zaria, Giwa Educational Zone, Kaduna State, Nigeria, it was revealed that high and average ability students had positive attitudes to conceptual change instructional strategy than their counterparts in the control group. Bunkure (2012) in a study on effects of constructivist teaching strategy on academic performance, retention and attitude of senior secondary school physics students of Kano State found that students in the experimental group show more positive attitudes than the control group taught with lecture method.

Akinbobola (2009) conducted a study to find out the attitude of students toward the use of cooperative, competitive and individualistic learning strategies in Nigerian Senior Secondary School Physics. He used a quasi-experimental design. A total of I40 students consisting of 66 males and 77 females were selected by a random sampling technique from a population of 680 senior secondary two (SSII) Physics students drawn from all the 13 coeducational secondary schools in Ife South Local Government area of Osun State, Nigeria. The data collected was analyzed using Analysis of Variance (ANOVA) and the result of the findings showed that cooperative learning strategy was the most effective in facilitating students' attitude toward Physics. This was followed by competitive strategies with the individualistic learning strategies being the least

facilitative. The result also showed an insignificant gender difference in the attitude of students toward Physics when taught with cooperative, competitive and individualistic strategies. Bitrus (2012) in a research on effects of science process skills approach on academic performance and attitude of integrated science students with varied abilities in Potiskum Educational Zone found no significant attitude change among students of varied abilities in both the experimental and control group.

There are many studies on 5E learning cycle and attitudes toward science. A study was conducted by Wilder and Shuttleworth (2004) investigated the effectiveness of 5E learning cycle in their study of "Cell Inquiry". It was reported that the high school students were motivated and by the 5E learning cycle. Garcia (2005) carried out a study to compare the effectiveness of using 5Es learning cycle instructional model with the traditional Hunter lesson plan to teach evolution concepts and enhance students' attitudes toward the subject of science. 160 seventh-grade life science students were used in this study as a sample. The results showed that although there was no significant difference between students who were instructed by 5Es learning cycle model and students who were instructed by traditionally designed instruction with respect to understanding evolution concepts and students attitudes towards science, a significant change was found based on paired pretest and posttest caparison. In addition it was revealed that 5E learning cycle model had some positive effects on lower level of students. The results may be affected by level of treatment fidelity that was discussed by Coulson's (2002) study. Additionally, Ozsevgec (2006) investigated the effect of 5E on 5th grade students' achievement and attitudes toward science and technology course. It was found that there was no statistically significant change in attitude.

Another study was carried out by Ersahan (2007). In his study 5E instruction method supported by video movies and role play instruction method were compared in order to find the most effective method for teaching Science-Technology-Society-Environment skills in the Matter and Change Strand for 6th grade students. According to the results of the study, it was found that there was no significant difference in the level of attitude to Science and Technology between students who instructed by 5E instruction method and role play instruction method. Keskin (2008) expressed the aim of his study was to compare the effectiveness of 5E learning cycle class to traditionally designed physics class on simple harmonic motion: simple pendulum concepts and attitudes toward physics on high school students. The study was carried out with eleventh-grade high school students. Research results showed that there was an increase in the scores of attitudes toward physics. However, it was found that there was no statistically significant difference in gained scores of the attitude.

There is ample evidence in literature to show that an enhanced instructional strategy improves students' attitudes to Biology. There seems to be no reported study to the knowledge of the researcher on the impact of 5E teaching cycle on the attitudes of pre-NCE Biology students with varied abilities in genetics. The researcher intends to study the impact of 5E teaching cycle, the extent to which attitudes of pre-NCE Biology students of varied abilities are affected towards genetics.

2.7.1 Retention Ability Levels and Academic Performance in Biology

Retention of knowledge is a very important factor affecting teaching and learning of science. Permanent and meaningful learning is the ultimate target of educational endeavour (Bunkure, 2012). According to Bichi (2002), understanding and retention are products of meaningful learning when teaching is effective and meaningful to the

students. Hornby (2010) defined retention as the ability to remember things. Lawal (2009) viewed retention as the ability of the memory to store information which can be recalled sometime after exposure to series of instruction or training. Bunkure (2012) defined retention as the ability to retain and consequently remember things experienced or learned by an individual at a time. Retention takes place when learning is coded into memory. According to Bichi (2002), appropriate coding of incoming information provides the index that may be consulted so that retention takes place without an elaborate search in the memory lane. Bichi further stated that the nature of the material to be coded contributes to the level of retention. Several factors influence retention. Bichi (2002) reported that learning improves retention while things that lead to confusion or interference among learned materials, decrease the speed and efficiency of learning and accelerates forgetting.

Several studies were carried out by different researchers on retention, some of which are: Akinbobola and Folashade (2009) who compared the effectiveness of Constructivist Teaching Methods and the conventional method with reference to achievement, retention and attitude. They also found that students exposed to constructivist teaching method had higher cognitive achievement, more positive attitude and higher retention level than those taught using the conventional teaching method. Jiya (2011) found that NCE I Biology students taught Biology using Teaching with Anology Strategy retain evolution concepts better than those taught with lecture method. Also, Aminu (2012) found out that students taught with Integrating Instructional Models with Lecture Method retain Biology concepts better in different class size than those not taught with lecture method only. On the issue of research on varied abilities and retention, Lakpini (2006) and Bunkure (2012) in their separate findings in Biology and

physics found that experimental group of varied abilities retain scientific concepts more than the control group. From the literature reviewed, it has been shown that improved instruction could enhance retention. This study, therefore split students into ability groups and each was encouraged to interact together, and find solution to problems confronting them together with the aim of finding out if 5E teaching cycle of inquiry method will make the students of varied abilities retain Biology concepts better.

2.7.2 Gender and Academic Performance in Biology

Gender issues in science, and in particular, Biology education has been the concern of many educators and series of researches have been going on in this area. Some researchers such as Aigbomian (2002), Njoku (2004) reported that boys perform better than girls in science, technical and mathematical subjects. Other researchers like Dahiru (2013) showed that sex plays no significant role in performance in science and technology. He still raised the concern and worries that female performance and achievement in science, technology and mathematics is not fully encouraging. Nwaiwu and Audu (2005) in the same vein agreed that the number of women enrolment for tertiary education has increased at a slower rate than male enrolment. Nwaiwu, et al (2005) viewed it that gender gap in education is at the highest with male enrolment, at least, three times higher that of female. More so, girls and women tend to enroll in humanities and are found to be under-represented in science subjects and mathematics where male or men dominate. This development perhaps has evolved from the fact that girls still have difficulty in understanding physical sciences, notably, physics, as observed by Aigbomian (2002). Nwagbo (2002) reported that female science students' appreciation of the role of science is as much as their male counterparts but lagging behind in knowledge-application and communication in science. Okeke (2001) agreed

that gender stereotyping which assigns science as male domain has also contributed to the poor enrolment and achievement of girls in science and technology in tertiary institutions. Ogunboyede (2003) in a study of sex difference and students' achievement at the primary school level indicated that boys are not better than girls in terms of educational achievements. Development of sex differences is facilitated and interwoven with the gradual process of socialization in many families, peer groups and age grades, religious institutions, school and mass media.

Umar (2012) defined gender as the amount of musculanity or feminity in an individual. Okeke (2008) has described gender as the socially and culturally-constructed characteristic and roles which are ascribed to male and female in any society. All the researches on gender issues are being carried out in order to improve the teaching and learning of science. In a study, Philip et al (2000) reveal that girls show greater participation in science than boys. Bichi (2004) findings show no significant difference between the post-test mean scores of male and that of the female. It is also observed by Oluwatoyin (2007) that when women are exposed to science, they better their scores. Lawal (2009) found no significant difference in gender when taught using conceptual change instructional strategy, but she found significant gender difference when exposed to traditional instructional strategy. On the issue of gender and retention ability, Lawal (2009) found that gender has no significant effect on retention ability of students when they were taught selected genetic concepts using conceptual change instructional strategy.

Lakpini (2006) in her study of gender and different ability levels found out that no gender difference existed when students were exposed to conceptual change instructional strategy in Zaria-Giwa Educational Zone. Bunkure (2012) also found same result when

he carried out similar study in Kano state. Concerning gender and achievement in science, Osborne (2003) opined that the early established difference in the interest and activities of boys and girls results in parallel difference in their science achievement. It is in this regard that this study was carried out at pre-NCE level to see the impact of 5E teaching cycle phases on the academic performance, retention and attitudes of both male and female students of different ability levels.

2.8 Overview of Similar Studies

Many educational studies have explored the effectiveness of 5E teaching cycle on learner performance. Some of the reviewed studies on 5E teaching cycle include that of Balcı, Çakıroglu and Tekkaya (2006) carried out a study to investigate the effects of the 5E learning cycle, conceptual change text, and traditional instructions on8th grade students understanding of photosynthesis and respiration in plants. 101 8^{th} grade students in three intact classes of the same school were used in this study. There were three groups in this study. Two of the groups were assigned as experimental groups in one of which 5E learning cycle model was used and in the other experimental group conceptual change text instruction was used. The third group was defined as control group in which the traditionally designed instruction was used. The results showed that there were significant differences between experimental and control groups in favor of experimental group with respect to students' understanding of photosynthesis and respiration in plants. On the other hand, there were no statistically significant difference between the students who were instructed 5E learning cycle and students who were instructed by conceptual change texts with respect to students' understanding of photosynthesis and respiration in plants.

In the study carried out by Kaynar (2007) the effectiveness of 5E learning cycle on sixth grade students' understanding of cell concepts, their attitudes toward science and

their scientific epistemological beliefs was investigated. The study was carried out with 160 sixth-grade elementary school students. While a statistically significant treatment difference with respect to collective dependent variables; understanding of cell concept and epistemological beliefs was found there was no significant difference on attitudes toward science. The outcomes of the study exhibited that students in the experimental group who were engaged in learning cycle instruction demonstrated significantly better performance over the control group students who were engaged in traditional instruction in students' understanding of cell concepts and epistemological beliefs.

Another study of the effectiveness of 5E teaching cycle on 8th grade students' achievement on photosynthesis and respiration in plants was investigated by Cakiroglu (2006). Students' knowledge on photosynthesis and respiration in plants was determined by a test developed by Haslam and Treagust. This test was applied to 67 eight-grade students in two classes of the same elementary school as pre-test and post-test while the experimental group students (n=33) learned the lesson by 5E learning cycle instruction, control group students (n=34) learned the lesson by traditional instruction. The significant difference was found between the experimental and control groups in favor of 5E learning cycle instruction.

Ndioho (2007) investigated the effect of constructivist instructional model on Senior Secondary students' achievement in biology using 5E learning cycle. The study adopted a quasi experimental design of non – equivalent control group involving two groups. Four schools were chosen for the study. Four schools were chosen for the study in which two co-educational boy's and one girl's school. From each school 30 students were selected. One group was assigned the experimental group while the other the control group. Experimental group were taught genetics using constructivist instructional

approach, the control group was taught using lecture method. Genetics Achievement Test was used to post-test both groups. The result showed that constructivist instructional approach was significantly more effective in increasing student's academic performance than lecture method in Kano state.

Bilgin (2009) investigated the effects of guided inquiry instruction using 5E learning cycle, incorporating with cooperative learning environment on University students' achievement of acid bases concepts and attitude toward guided inquiry instruction. He selected 55 first year university students from two intact classes of a chemistry course instructed by the same teacher. One of the classes was randomly assigned as the experimental group and the other was assigned as the control group. The experimental group cooperatively studied worksheets which were related to acid- base concepts in the group while the control group individually studied the worksheets in the class. The data collected were analyzed using Multi Variance Analysis (MANOVA). The result showed that, students in the experimental group had better understanding of acid and base concepts and a more positive attitude toward guided inquiry instruction.

Pulat (2009) investigated the impact of 5E learning cycle on sixth grade students' mathematics achievement on and attitudes toward mathematics. The study was carried out in a public school in one of the towns of the Central Anatolia Region with 28 sixth-grade elementary school students. One group pretest-posttest design was used. Mathematics Achievement Test and Mathematics Attitude Scale were administered to collect the necessary data. The instructional was applied by the researcher five hours per week in a 15-week. The data were analyzed by using one-way repeated measures analysis of variance and a paired-samples t-test. According to the results of the study it was found that there was a statistically significant change in mathematics achievement of sixth grade

students who participated in the instruction based on 5E teaching cycle over three time periods (pre-intervention, post-intervention, and follow-up). There was only no statistically significant mean difference between post-intervention and follow-up mathematics achievement. Furthermore, there was a statistically significant decrease in mean scores of attitudes toward mathematics from prior intervention to after intervention. Açışlı, Altun and Yalçın (2011) evaluated the efficiency of student guiding materials on student achievement, using the 5E teaching model. The materials were developed by the researcher, based on the "Movement and Force" unit's objectives. Quasi experimental research design included 60 students (30 experimental, 30 control group). Control group students were given experiment booklets, which were prepared for each experiment in accordance with the 5E learning model. To determine whether any differences exist between the two groups' academic achievements, Achievement Tests on Movement and Force Issues were applied to the groups, both at the beginning and at the end of the semester as pre- and post-tests. Pre- and post-test results were compared, using a t-test in SPSS packet program. Results showed a meaningful difference between groups in favor of the experimental group (t_{58}=5.06; p=.00 < .05).

Turgut and Gurbuz (2011) investigated eighth grade students' misconceptions related to heat and temperature compared the effectiveness of 5E learning model and traditional instruction method on eighth grade students' understanding of heat and temperature concepts and their attitudes towards science and technology in order to determine whether consisting of conceptual change to be retentive. The subjects of the study were 37 eighth grade students at a primary school in Erzurum, who were in two different classes and taught by the same teacher at 2009-2010 education years. One of the classes was randomly selected as experimental group in which students were thought

by means of activities which were prepared according to the 5E model, and the other was determined as the control group in which students were thought by traditional methods (teacher-centered, based on straight narrative and question-answer method). The data were obtained through the use of three-phase Heat and Temperature Misconception Test (HTMT) and the Attitude Scale towards Science and Technology (ASST). The study results were analyzed by SPSS. To analyze data, independent and paired sample t-test, and percentage and mean scores were conducted. Results of Heat and Temperature Concept Success Test revealed that 5E teaching model is more successful on remediation of misconceptions and effective in providing a permanent conceptual change than the traditionally designed instructions. However, there was no statistically significant difference between the experimental and control group in terms of students' attitude towards science and technology.

Bunkure (2012) investigated the effects of constructivist instructional strategy on the academic achievement, retention and attitude to physics among Science Secondary School Student's of varied ability levels in Kano State using 5E learning model. Pretest posttest experimental design was used for the study. A simple random sampling technique was used to select 4 schools out of 7 Science Secondary Schools in Kano State. 160 out of 1559 SS II physics students were used for the study. Physics Achievement Test (PAT) and Physics Attitude Questionnaire (PAQ) were used to collect data. The reliability of PAT was calculated using Pearson's Product Moment Correlation Coefficient to be 0.86. Six null hypotheses were tested at $p<.05$ level significance using t-test, one way Analysis of Variance (ANOVA), and Mann Whitney U test statistics. The following major findings were obtained: (i) students exposed to constructivist instructional strategy achieved, retained the learnt concepts and developed more positive

attitude to physics than their counterparts exposed to conventional method of teaching. (ii) There was no significant difference in students' achievement with reference to gender. (iii) The strategy is suitable for students' of varied ability levels. On the basis of these findings a number of recommendations were made for the improvement of teaching physics in secondary schools. One major recommendation is that physics teachers should incorporate 5E constructivist instructional strategy into mainstream of pedagogy in the teaching of physics as it seems to have high potentials for enhancing understanding, achievement and retention on the part of the learners.

Shittu (2013) conducted a study on the effects of guided inquiry strategy using 5E learning cycle on learning outcomes of low achieving secondary school physics students in Kaduna Metropolis. The population consisted of 1,714 SS2 students and subjects were made into experimental and control group. Quasi-experimental control group design consisting of pretest and post-test was used as the design for the study. He randomly selected 91 low achieving students as the sample of the study. Experimental group was taught by inquiry method while the control group was taught using lecture method for six weeks. After using t-test and Wilcoxon statistics to analyze his data, the result showed that low achieving students taught using inquiring method in physics concept achieved significantly higher than those taught using lecture method and the attitude of experimental group had greatly improved. The study also revealed that guided inquiry method favored both male and female low achieving Physics students.

Njoroge, Changeiywo, and Ndirangu, (2014) investigated the Effects of inquiry-based teaching approach using 5E learning cycle on Secondary School Students' performance and motivation in Physics in Nyeri County, Kenya. The study adopted a Quasi-Experimental Research Design. Solomon-Four Non-equivalent Groups Design was

involved. Stratified random sampling technique was used to select four boys' and four girls' county secondary schools in Nyeri, County. The four schools in each category were assigned to treatment and control groups by simple random sampling technique. Each group had one boys' and one girls' county secondary school. Each school provided one form two class for the study and a total of 370 students were involved. Students in all the groups were taught the same physics content but the experimental groups were taught using IBT approach while the control groups were taught through Regular Teaching Methods (RTM) such as lecture method and teacher demonstrations. The experimental group I and the control group II were pre-tested prior to the implementation of the IBT treatment. After four weeks, all the four groups were post-tested using the Students' Physics Achievement Test (SPAT). The instrument had been validated by five experts in education and pilot tested before use to estimate its reliability. The reliability coefficient using K-R21 was 0.87. The acceptable threshold for reliability coefficient is 0.7 and above. The instruments were scored and data was analyzed using t-test, one way ANOVA and ANCOVA at a significance level of coefficient alpha (α) equal to 0.05. The findings of the study showed that Inquiry-Based Teaching (IBT) approach resulted into higher students' scores in achievement in physics. The study recommends that Teacher training institutions, Kenya Institute of Curriculum Development (KICD) and physics teachers should enact IBT approach as the preferred physics teaching approach in Kenyan secondary schools.

In conclusion, most studies reviewed were carried in different subjects at secondary school levels. Even those conducted in Biology did not consider the ability levels of students and Genetics concepts. This present study used Pre-NCE students and genetics. Therefore, this work filled the gap of using 5E teaching cycle on the academic

performance, retention and attitudes among pre-NCE Biology students of different ability levels in North-West zone which was new.

2.9 Implications of Reviewed Literature on the Present Study

The related literature reviewed so far have given some insights into the effects of inquiry method on academic performance, retention and attitude of students in different places home and abroad, at different levels of education and this has some implications on the present study.

5E teaching cycle has been found by science educators like Bilgin (2009), Pulat (2009) , Açışlı, Altun and Yalçın (2011),Turgut and Gurbuz (2011), Bunkure (2012), Shitu, 2013, Ado, (2014), Njoroge, Changeiywo, and Ndirangu, (2014) to have positive effects on variables such as academic performance, retention, attitude and gender. These variables have been shown to have effects on learning. The related literatures reviewed for the purpose of this study showed that the use of 5E teaching cycle in science instruction enhanced students' performance, retention as well as improved students' attitude to science. However, the use of the lecture method of teaching has been shown to be of little help for learners in enhancing learners' performance. Most of the studies reviewed were carried out using secondary students and not pre-NCE students. The present study is carried out using pre-NCE students in genetics.

According to Ahmed (2010) students of all mental abilities are found mixed in the classroom and are usually given the same assignments and are expected to perform the same work without grouping them based on their ability level. This makes high ability students to dominate the lesson hindering low and average students from participating fully. Anaso (2008), Lakpini (2006), and Bitrus (2012) agreed that grouping students with similar achievement and talent is essential if the desire is to help students achieve at

the levels commensurate with their abilities and sustain or increase their motivation to learn a given task. They also concluded that schools can best deal with individual differences in ability by dividing students into subgroups within a heterogeneous class and thereby supported the use of within-class ability grouping. The present study is unique in that, it is aimed at grouping students based on their ability levels ((homogeneous class grouping) rather than mixing them together in the same group (heterogeneous class grouping).

Study on 5E teaching cycle showed that it enhances the academic performance of students. From the knowledge of the researcher, no work was done on 5E teaching cycle in genetics using pre-NCE students in North-West Nigeria. Specifically, the study investigated the impact of 5E teaching cycle on attitude, retention and academic performance of pre-NCE Biology students of varied abilities in North-West Zone.

CHAPTER THREE
METHODOLOGY

3.1 Introduction

In this chapter, the methods and procedures employed in conducting the research are discussed under the following sub-headings:

- Research Design
- Population of the Study
- Sample and Sampling Technique
- Selection of Concepts to be Taught
- Instrumentation
    - Validity of the Instruments
    - Pilot Testing
    - Reliability of the Instruments
    - Item Analysis: Difficulty Index, Facility Index
- Administration of the Treatment
- Treatment of the Experimental and Teaching the Control Groups
- Data Collection Procedure
- Procedure for Data Analysis

3.2 Research Design

The research design was a quasi-experimental and control group design employing Pretest and Posttest and Post-posttests (Kerlinger, 2000). Simple random sampling technique by balloting method was used to select two schools out of the eleven coeducational colleges of education that served as population of the study. Federal College of Education Zaria served as experimental group while Federal College of

Education Katsina served as the control group. Fifty five (55) Pre-NCE Biology students (38 males and 17 females) were selected from each college of the study as guided by Central Limit Theory by Dana (2000), Fraenkel & Wallen (2000) and John & James (2011) which proposed that thirty or more subjects are considered as large sample for experimental research of this nature. This is to ensure that:

- every student had equal chances to participate actively in the study;
- to obtain an unbiased assessment of students' performances;
- The researcher to have good varied ability groups among the subjects under study. A total of one hundred and ten (110) students were used for the study. Equal numbers of subjects were randomly selected for each group in order to have a fair representation of the subjects in the study (Sambo, 2008).

Pretest was administered on the subjects, before they were exposed to the treatment 5E learning cycle to determine that they are not different significantly in their ability level. The experimental and control group subjects were assigned to sub-groups according to their ability levels by stratifying sampling technique after the pretest. The ability grouping was carried out by categorizing the subjects into high average and low ability group where students who scored 60-100 range of scores comprised high ability, those that scored 40-59 were categorized as average ability and those with 0-39 comprised low ability subjects. The experimental groups were exposed to 5E learning cycle while the control group was exposed to lecture method. The research design is represented in Figure 3.1:

The posttest was given to determine the effects of exposure to 5E learning cycle which was for experimental and control groups. The Post-posttest was administered after

two weeks from the administration of the Post-test as recommended by Tuckman (1975) in order to determine the retention ability of the subjects in the study.

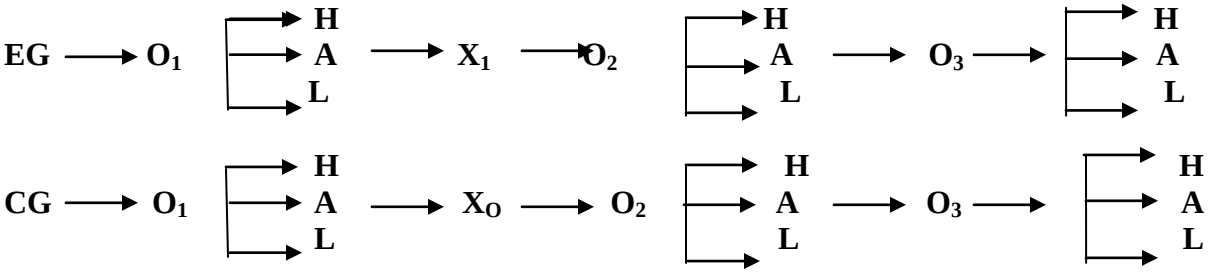


Figure 3.1 Research Design

KEY

EG = Experimental Group

CG = Control Group

O_1 = pre-test

O_2 = Post-test

O_3 = Post-post test

H = High ability group for experimental group

A = Average ability group for experimental group

L = Low ability group for experimental group

X_1 = Treatment for experimental group (taught with inquiry method)

X_0 = Control group taught with lecture method.

A quasi-experimental and control group design employing Pretest and Posttest and Post-posttests is suitable for this study because of the advantages listed by (Lakpini, 2006). This could be summed up as follows:

a. The superiority of one instructional strategy over the other can easily be tested;
b. It gives indications of concept attainment ability or understanding gained by students after they have been exposed to a particular teaching treatment;

c. The pretest scores giving indication as to whether the groups are equal in the concepts they hold before interaction was given.

3.3 Population of the Study

The population of this study comprised all the pre-NCE Biology students in the coeducational Colleges of Education in the North-West zone of Nigeria. North-West Zone had 11 States and Federal Colleges of Education, with a total number of 2231 pre-NCE students: 1,168 male and 1,063 female. The population for the study had already been exposed to Biology teaching for three years in their secondary schools. The detail of the population is presented in Table 3.1.

Table 3.1: Population of the Study

S/No	Name of College	Status	Type	Enrolment of Pre-NCE Science Students		
				Male	Female	Total
1	FCE Kano	Federal	Co-educational	130	95	225
2	FCE (Techn.) Bichi	Federal	Co-educational	120	100	220
3	FCE Katsina	Federal	Co-educational	140	122	262
4	FCE Zaria	Federal	Co-educational	139	176	315
5	COE MaruZamfara	State	Co-educational	80	60	140
6	Jigawa State COE Gumel	State	Co-educational	90	50	140
7	ShehuShagari College of Education Sokoto	State	Co-educational	75	60	135
8	Isa Kaita College of Education D/ma	State	Co-educational	169	190	359
9	Kaduna state College Of Education Gidan waya kafanchan	State	Co-educational	100	95	195
10	Kano state College of Education Kumbotso	State	Co-educational	80	75	155
11	Adamu Augie College of Education Argungu, Kebbi State	State	Co-educational	45	40	85
	TOTAL	**-**	**-**	**1,168**	**1,063**	**2,231**

Sources: Academic Secretary Office of Each College of Education, 2015

3.4 Sample and Sampling Technique

Two co-educational Colleges of Education were selected through simple random sampling technique by balloting and assigned to experimental group and control group as shown in Table 3.2. A total of fifty five (55) Pre-NCE Biology students (38 males and 17 females) were selected from each college of the study by simple balloting technique as guided by Central Limit Theory by Tuckman (1975), Dana (2000), Fraenkel & Wallen (2000) and John & James (2011) which proposed that thirty or more subjects are considered as large sample for experimental research of this nature. Equal numbers of subjects were selected for each group in order to have a fair representation of the subjects in the study (Sambo, 2008). In the experimental group, high ability consisted 15 students, 30 average ability students and 10 low ability students. The same procedure and numbers were used as the control group and boys and girls were sorted as presented in Table 3.2:

These were categorized into high, average, and low ability groups through stratify sampling technique. The mode of categorization was done by giving them pre-test of Genetic Academic Performance Test (GAPT), where those that scored sixty (60) and above were categorized as high ability, those that scored 40 -59 were categorized as average ability while those that scored 0 – 39 were categorized as low ability group.

Table 3.2: Sample of the Study

	Name of College	**Status**	**Types**	**No of boys**	**No of girls**	**Total**	**State**	**Group**
1	F.C.E Zaria	Federal	Co-edu.	38	17	55	Kaduna	Experimental
2	FCE Katsina	Federal	Co-edu.	38	17	55	Katsina	Control
	TOTAL	**-**	**-**	**55**	**55**	**110**		

3.5 Selection of Concepts to be Taught

The following concepts were selected from Biology curriculum for pre-NCE students:

1. Morphological variation in the physical appearances of individuals;
2. Psychological variation and application of variation;
3. Causes of variation;
4. Chromosomes, the basis of heredity;
5. Transmission and expression of characteristics of organisms (monohybrid inheritance)
6. Mendels Dihybrid inheritance.

The choice of these concepts is informed by a number of reasons; Studies show that students have difficulties in understanding some concepts in Biology, Ecology, Evolution, Genetics (Umeh, 2006 and WEAC Chief Examiners Report, 2014).

The concepts are taught at the senior secondary schools, as well as at the university level, as such, the understanding of the concepts is very important for the learner. In addition, Umeh (2006) stated that students find these concepts difficult earlier because they were not taught in most cases or the teaching method used by the teacher was not appropriate.

3.6 Instrumentation

Two (2) instruments were used in this study. These were:

1. Genetic Academic Performance Test (GAPT);
2. And Students Attitude to Genetic Questionnaire (SAGQ);

1. Genetic Academic Performance Test (GAPT)

The Genetic Academic Performance Test (GAPT) consisted of section A which contained name of school, sex, and Section B which consisted of thirty multiple choice genetic test items designed by the researcher from past WAEC question papers to find out the extent to which the students understand the selected genetic concepts. The performance test was based on the objectives of the topics selected as stated in Pre-NCE syllabus. The items constructed were checked for appropriateness and cognitive level by a panel of Science Educators and seasoned Biology Lecturers with minimum of Ph.D qualification and rank of Senior Lecturer. To ascertain the internal consistency of the GAPT item, a pilot version of the test containing 30 items was administered on 30 pre-NCE science students in one College of Education other than the one used in the study. The reason for using multiple choice formats is that it allows for wider range and coverage of the content that was taught. It is normally bias free in marking. Each of the thirty (30) multiple choice items consisted of four response options (A,B,C and D), one of which was the correct answer and the remaining three were distracters as presented in Appendix 1. The students were asked to select the correct option by ticking the letter bearing it. The test items reflected the six (6) cognitive levels based on Bloom (1975) taxonomy for the cognitive domain as well the psychomotor domain.

The multiple choice items referred to as Genetic Academic Performance Test (GAPT) was used on three different occasions: first, as Pre-test to determine the strength of the sample at the start of the study and also to categorize students based on their ability level, secondly, as a Post-test in order to determine the effectiveness of the treatment or otherwise; thirdly as a Post-posttest to determine the retention ability of genetic concepts

by the Study Subjects. The detail of item specification for GAPT based on topics selected is presented in Table 3.5

Table 3.3 Item Specification for GPT based on Bloom Taxonomy of Cognitive Domain.

Topic Selected	**Knowledge**	**Comprehension**	**Application**	**Analysis**	**Synthesis**	**Evaluation**	**Total**	**%**
Morphological variation	2	1	1	-	-	1	5	16%
Physiological variation	1	1	1	-	-	-	3	10%
Causes of variation	1	1	-	-	-	_	2	7%
Chromosomes the basis of hereditary	4	3	2	-	1	-	10	34%
Transmission of characteristics of organism (Mendel's' work in genetics)	3	2	1	1	1	-	8	28%
Mendel's dihybrid Inheritance	1	1	-	-	-	_	2	7%
Total	**11**	**8**	**5**	**-**	**-**	**2**	**30**	100%

2. Students' Attitude to Genetics Questionnaire (SAGQ)

This was a questionnaire developed by the researcher on a five-point Likert scale. It consisted of 20 items about Genetics. The first ten expressed positive feelings while the second expressed negative feelings. It was validated by two experts from Biology education and English language department of A.B.U., Zaria. The SAGQ questionnaire required the students to respond by indicating their degree of agreement or disagreement to the items along five-point scale. SA = Strongly Agree, A= Agree, U = Undecided, D =

Disagree and SD = Strongly Disagree. For positive and negative responses, one mark was awarded to each. This grading measured the attitude of the students on the questionnaire.

3.6.1 Validation of the Instruments

The content validity of the Genetic Academic Performance Test (GAPT) and Students Attitude to Genetics Questionnaire (SAGQ) were carried out by a panel of experts comprising the following:

a) Two Science Educators from Science Education Section, Ahmadu Bello University Zaria with at least Ph.D qualification and a rank of Senior Lecturer.
b) A psychologist from Ahmadu Bello University, Zaria with at least Ph.D qualification and a rank of Senior Lecturer.
c) Three pre-NCE Lecturers in Colleges of Education with at least Master degree and the rank of Chief Lecturers.
d) A professor of Genetics in Biological Science Department of Ahmadu Bello University Zaria.

These experts among other things critically assessed GAPT, and SAGQ with respect to:

i) The appropriateness of the items;
ii) Whether or not the statements in the tests were clear, readable, difficult or too simple for pre-NCE Biology students;
iii) Whether or not the test items are related to the objectives of the study;
iv) Give suggestions and criticisms that were helpful in improving the quality of the test items;

Their suggestions were taken into consideration in the final formulation of the test instruments before administration. The letter written to validators is presented in Appendix 4.

3.6.2 Pilot Testing

A pilot testing was conducted using Genetic Academic Performance Test (GAPT) on Pre- NCE Biology students of Isa Kaita College of Education Dutsinma, Katsina State who are not part of the sample for the study. The instrument consist of 30 multiple items and it was administered to 30 Pre-NCE science students. The researcher, with the assistance of Biology Pre-NCE lecturers of the colleges administered the instrument which lasted for one hour. Instructions on how to answer the questions were read and explained to the students by the researcher. This was done to ensure that the students answer the instrument (i.e. test items GAPT) carefully. Problems and difficulties arising from the pilot testing were carefully noted to improve upon the final instrument. After two weeks, the same test items were administered to the student as recommended by Tuckman (1975).The same procedure was done to SAGQ and reliability coefficient of the two instruments was calculated.

3.6.3 Reliability of the Instruments

Reliability is the consistency with which an instrument measures what it claims to measure at any given time. An index of reliability measure is the reliability coefficient (Usman, 2000 and Bichi, 2002).In this study, test re-test method was used to determine reliability of the Genetic Academic Performance Test (GAPT), using Pearson Product Moment Correlation Coefficient (PPMCC) statistical tool. The test items were measured in interval or ratio scale and their correlation coefficient was found to be 0.78. This showed that, the test items were consistent within the average ability of the students and

will surely measure what they are expected, hence they were used for this study. The test reliability of Students Attitude to Genetic Questionnaire (SAGQ) was also obtained by split-half method using odd-even number procedure using Spearman Brown Prophesy formula (Usman, 2000) and a reliability coefficient of 0.82 was obtained.

3.6.4 Item analysis

The result from the data collected from the pilot study was used to determine the facility index (F.I.) and discrimination index (Di.) of each of the forty items.

The facility index gives the difficulty level or ease of answering an item. It indicates the percentage of candidates that got an item right (Tuckman, 1975). The facility indices for each GAPT item was calculated using the formula given by Furst (1958) and Atadoga (2001) who stated that if facility index of a test is between 0. 30-0. 70, the items are then recommended for use.

Using the Furst (1958) and Atadoga (2001) formula for the calculation of facility index (F.I.) is as follows:

F.I. = $\frac{Ru + RL}{N}$ x 100;

Where

F.I. = Facility Index

Ru= The number among the upper 27 percent of the respondents who scored item correctly.

RL= The number among lower 27 percent of the respondents who scored the item correctly.

N = The total number of respondents in each of the upper and lower groups.

From the calculation, the test item with the facility indices between 0.01-0.29 was difficult and it was rejected. Test item with facility indices between 0.30-0.70 was moderate and accepted for use but the test item with facility indices of 0.71 and above is simple and it was also discarded. From appendix 7, the test item 4,6,17,20,21,23,26,35,38

and 40 were discarded while all the other ones were retained. Test items with facility indices in the range of 0.30to 0.70 were used in this study. Based on this analysis, thirty items were used for the study. A detail of the facility index of GAPT is presented in Appendix 7.

Discrimination indices (D.I.) Discrimination indices of a test is the capacity of such a test to distinguish between high and low achievers, between good and not so good achievers. It enables students to be ranked in a given test. It was calculated by using the following formula by Furst (1958) and Atadoga (2001).

D.l = $\frac{Ru—RL}{1/2_N}$

Where

D.I. = Discrimination Index

Ru= The number among the upper 27 percent of the respondents who scored item correctly.

RL= The number among lower 27 percent of the respondents who scored the item correctly.

N = The total number of respondents in each of the upper and lower groups.

Discrimination indices ranging from 0.30 to 0.49 were described as moderately positive, those above 0.59-0.70 were high positive values while those of 0.30 to 48 or below were described as low positive values. Discrimination Indices (D.I.) selected was 0.30-0.70 as used by Atadoga (2001). The discrimination indices of all the test items were calculated as presented in (Appendix 7). Items that were marked RR in the table were reframed and accepted while those marked* were discarded.

Items discarded or rejected include …4, 6 ,11, 17, 20, 21, 23, 26, 35, 38,……

Items selected with Modification are 32, 34, 36, 37, 39, 40……...

Items selected without modification are 1, 2, 3, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 19, 22, 24, 27, 28, 29, 30, 31……..

Thirty items were used for the study (Appendix 1).

3.7 5E Teaching Cycle Model

The 5E constructivist instructional model of learning proposed by Bybee, et al (2006) was adopted in this study which is more precise in nature. It is an instructional model of learning, in which the learners build or construct new ideas on top of their old ideas. Each of the 5Es describes a phase of learning, and each phase begins with the letter "E". Engage, Explore, Explain, Elaborate, and Evaluate. The 5Es can be used with students of all ages and ability levels. It enables students and teachers to experience common activities, to use and build on prior knowledge and experience, to construct meaning, and to continually asses their understanding of a concept.

The Bybee's 5Es lesson Planning Model is illustrated on a flow chart as follows:

The 5E Teaching Cycle Model

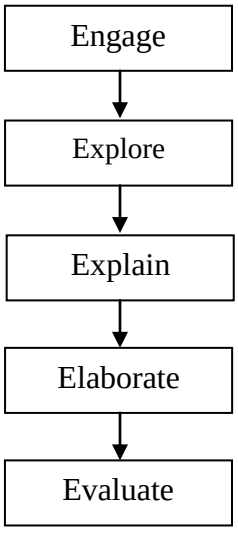


Fig 3.2: Flow chart 5E Teaching Cycle Model

1. In the engagement phase, students make connections between past and present learning experience.

2. Anticipate activities and focus students' thinking on the learning outcomes of current activities. Students should become mentally engaged in the concept, process, or skill to be learned.

- The exploration phase of 5E's provides students with a common base of experiences. They identify and develop concepts, processes, and skills. During this phase, students actively explore their environment or manipulate materials. This phase enable the students to acquire adequate knowledge of the science concepts taught to them. Thus the 5E Constructivist Instructional Model facilities and enhances academic achievement.
- The explanation phase of the 5Es helps students explain the concept they have been exploring. They have opportunities to verbalize their conceptual understanding or to demonstrate new skills or behaviors. This phase also provides opportunities for teachers to introduce formal terms, Definitions, and Explanations for Concepts, Processes, Skills or behaviors.
- The elaboration phase of the 5Es extends students' conceptual understanding and allows them to practice skills and behaviors. Through new experiences, the learners develop deeper and broader understanding of major concepts, obtain more information about areas of interest, and refine their skills.

Both the explanation and elaboration phases provide opportunity for the learner to retain the science concepts taught to them.

- The evaluation phase of the 5E encourages learners to assess their understanding and abilities and allows teachers to evaluate students' understanding of key concepts and skill development.

3.8 Administration of Treatment

Activities involving inquiry method package were taught to experimental group. The control groups were exposed to lecture method. The treatment that was administered to the subject involved teaching the concept of genetics by the researcher using:

(a) The inquiry strategy adapted from Bybee, Westbrook and Landes (2006) for the experimental group based on the constructivist theory of learning where learners construct new ideas or concepts based on their current/past knowledge. The lesson plan is presented in Appendix 5.

(b) Lecture method for the control group

Lesson notes were prepared for each topic for a teaching period of 80 minutes per lesson for each group; lasting a total period of eighteen hours (the lesson notes were presented as Appendix 6). In other words, each group will have six lessons over a period of six weeks. The lessons were taught to each group during school hours to enable all the study samples to participate actively in the study. The subjects in each group had contact with the researcher once a week. The researcher personally taught all the groups in order to reduce intervening variable of teacher factor, that is, to ensure that each student has the opportunity of participating actively in the study and to avoid bias. The same apparatus, contents and evaluation questions (Appendix 1) were used throughout the lessons. This is to ensure that any differences in students' academic achievement or retention in relation to ability levels were attributed only to inquiry method that was used.

After 18 teaching periods of six weeks, a post-test was given to all the three groups in the two colleges (see Appendix 1). The post-post test was administered to all the groups two weeks after the administration of the post-tests (Appendix I). This was to

ascertain or determine their retention level. All the test items (GAPT) were the same, except that the options were interchanged to minimize the effect of maturation. The students' scores on the Genetics Academic Performance Test were recorded and these formed the data for testing the stated hypotheses.

3.8.1 Treatment of Experimental Group

Based on the Pre-test scores of the subjects obtained from the schools, the Pre-test results of the experimental group were divided into ability sub-groups as mentioned earlier. The high ability group comprised 15 students. The average ability group comprised 30 students. The low ability group also consisted of 10 students. Each sub-group was mixed up with (Males and Females) to allow for better interaction between the students within the group and also take care of the gender issue. Regular classrooms were used for the lessons. The detailed procedure of the lesson plan for the experimental group is seen in Appendix 5, using Beebys 5E teaching cycle which uses inquiry model package described as follows:

This study was based on Bybee's 5E teaching cycle model which is an Inquiry-Based Teaching (IBT) approach model (Llewellyn, 2005) as seen in Figure1. The 5 E learning cycle model sequences learning experiences so that students have the opportunity to construct their understanding of a concept during the teaching and learning process (Bybee, 2002). The model leads students through five phases of teaching that are easily described using words that begin with the letter E: Engagement, Exploration, Explanation, Elaboration and Evaluation.

Phase 1 Engagement phase: The teacher captures students' interest and makes them curious about the topic and concepts to be learnt. This phase provides an opportunity for

the teacher to find out what students already know or think they know about the topic and concepts to be developed (Bybee, 2002).

Phase 2 Exploration phase: Students interact with materials and ideas through classroom and small group discussions (Llewellyn, 2005). This helps the students to acquire a common set of experiences so that they can compare results and ideas with their classmates.

Phase 3 Explanation phase: In the explanation phase students are provided an opportunity to connect their prior experiences with current learning and generate knowledge from main ideas. This phase also provides the opportunity for the introduction of formal language, scientific terms and content information that might make students' prior experiences easier to describe.

Phase 4 Elaboration phase: In the elaboration phase students are provided with the opportunity to apply introduced concepts to new experiences (Llewellyn, 2005). This phase helps students to make conceptual connections between new and prior experiences, connect ideas and deepen their understanding of concepts and processes.

Phase 5 Evaluation phase: In the evaluation phase that is centrally placed in the model and takes place virtually in every phase of the 5E learning cycle model provides a summative assessment of what students know (Bybee, 2002). The lesson plans of guided strategy as used in the study can be illustrated on a flow chart as follows:

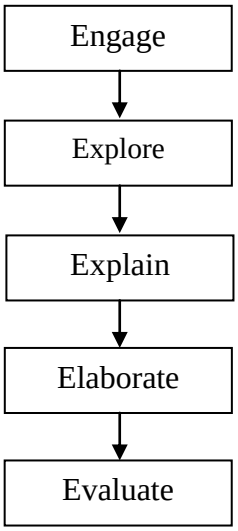


Figure 3.3 Flow Chart of Bybee et al (2006) Model

Engage: learners encounter the material, define their questions, lay the groundwork for their tasks, and make connection from new to known.

Explore: learners directly involve with material, inquiry drives the process, teamwork is used to share and build base.

Explain: learners explain the discoveries and concepts that have been learned through written report.

Elaborate: expand on their knowledge, connect it to similar concept, and apply it to other situation-can lead on new inquiry.

Evaluate: on-going process by both instructor and learner to check for understanding. The model is further illustrated thus:

Engage	Learners have need to know, therefore, define questions, issues or problems relate to topic at hand.
Exploration	Objects and phenomena are explored. Hands-on activities with guidance.
Explanation	Learners explain/report their understanding of concepts and processes.
Elaboration	Activities allow students to apply concepts in contexts and build or extend understanding/skill.
Evaluation	Learners assess their knowledge, skills and abilities.

Bybee et al (2006) Model

Before the commencement of the treatment, the subjects in both groups (experimental and control) were given Genetics Academic Performance Test (GAPT) as pretest in order to determine group equivalence. Students' Attitude to Genetics questionnaire (SAGQ) was administered to the subjects in the experimental and control group where the students are taught the concept of genetics in order to ensure the effective utilization of the adapted inquiry method model and to ensure that the teaching procedure was in conformity with the direction of the model. This comprised laboratory work, problem solving and discussions. The subjects were allowed to explore the concepts in questions through practical activities and problem solving and small group discussions. In the exploration session, they were asked focusing questions meant to lead them to observe and discuss their experiences. This is with a view to stimulating the subjects to articulate the inconsistencies and discrepancies between the phenomenon under consideration and their own previously held ideas. The teaching lasted for six weeks consisting of 6-double periods of 80 minutes each.

The subjects were taught morphological variation, physiological variation, causes of variation, and chromosomes as the basis of heredity, monohybrid inheritance and dihybrid inheritance. The control groups were also taught same concepts by the researcher for six weeks using lecture method.

3.8.2 Teaching the Control Group

The control group subjects that were assigned to ability groups based on the pre-test scores and were taught by the researcher through lecture method. The lesson taught through lecture method was validated by groups of experts in Department of Science Education, Faculty of Education, Ahmadu Bello University, Zaria. The detailed procedures of the lesson plan for the control group are seen in Appendix 6.

3.9 Data Collection Procedure

The data collection for this study involves the following:

Genetic Academic Performance Test (GAPT) which was given to both the experimental and control group as Pre-test and Post-test and Post-post test and marked over 30 as seen in Appendix 1. The scores were completed and fed into a computer based on the experimental and control group, ability level as well as gender.

Students Attitude to Genetic Questionnaire (SAGQ) was administered to both experimental and control group before and after the treatment in order to find out if pre-NCE students have attitudinal change in Genetics. The scripts and questionnaire were marked and arranged based on Experimental and Control group, attitude and gender for analysis.

3.10 Procedure for Data Analysis

Data collected for the purpose of this study was analyzed based on research questions formulated and hypothesis testing as follows:

3.10.1 Hypotheses Testing

The following hypotheses are tested at $P \leq 0.05$

Ho_1**:** There is no significant difference in the mean performance scores of pre-NCE students of varied abilities taught with 5E teaching cycle and those taught with lecture method.

Analysis of Covariance (ANCOVA) was used to analyze this hypothesis

Ho_2**:** There is no significant difference in the mean performance scores of male and female pre-NCE students of varied abilities taught with 5E teaching cycle.

Analysis of Covariance (ANCOVA) was used to analysis this hypothesis.

Ho_3**:** There is no significant difference in the retention ability of pre-NCE students of varied abilities taught with 5E teaching cycle and those taught with lecture method.

Analysis of Covariance (ANCOVA) was used to test this hypothesis

Ho_4**:** There is no significant difference in the retention ability of male and female pre-NCE students of varied abilities taught with 5E teaching cycle.

Analysis of Covariance (ANCOVA) was used to test this hypothesis.

Ho_5**:** There is no significant difference in the attitude change of pre-NCE students of varied abilities taught Genetics with 5E teaching cycle.

Kruscal Wallis statistical tool was used to analyze this hypothesis.

CHAPTER FOUR

ANALYSIS, RESULTS AND DISCUSSION

4.1 Introduction

This chapter contains analysis, result and discussions. The results are presented according to the sequence of the research questions and hypotheses which guided the study. The level of significance adopted for retaining or rejecting each of the null hypotheses is $P \leq 0.05$. The chapter is presented in the following sub-headings:

- Analysis result presentation
- Summary of major findings
- Discussion

4.2 Analysis and Results Presentation

Research Question 1:

What is the difference in the mean performance scores of pre-NCE students of varied abilities taught with 5E teaching cycle and those taught with lecture method?

To answer question one, a descriptive statistics of mean and standard deviation was used. The detail of the result is presented in Table 4.1a

Table 4.1a: Mean and Standard Deviation of students of Experimental and Control Group.

Ability groups	N	treatment Group	Mean	Std. Deviation	Mean difference
	15	Exp	27.07	1.83	3.50
High	15	Control	23.00	2.42	
	30	Exp	21.97	2.34	9.8
Average	30	Control	18.47	1.81	
	10	Exp	19.40	1.35	4.80
Low	10	Control	9.60	2.46	

The results in Table 4.1a showed that the experimental group with mean of 27.07 for high ability, 21.97 for average ability and 19.40 for low ability sub-group performed higher than the control group with mean of 23.00 for High ability group, 18.47 for Average ability and 9.60 for low ability group .This implied that differences exist between the means of experimental and control group. To show whether the difference is significant or not, null hypothesis one was formulated and tested using Analysis of Covariance (ANCOVA) statistics.

H_{01}: There is no significant difference in the mean performance scores of pre-NCE students of varied abilities taught with 5E teaching cycle and those taught with lecture method.

Table 4.1b: Analysis of Covariance (ANCOVA) of the Mean Scores of Experimental and Control Groups.

Source	Type III Sum of Squares	Df	Mean Square	F	P-Value	Remark
Corrected Model	2129.324	5	425.865	97.519	0.01	*S
Intercept	35700.625	1	35700.625	8175.116	0.01	*S
Ability G	1341.341	2	670.670	153.577	.001	*S
Tg	754.003	1	754.003	172.660	.001	*S
Ability G * Tg	154.383	2	77.192	17.676	.001	*S
Error	454.167	104	4.367			
Total	48770.000	110				
Corrected Total	2583.491	109				

*S= Significant at P≤0.05 level

Analysis of Covariance (ANCOVA) statistics presented in Table 4.1b showed that significant difference exists in the mean scores of pre-NCE Biology students of varied abilities levels taught with 5E teaching cycle and their counterparts taught with lecture method. Reasons being that the intercept P-value of 0.001 is less than P≤ 0.05 level of significance in both experimental and control group. Therefore the null hypothesis which state that there is no significant difference in the mean scores of pre-

NCE Biology students of varied abilities levels taught with 5E teaching cycle and their counterparts taught with lecture method is hereby rejected.

To show which groups among the ability groups of experimental and control group shows significant difference Scheffes post hoc test was carried out as presented in Table 4.1c.

Table 4.1c: Post Hoc Tests (LSD) Multiple Comparison Pair wise Between Experimental and Control Groups.

	(I) Ability groups	(J) Ability groups	Mean Difference (I-J)	Std. Error	P-val	Remark
Scheffe	High	Average	4.8167*	.46728	.001	*S
		Low	10.5333*	.60325	.001	*S
	Average	High	-4.8167*	.46728	.001	*S
		Low	5.7167*	.53957	.001	*S
	Low	High	-10.5333*	.60325	.001	*S
		Average	-5.7167*	.53957		

*S=Significant at P≤0.05 level

The post hoc analysis using the scheffes test showed that significant difference exist between the pair wise mean of high ability level compared with each of the mean of those in either average or low ability groups and vice versa. This is because in each pair wise comparison of means, the calculated P-value was found to be lower than 0.05 alpha level of P-value. Therefore, the null hypothesis which states that there is no significant difference in the mean scores of pre-NCE Biology students of varied ability levels taught with 5E teaching cycle and their counterparts taught with lecture method is hereby rejected.

Research Question 2:

What is the difference in the mean performance scores of male and female pre-NCE students of varied abilities taught with 5E teaching cycle?

To answer question two, a descriptive statistics of mean and standard deviation was used. The detail of the result is presented in table 4.2a:

Table 4.2a: Mean & Standard Deviation of Male and Female Experimental Group.

Ability groups	N	Sex	Mean	Std. Deviation	Means difference
High	20	Male	25.4500	2.30503	1.25
	10	Female	24.2000	3.96653	
Average	40	Male	20.2750	2.85538	0.18
	20	Female	20.1000	2.51103	
Low	14	Male	14.3571	5.45763	0.47
	6	Female	14.8333	5.70672	

From Table 4.2a, the performance of male and female in the experimental group for high ability is 25.45 and 24.20, Average ability is 20.28 and 20.10 and low ability with 14.36 and 14.83 respectively.

To show the difference in the mean performance scores of male and female pre-NCE students of varied abilities taught with 5E teaching cycle, null hypothesis two was formulated and tested using Analysis of Covariance (ANCOVA) statistic.

$H_{02:}$ There is no significant difference in the mean performance scores of male and female pre-NCE students of varied abilities taught with 5E teaching cycle.

Table 4.2b: Analysis of Covariance of Male and Female Experimental Group.

Source	Type III Sum of Squares	Df	Mean Square	F	P-value	Remark
Corrected Model	1353.118[a]	5	270.624	22.875	.001	*S
Intercept	30689.864	1	30689.864	2594.129	.001	*S
AbilityG	1089.774	2	544.887	46.058	.001	*S
Sex	1.944	1	1.944	.164	.686	*NS
AbilityG * sex	8.674	2	4.337	.367	.694	*NS
Error	1230.373	104	11.831			
Total	48770.000	110				
Corrected Total	2583.491	109				

a. R Squared = .524 (Adjusted R Squared = .501)

*S = Significant at P≤0.05 level
*NS= Not Significant at P≤0.05 level

In Table 4.2b Analysis of Covariance (ANCOVA) statistics showed that there is no significant difference in the mean scores of Male and female pre-NCE Biology students of varied abilities levels taught with 5E teaching cycle. Reasons being that the p-value for abilities levels vs sex is 0.69 which was found to be higher than P≤ 0.05 alpha level of significance. The significant P- value for varied abilities was 0.001 and that of sex group was 0.68 was found to be higher than P≤ 0.05 alpha levels. This means that between sex and varied abilities group, no significant differences exist.

Therefore, the null hypothesis which states that there is no significant difference in the mean scores of Male and female Pre-NCE Biology students of varied ability levels taught with 5E teaching cycle is hereby accepted and retained.

Research Question 3:

How do pre-NCE students of varied abilities retain genetic concepts when taught with 5E teaching cycle and lecture method?

To answer question three, a descriptive statistics of mean and standard deviation was used. The detail of the result is presented in Table 4.3a:

Table 4.3a: Mean and Standard Deviation of retention ability of experimental group and control group.

Ability groups	N	Treatment group	Mean	Std. Deviation	Mean difference
High	15	Exp	26.4667	1.50555	5.73
	15	Control	20.7333	2.78944	
Average	30	Exp	22.1667	2.54725	3.63
	30	Control	18.5333	1.83328	
Low	10	Exp	19.7000	1.41814	10.4
	10	Control	9.3000	2.00278	

The results in Table 4.3a showed that the experimental group with mean of 26.47 for High ability, 22.17 for Average ability and 19.70 for low ability sub-group performed higher than the control group with mean of 20.73 for high ability group, 18.53 for average ability and 9.30 for low ability group. To show whether the difference is significant or not, null hypothesis three was formulated and tested using Analysis of Covariance (ANCOVA) statistic.

H_{03}: There is no significant difference in the retention ability of pre-NCE students of varied abilities taught with 5E teaching cycle and those taught with lecture method.

Table 4.3b: Analysis of Covariance (ANCOVA) of difference in the mean retention ability of Experimental and Control Groups.

Source	Type III Sum of Squares	Df	Mean Square	F	P-value	Remark
Corrected Model	1983.218[a]	5	396.644	85.850	.001	*S
Intercept	34164.025	1	34164.025	7394.503	.001	*S
Ability G	997.868	2	498.934	107.990	.001	*S
Tg	976.803	1	976.803	211.420	.001	*S
Ability G * Tg	172.614	2	86.307	18.680	.001	*S
Error	480.500	104	4.620			
Total	47227.000	110				
Corrected Total	2463.718	109				

*S = Significant at P≤ 0.05 level

From Table 4.3b, Analysis of Covariance (ANCOVA) statistics showed that significant difference exist in the mean retention ability of pre-NCE Biology students of varied abilities taught with 5E teaching cycle and those taught with lecture method. Reasons being that the intercept P-value of 0.001 is less than P≤ 0.05 alpha level of significance. The significant P-value for varied abilities was 0.001 and that of treatment group was 0.001. The P-value of treatment group was 0.001 which were all found to be lower than P≤0.05 alpha level of significance. Therefore, the null hypothesis which states that there is no significant difference in the mean retention ability scores of pre-NCE Biology students of varied abilities taught with 5E teaching cycle and their counterparts taught with lecture method is hereby rejected.

Table 4.3c: Post Hoc Test of Analysis of Variance Differences in the Mean Retention Ability of Experimental and Control Group.

	(I) Ability groups	(J) Ability groups	Mean Difference (I-J)	Std. Error	P-value	Remarks
Scheffe	High	Average	3.2500	.48063	0.001	*S
		Low	9.1000	.62050	0.001	*S
	Average	High	-3.2500	.48063	0.001	*S
		Low	5.8500	.55499	0.001	*S
	Low	High	-9.1000	.62050	0.001	*S
		Average	-5.8500	.55499	0.001	*S

*S =Significant at P≤0.05 level

The post hoc analysis using the scheffes test showed that significant difference exist between the pair wise mean of high ability level compared with each of the mean of those in either average or low ability groups retention abilities and vice versa. This is because in each pair wise comparison of means, the calculated P-value was found to be less than P≤0.05. Therefore, the null hypothesis which states that there is no significant difference in the mean retention ability scores of pre-NCE Biology students of varied abilities taught with 5E teaching cycle and their counterparts taught with lecture method is hereby rejected.

Research Question 4:

Are male and female pre-NCE Biology students capable of retaining genetic concepts when taught with 5E teaching cycle?

To answer question five, a descriptive statistics of mean scores and standard deviation was used. The detail of the result is presented in Table 4.4a.

Table 4.4a: Mean and Standard Deviation of the Retention Ability of Male and Female of the Experimental Group.

Ability groups	N	Sex	Mean	Std. Deviation	Mean Difference
High	20	Male	23.5500	3.47131	0.15
	10	Female	23.7000	4.19126	
Average	39	Male	20.5128	3.00764	0.46
	21	Female	20.0476	2.61680	
Low	14	Male	14.4286	5.80072	0.24
	6	Female	14.6667	5.60952	

There is no difference in the retention of male and female pre-NCE Biology students of varied abilities in the experimental group. From Table 4.4a, the achievement of male and female in the experimental group for high ability is 23.55 and 23.70, Average ability is 20.51 and 20.04 and low ability with 14.42 and 14.66 respectively.

To find out if there is difference in the mean scores of male and female pre-NCE students of varied abilities taught with 5E teaching cycle, null hypothesis four was formulated and tested using Analysis of Covariance (ANCOVA) statistics as presented in Table 4.4b.

H_{04}: There is no significant difference in the retention ability of male and female pre-NCE students of varied abilities taught with 5E teaching cycle.

Table 4.4b: Analysis of Covariance of the Retention Ability of Male and Female of the Experimental Group.

Source	Type III Sum of Squares	Df	Mean Square	F	P-value.	Remark
Corrected Model	1001.210[a]	5	200.242	14.239	.001	*S
Intercept	29623.453	1	29623.453	2106.545	.001	*S
Ability G	849.912	2	424.956	30.219	.001	*S
Sex	.013	1	.013	.001	.976	*NS
Ability G * sex	2.570	2	1.285	.091	.913	*NS
Error	1462.508	104	14.063			
Total	47227.000	110				
Corrected Total	2463.718	109				

*S = Significant at P≤0.05 level
*NS=Not Significant at P≤0.05 level

From Table 4.4b, Analysis of Covariance (ANCOVA) statistics showed that there is no significant difference in the mean retention ability of Male and female Pre-NCE Biology students of varied abilities taught with 5E teaching cycle. Reasons being that the P≤0.05 for abilities vs sex was significant level of 0.91 which was found to be greater than P≤ 0.05 level of significance. The significant P- value for varied abilities was 0.001 and that of sex group was significant level of 0.97 was found to be higher than the 0.05 alpha levels. This means that between sex and varied abilities group, no significant differences exist in their retention abilities. Therefore, the null hypothesis which states that there is no significant difference in the mean retention ability of Male and female pre-NCE Biology students of varied abilities levels taught with 5E teaching cycle is hereby retained.

Research Question 5:

What is the difference in the attitude change of pre-NCE students of varied abilities taught Genetics with 5E teaching cycle?

To answer this research question Mean Ranks and Standard Deviation was used as in Table 4.5a:

Table 4.5a: Descriptive Statistics (Means ranks) Results of attitude change of experimental Group.

	Ability Group	N	Mean Rank	Sum of mean rank	Mean rank difference
Pretest	High	15	39.67	77.97	
	Average	30	28.10		
	Low	10	10.20		
					2.93
Post test	High	15	40.07		
	Average	30	26.53	80.90	
	Low	10	14.30		

From Table 4.5a, there is attitudinal change in the experimental group exposed to 5E learning cycle .The mean rankings showed that in the pretest their attitude scores were 39.67, 28.10 and 10.20 for high, average and low ability levels respectively. In their post-test scores the mean rankings showed that their attitude scores were 40.07, 26.53 and 14.30 for high, average and low ability levels respectively. This shows that significant change has taken place between their pre-test and their post-test attitude scores in each of the three ability groups. To find out if the attitude change in the experimental group is significant or not, null hypothesis seven was formulated and tested using Kruscal Wallis test statistics.

Hypothesis 5:

There is no significant difference in the attitude change of pre-NCE students of varied abilities taught Genetics with 5E teaching cycle.

Table 4.5b: Kruskal Walis Analysis in the Attitude Change of Experimental Group

	Ability Group	N	Mean Rank	DF	Sum of rank	P-value	Remark
Pretest	High	15	39.67				
	Average	30	28.10		77.97		
	Low	10	10.20				
				2		0.001	*S
Post test	High	15	40.07				
	Average	30	26.53		80.90		
	Low	10	14.30				

*S= Significant at P≤0.05

Result of the kruskal Walis analysis in Table 4.5b showed that significant difference exist in the attitude change of pre-NCE Biology students of varied abilities taught with 5E learning cycle. Reason being that the P-value of 0.001is less than P≤ 0.05 alpha values. The mean rankings showed that in the pretest their attitude scores were

39.67, 28.10 and 10.20 for high, average and low abilities levels respectively. In their post- test scores the mean rankings showed that their attitude scores were 40.07, 26.53 and 14.30 for high, average and low abilities levels respectively. This shows that significant change has taken place between their pre-test and their post-test attitude scores in each of the three abilities groups. Therefore, the null hypothesis which states that there is no significant difference in the attitude change of pre-NCE Biology students of varied abilities taught with 5E teaching cycle is hereby rejected.

4.3 Summary of Major Findings

In this study, the following findings were made:

1. Significant difference exists in the mean scores of pre-NCE Biology students of varied abilities taught with 5E teaching cycle and their counterparts taught with lecture method in North-West, Nigeria. (Table 4.1b).
2. There is no significant difference in the mean scores of male and female pre-NCE Biology students of varied abilities taught with 5E teaching cycle in North-West Zone, Nigeria. Thus, indicating that 5E teaching cycle is gender friendly. (Table 4.2b)
3. Significant difference exists in the mean retention abilities of pre-NCE Biology students of varied abilities levels taught with 5E teaching cycle and those taught with lecture method. This testified that 5E teaching cycle enhances more retention among pre-NCE Biology students of varied abilities in the North-West Zone, Nigeria.(Table 4.3b)
4. There is no significant difference in the mean retention abilities of Male and female pre-NCE Biology students of varied abilities taught with 5E teaching cycle. This also proved that 5E teaching cycle is gender friendly(Table 4.4b).

5. Pre-NCE Biology students of varied abilities taught with 5E teaching cycle developed positive attitude than those taught with traditional approach in North-West, Zone, Nigeria(Table 4.5b **)**

4.4 Discussion of the Results

This study investigated the impact of 5E learning cycle on the academic performance of pre-NCE Biology students of varied abilities in North-West Zone, Nigeria. The data collected from the posttest administered was analyzed employing Analysis of Covariance (ANCOVA) and Kruscal Walis test statistic at $P \leq 0.05$ levels of significance.

In Table 4.1b the result of testing Hypothesis One shows that there is significant difference in the mean academic achievement scores of pre-NCE Biology students of varied abilities exposed to 5E teaching cycle and those taught with lecture method. The significant difference found between the two groups is likely to be due to the use of 5E learning cycle (an activity-oriented method) on the experimental group. If the treatment administered has no effect, the two groups are expected to perform equally the same. Since the experimental group performed significantly better, it implies that using 5E teaching cycle in teaching pre-NCE Biology students of varied abilities improves their performance. The result confirms earlier findings of(Campbell, 2000;Coulson,2002; Boddy et al., 2003;Whilder & Shuttleworth, 2004; Akar, 2005; Ates, 2005 Garcia, 2005; Balcı, Çakıroglu and Tekkaya,2005; Ozsevgec, 2006;Ceylan, 2008; Pulat, 2008, Bilgin (2009), Pulat (2009) , Açışlı, Altun and Yalçın (2011),Turgut and Gurbuz (2011) , Bunkure, 2012, Shitu 2013, Ado,(2014), and Njoroge, Changeiwo and Ndirangu (2014) who found that students exposed to inquiry method using 5E teaching cycle performed significantly better in the experimental groups than those in the control group .The study

contradicts that of Rigdeway (2004) and Idris (2012) who found no significant difference in the mean achievement scores of students in the experimental and control group when taught with 5E learning cycle using inquiry method.

The study also showed that pre-NCE Biology students of varied abilities in the experimental group taught with 5E teaching cycle performed better than those in the control group taught with lecture method. The result confirms earlier findings of Eze (2002), Anaso (2008), Lakpini (2006), Bunkure (2012) and Bitrus (2012) who found that students of varied abilities performed significantly better in the experimental groups than those in the control group different subjects but the study contradicts that of Rigdeway (2004) and Idris (2012) who found no significant difference in the mean achievement scores of students with varied abilities in the experimental and control group.

On the issue of gender and academic achievement of pre-NCE students of varied abilities when exposed to 5E teaching and lecture method, the results in Table 4.2b shows that 5E teaching cycle does not differentiate the academic performance of both male and female pre-NCE Biology students of varied abilities. This finding is in agreement with those of Bichi (2002), Adedayo (2004), Atadoga (2005), Ceylan (2008), Hiccan(2008) Lakpini (2008), Anaso (2008), Lawal (2009), Bitrus (2012), Bunkure (2012) and Dahiru (2013) who individually found out that there is no gender difference in the academic performance of secondary School students of varied abilities when exposed to activity-based methods of instruction such as inquiry, discovery, science process skills, constructivist, conceptual change and problem solving e.t.c. The finding is however in disagreement with that of Musa (2000), Usman (2008), Ibrahim (2012), Olorukooba, Lawal and Jiya (2012) Umar (2013), who reported a significant difference in the performance of male and female of the experimental group-favouring male of the

experimental. Also in line with the finding of this study there is no gender difference in the academic performance of pre-NCE Biology students of varied abilities exposed to 5E teaching cycle. Since the method allows students to carry out investigation on their own and to arrive at a particular concept, it makes what they learn meaningful and promotes their understanding of the concept despite gender difference among the students.

With regards to retention ability, significant difference exist in the mean retention abilities of pre-NCE Biology students of varied abilities levels taught with 5E teaching cycle and those taught with lecture method as shown in Table 4.3b.This agrees with the findings of Anaso (2008), Lakpini (2006), and Bunkure (2012), who found that students in the experimental group of varied abilities had higher retention than the control group of varied abilities .The analysis of the hypothesis showed that the use of 5E teaching cycle led to higher retention than the traditional method. The result of the mean scores of the subjects in the three ability groups of experimental group maintained higher retention rates than the subjects in parallel levels in the control group. From Table 4.4b there is no significant difference in the mean retention abilities of Male and female pre-NCE Biology students of varied abilities taught with 5E teaching cycle. This also buttresses the studies of Lakpini (2006), and Bunkure (2012).

On the issue of 5E teaching cycle and students' attitude to Genetics, the results in Table 4.5a showed that 5E teaching cycle enhanced positively the attitudes of high, average and low ability pre-NCE students to Genetics. This finding agrees with the findings of Wilder and Shuttleworth (2004);Garcia, (2005); Bybee et al. (2006); Lakpini (2006), Ceylan (2008), Akinbobola (2009) Bunkure (2012), and Poderaso (2013) who found significant change of attitude of secondary school students of varied abilities compared with their counterparts in the control group. These findings proved that the

nature of science teaching affects students' attitude strongly. The greater success and positive attitude toward 5E teaching cycle method of students in experimental group can be explained as follows; students' participation and teaching materials which is prepared based on 5E learning cycle helped them to recognize their ideas, share their ideas and facilitate their understanding as well as encouraged their conceptual restructuring and attitude toward 5E teaching cycle. In the contrary studies of (Ozsevgec, 2006 , Ersahan, 2007; Kaynar, 2007; Keskin, 2008;,Pulat 2008) found no statistically significant effect of 5E learning cycle on attitudes toward the various subjects studied.

The study also contradicts the findings of Bitrus (2012) who found no significant difference in attitude change of students of varied abilities when exposed to process approach teaching strategy. This might be due to the fact that, students had positive attitude toward the subject and had no negative impression about the teacher who normally brings change of attitude in the subject.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter summarizes the entire study as presented in the following sub-headings:

- Summary
- Conclusion
- Contribution to Knowledge
- Recommendations
- Limitation of the Study
- Suggestion for Further Studies

5.2 Summary

This study investigated the impact of 5E teaching cycle on the academic performance, retention and attitude of Pre-NCE Biology students of varied abilities in North-West Zone. It also investigated the effects of gender-related differences on students' academic performance, retention and attitude in the teaching of concepts of genetics using 5E teaching cycle. Available literatures relevant to the study were reviewed. Most of these literatures concluded that academic performance can be enhanced using effective instructional strategies which recognized active participation of students.

The design of the study was quasi-experimental and control group design employing Pretest and Posttest and Post-posttests (Kerlinger, 2000). The population of the study consists of all the 2231 pre-NCE Biology students (1168 males and 1,063 females) in all the coeducational Colleges of Education in North-West Zone. Two

colleges were sampled out using random sampling technique by balloting method and were assigned to experimental and control group. Students of varied abilities from these colleges were identified based on their pre-test scores according to Lapkini (2006) .These were categorized into high, average, and low ability groups through stratify sampling technique. The mode of categorization was done by giving them pre-test of Genetic Academic Performance Test (GAPT), where those that scored sixty (60) and above were categorized as high ability, those that scored 40 -59 were categorized as average ability while those that scored 0 – 39 were categorized as low ability group. Fifty five (55) Pre-NCE Biology students (38 males and 17 females) were selected from each college of the study as guided by Central Limit Theory by Tuckman (1975), Dana (2000), Fraenkel & Wallen (2000) and John & James (2011) which proposed that thirty or more subjects are considered as large sample for experimental research of this nature. Equal numbers of subjects were randomly selected for each group in order to have a fair representation of the subjects in the study (Sambo, 2008). In the experimental group, high ability consisted 15 students, 30 average ability students and 10 low ability students. The same procedure and numbers were used as the control group and boys and girls were sorted as presented in Table 3.2:

Two instruments, Genetics Academic Performance Test (GAPT) and Students Attitude to Genetics Questionnaire (SAGQ) were used for data collection. The Genetics Academic Performance Test (GAPT) consists of 30 items multiple choice questions on genetics concepts with reliability coefficient of 0.78. While the Students Attitude to Genetics Questionnaire (SAGQ) was used on pre-NCE Biology students to test for change in attitude after being taught with 5E learning cycle with reliability coefficient of 0.82. The questionnaire consists of 20 questions constructed based on Likert five- point

scale of Strongly Agree (SA), Agree (A), Undecided (UD), Strongly Disagree (SD) and Disagree (D) respectively. The reliability coefficient of SAGQ was found to be 0.82 using Pearson-Product Moment Correlation Coefficient Statistic.

The treatment lasted for six weeks consisting of six periods of 80 minutes each. The subjects were taught the concept of genetics comprising of Morphological variation in the physical appearances of individuals, psychological variation and application of variation, causes of variation, chromosomes, the basis of heredity, transmission and expression of characteristics of organisms (monohybrid inheritance) and Mendel's Dihybrid inheritance using 5E learning cycle adapted from Bybee *et al* (2006).The control groups were taught same concepts using lecture method. At the end of the treatment, study subjects were post-tested. The data collected through the use of GAPT and SAGQ was subjected to Analysis of Covariance (ANCOVA) and Kruscal Wallis test statistics to determine the significant difference in the academic performance, retention and attitudinal change of the experimental group. The results indicated that the academic performance of pre-NCE students of varied abilities taught genetic concept using 5E learning cycle was significantly better. Student's gender had no significant effect in their performance in genetics when 5E teaching cycle is used. From the results, hypotheses one, three, and five of the study were rejected, while hypothesis two and four were retained.

5.3 Conclusion

As a result of the findings in this study, it could be concluded that a better understanding, retention of genetics concepts in Biology was provided by 5E teaching cycle. This because all pre-NCE students exposed to it, showed better performance, better retention ability when compared to those not exposed to it. When the effect of gender on

students' performance and retention subject was investigated, it was found that there was no significant difference between male and female with respect to performance and retention when taught with 5E teaching cycle. This showed that 5E teaching cycle model is gender friendly.

Attitudes of pre-NCE students exposed to 5E teaching cycle drastically increased than those taught with lecture method. This is because when students are taught through 5E teaching cycle strategy, they engaged themselves in solving practical activities such as experimentation, investigation and critical thinking.

5.4 Contribution to Knowledge

i. The 5E teaching cycle adapted from Bybees et al (2006) was used by the researcher for the first time to teach the concept of genetics to pre-NCE Biology students. Pre-NCE Biology students of varied abilities taught with 5E teaching cycle perform higher than the control group of varied abilities taught with lecture method. Thus, in this field it serves as contribution to knowledge since it was found effective in increasing students understanding of difficult and abstract nature of genetics concepts. Besides, 5E teaching cycle is not commonly used by pre-NCE lecturers in Colleges of Education.

ii. The Students Attitude to Genetics Questionnaire (SAGQ) was developed by the researcher for the purpose of testing attitude of students to genetics, and students taught using 5E teaching cycle develop positive attitude towards genetics.

iii. The Genetic Academic Performance Test (GAPT) was purposely designed and developed by the researcher using six levels of mental processes of the cognitive domain outlined by Bloom to test student's academic performance in genetics. This was found to be effective and thus unique in this study.

iv. The low ability students taught with 5E teaching cycle performed better than the low ability students in the control group taught with lecture method. Hence 5E teaching cycle is good for boosting academic performance of low ability students.

v. The findings of the study have also added new information to the existing literature on Genetics teaching and classroom practices as it affects teachers and students.

vi. The research is the first known study carried out on impact of 5E teaching cycle on attitude, retention and academic performance of pre-NCE Biology students of varied abilities in North-West, Nigeria.

5.5 Recommendations

On the basis of findings emanating from this study, the following recommendations are made:

1. The teaching of Biology especially genetics should be conducted using 5E teaching cycle as it make students learn meaningfully, enhances better retention of knowledge and develop positive attitude towards the subject. It should therefore be incorporated into the main stream of pedagogy in the teaching of pre-NCE Biology students of varied abilities in all colleges of education. Also, appropriate learning environments should be provided for the students in order for the effective application of 5E teaching cycle method in the classroom. To implement an activities based learning cycle, this requirement needs to be met in all schools.
2. This study showed that gender does not play a significant role in the learning of genetics, retention of knowledge among pre-NCE students of varied abilities

using 5E teaching cycle. Hence, the method is recommended, as it is gender friendly and aided learning between male and female.

3. 5E Teaching cycle encourages better retention of learnt concepts and increased attitude of pre-NCE students towards it. It should therefore be used regularly in the teaching and learning situation.
4. In-service training for science teachers in form of seminars, workshops - conferences should focus more on how to use 5E teaching cycle for the teaching of genetics concepts."The government or relevant professional bodies like Science Teachers' Association of Nigeria (STAN) could do this.
5. There should be proper provision of facilities/equipment, which are necessary for effective 5E teaching cycle.
6. Adequate funds should be provided by the government to sponsor Biology lecturers, teachers for retraining on 5E teaching required to improve academic performance of students.
7. Based on the findings, the study therefore recommends among others that, in service training for science teachers in form of seminars, workshops and conferences should focus more on how to use 5E teaching cycle for the teaching of genetic concepts.
8. In addition, the use of lecture method by science teachers especially Biology should be minimized and done with caution to avoid poor performance and negative attitude among science students to genetics. The use of lecture method of teaching has been found to be less effective in this study with respect to academic performance and attitude of pre-NCE students of varied abilities. Science teachers should therefore exercise their expertise and caution in the use of lecture method

to avoid a situation, where under achievement and negative attitude is promoted among pre-NCE students.

5.6 Limitations of the Study

This study has some limitations, which include the following:

1. The study is restricted to only two Colleges of Education in the North-West Zone, Nigeria as such generalization of the study is narrow.
2. A sample size of only 110 pre-NCE students is used in this study. It may be possible that when larger sample size is used the result will not be the same.
3. The conclusion reached about the effectiveness of 5E teaching cycle in this study is only limited to genetics concepts.

5.7 Suggestions for Further Studies

1. A similar study on pre-NCE students of varied abilities should be carried out focusing on the teaching of other science subjects using 5E teaching cycle with a view to finding out if similar or different results as in this study may be obtained.
2. This study can be extended to NCE students, undergraduate students, to investigate if these levels of education have an effect on the variables that this study dealt with.
3. There is need to conduct similar studies to investigate the effects of other activity oriented teaching methods such as problem-solving method, project method, discussion method etc. in teaching the concepts of genetics to pre-NCE students of varied abilities.
4. In order to increase the scope of generalization, this study should be replicated in many other geopolitical zones of Nigeria and many other countries in the world.

5. Other difficult areas of Biology or any other science subject should be investigated using the same approach.

REFERENCES

Abdi, A. (2014). The effect of inquiry based learning method on students' academic achievement in science courses: *Universal Journal of Educational research* 2(1): 37-41.

Abdullahi, A. (2007). Functional Science, Technology and Mathematics Education for National Economic Empowerment and Development. A Speech Delivered at the 2007 School of Science National Conference Held at FCE, Zaria, April, 2 – 5.

Açışlı, S. Altun, S. Y. and Turgut, U. (2011) Effects Of The 5e Learning Model On Students' Academic Achievements In Movement And Force Issues. Procedia - social and behavioral sciences volume 15, 2011, pages 2459–24623rd world conference on educational sciences – 2011.

Adedayo, B.A. (2004), A cross sectional investigation of gender differences in tertiary mathematics among pre-service NCE mathematics teachers in lagos state. *Journal of Teacher Education* 12(1) NCCE Abuja.

Adedura, O. and Tayo, K. (2007). Perception of knowledge, attitude and teaching skills as predictor of academic perfection in Nigerian secondary schools. *Education Research and Review* 2(7) 165-171.

Adeyemi, B.A. (2008).Effects of cooperative learning on junior secondary school students' achievement in social studies. *Electronic Journal of Research in Education Psychology*, *16(3): 691-708.*

Ado, I. K. (2014) Impact Of Constructivist Teaching Strategy In Students Academic Performance, Retention And Attitude Towards Trigonometry Among Senior Secondary Students In Kaduna State Niger Ph.D Thesis, Science Education Department A.B.U.

Ahmed, E.J. (2010).Effects of Class-size on Ability levels and Performance in Mathematic of Senior Secondary School in Zaria Educational Zone. Med Thesis, Department of Science Education Ahmadu Bello University. Zaria.

Aigboimian, D.O. (2002). *Science for all: Implication for the Teacher and National Development*. Ambik Press, Benin City.

Ajagun, G.A. (2001). A study of the performance of science students in the senior school certificate examination in selected schools in Kaduna State, *Tambari. Kano Journal of Education,* 6(2): 11 – 126.

Ajewole, G.A. & Okebukola, P.A.O. (1998). Effect of guided discovery and expository instructional method on attitudes in students to Biology. *Journal of Research in Science and Technology*, 28(5): 401-405.

Akinbobola A.O.(2009).Enhancing students attitude towards Nigerian Senior Secondary School physics through the use of cooperative, competitive and individualistic strategies. *Australian Journal of Teacher Education*.1(34):1-9.

Akinbobola, A. O. and Folashade, A. (2009). Constructivist problem-based learning technique and the academic achievement of physics students in nigerian secondary schools. *Eurasian Journal of Physics and Chemistry Education.* 1(1): 45-51.

Akins, K., Durham, J., Smit, J. A., & VanDenend, J. (2008). Project Based Learning vs. Traditional Instruction in the Fourth Grade Science Curriculum. Retrieved from http://oaisd.saturn.foxbright.com/oaisd/departments/instructionalservices/actionresearch/200708classroomactionresearchreports/ .

Akinsola, A. T. Lawal, J. And Oyedokun, M. R. (2007). The Quality of Human Resources for Teaching Science in Primary Schools in Niger State: Implication for Sustainable Development.*Proceedings of 50th Annual Conference of STAN,* 15 – 18.

Akuezuilo, E. O. & Chinwoeke, F. U. (2009) Effectiveness of prior knowledge of behavioural objective and study questions on female students' mathematics achievement. *Unizik Journal of STM Education 1 (1) 1-7.*

Akus, R., Gunel, M., & Hand, B. (2007). Comparing an inquiry-based approach known as the science writing heuristic to traditional science teaching practices: Are there differences? .*International Journal of Science Education*. 29 (14) :1745-1765.

Amaral, O., Leslie, G., Klentschy, M. (2002). Helping English learners Increase achievement through Inquiry-based science instruction. *Bilingual Research Journal.* 26 (2): 225-234.

Ambuno, S. Egunyom, A and Osakwe, V.C. (2008). *Comprehensive Certificate Biology for Senior Secondary School.* New Edition. University Press, Plc. Ibadan, Nigeria.

Aminu, Y. (2012). Effect of Integrating Instructional Models with Lecture Method on Academic Achievement and Retention of Students of Various Class Sizes in some Biology Concepts. Unpublished *M.ed Thesis.* Department of Education, ABU, Zaria.

Anamuah-mensah,J. Otuka, J. E. And Ngman – Wara E. (2006). Words in science: a study of Ghana Junior Secondary School students' meanings. *Keffi Journal of Education Studies, 1(1):1-11*.

Anaso, J. N. (2008). Effect of Class-Size on the Academic Achievement and Retention of Different Ability Groups among Senior Secondary School Chemistry Students. Ph.D Dissertation, A.B.U., Zaria.

Ansalone, G. (2006). Perceptions of Ability and Equity in the U.S. and Japan: Understanding the Pervasiveness of Tracking. *Radical Pedagogy*, 6(l). Retrieved June 1, 2006, from http://radicalpedagogy.icaap.org/content/issue8_1/ansalone.html

Ansalone, G., & Biafora, F. (2004). Elementary school teachers' perceptions and attitudes to the educational structure of tracking. *Education/*125 (2), 249-257.

Araz, G. (2007). The Effect of Problem-Based Learning on the Elementary School Students' Achievement in Genetics. Master's Thesis Submitted to Graduate School of Social Science, Middle East Technical University.

Atadoga, M.M. (2005), Gender related problem-solving strategies and senior secondary students achievement in physics. *Nigeria Journal of Science and Educational Research* (1) 69-73.

Ates, S. (2005). The effectiveness of the learning cycle method on teaching DC circuits to prospective female and male science teachers. *Research in Science & Technological Education*, 23 (2), 213-227.

Aweriale, P.E.O. (2006). Gender performance in physics. A case study in Auchi Polytechnics, Auchi. *Nigeria Journal of Professional Teachers*, 1(2): 223-234.

Bailey, R. (2013).*Basic, Biology.* About.com.Biology@2014about.comBiology.about.com/00/Biologydictionary/u/basicBiology.htm

Balcı, S. (2005). Improving 8th grade students' understanding of photosynthesis and respiration in plants by using 5E learning cycle and conceptual change text, Unpublished master's thesis, Middle East Technical University, Ankara, Turkey.

Başer, E. T. (2008). 5E modeline uygun öğretim etkinliklerinin 7. sınıf ögrencilerinin matematik dersindeki akademik basarılarına etkisi, Yayınlanmamış yüksek lisans tezi, Gazi Üniversitesi, Ankara, Türkiye.

Bason, M.D. (2012). Biolexicon: A Guide to the Language of Biology: *Yaje Journal of Biology and Medicines No. 4*. http://www.ask.com/wiki/outline-of-Biology?0=416479998-qsrc=4145x1=dir

Bassey, M.P.(2002).Availability of Resources for the Teaching of Science Subjects in Public Secondary Schools; A Case Study of Some Selected Secondary Schools in Ahmosho Local Government Area of Lagos State. Unpublished B.sc (ED) project University of Lagos.

Bello, A. (2012). Effects of Learning Cycle Teaching Strategy on Students' Acquisition of Formal Reasoning Ability and Academic Achievement in Genetics in SSII Biology Students in Sabon-Gari, Kaduna State. Unpublished P.hD (Science Education) Dissertation. Ahmadu Bello University Zaria, Nigeria.

Bichi, S. S. (2002). Effects of Problem-Solving Strategy and Enriched Curriculum on Students' Achievement in Evolution Concept among Secondary School Students. An Unpublished PhD Dissertation: Ahmadu Bello University, Zaria, Nigeria.

Bilgin, I.(2009).The effect of guided inquiry instruction incorporating a cooperative learning approach on university students achievement of acid and bases concept and attitude toward guided inquiry instruction. *Academic Journals: Scientific Research and Essay*.4 (10):1038-1046.

Bitrus, I.G. (2012). Effect of Science Process Skill Approach on Academic Performance and Attitude of Integrated Science Students with varied abilities. M.ed Unpublished thesis, Department of Science Education, A.B.U. Zaria.

Bloom, B.S. (1975) .*Human Characteristics and School Learning*, New York McGraw Hill.

Boddy, N., Watson, K. & Aubusson, P. (2003). A trial of five Es: A referent model for constructivist teaching and learning. Research in Science Education. 33 (1), 27-42.

Bunkure, Y. I. (2008). Effects of Computer-Assisted Instructional Software on Students' Academic Achievement in Physics. Unpublished M ED Thesis. Department of Science Education, Faculty of Education, Ahmadu Bello University, Zaria.

Bunkure, Y.I. (2012). Effect of a Constructivist Instructional Strategy on the Academic Achievement, Retention and Attitude to Physics among Secondary School Students of Different Ability Levels in Kano State, Nigeria. Unpublished Ph.D Dissertation, Department of Science Education, Ahmadu Bello University, Zaria.

Bybee R.W. (2002). *Scientific Inquiry, Student Learning, and the Science Curriculum: Learning Science and the Science of Learning*. Arlington, VA: NSTA Press.

Bybee, R. W. (2005) Science and technology education for the elementary years: (third edition). Frameworks for curriculum and instruction. Washington, D.C. the National Centre for improving instruction. www.encyclopedia.com/doc/iGi-1723767.html. retrieved on May 11, 2015.

Bybee, R. W. (2009). The BSCS 5E Instructional Model and 21st Century Skills: A Commission Paper Prepared for a Workshop on Exploring the Intersection of Science Education and the Development of 21st Century Skills Submitted to the National Academics Board on Science Education.

Bybee, R., Taylor J., Gardner A., Scotter, P., Powell, J., Westbrook, A., & Landes, N., (2006). *The BSCS 5E Instructional Model: Origins, Effectives, and Applications*. Executive Summary, BSCS, Colorado Springs, CO.

Çakıroğlu, J. (2006). The effect of learning cycle approach on students' achievement in science, Eurasian Journal of Educational Research, 22, 61-73.

Campbell, M. A. (2000). The effects of the 5E learning cycle on students' understanding of force and motion concepts. MS Thesis. University of Central Florida.

Çardak, O., Dikmenli, M. & Sarıtaş, O. (2008). Effect of 5E instructional model in student success in primary school 6th year circulatory system topic. Asia-Pacific Forum on Science Learning and Teaching, 9(2), 1-11.

Ceylan, E. (2008). Effects of 5e learning cycle model on understanding of state of matter and solubility concepts, Unpublished PhD Dissertation Thesis, Middle East Technical University, Ankara, Turkey.

Corbit, J. (2002). *Building Virtual Worlds for Information Science Learning (Scentr and Scifair) in the Active Worlds Educational Universe (AWEDU).* Presence: Telecoperators & Virtual Environments.

Dahiru, A.H. (2004). *Mental Health and Treatment of Mental Illness* (2'ed) Kaduna Communication.

Dahiru, S. (2013) The Effects of Using Gagne's Learning Hierarchy in Chemistry Students Academic Performance and Anxiety Level in Balancing Chemical Equations in Secondary Schools in Katsina Metropolis. Unpublished Ph.D Thesis, Faculty of Education, Ahmadu Bello University Zaria.

Dana, S. D. (2000) *Statistical and Data Analysis for the Behavioural Sciences.* MC Grae – Hill Higher Education, new York NY1002 65 – 69.

Demircioğlu, G., Özmen, H. & Demircioğlu, H. (2004). Bütünleştirici öğrenme kuramına göre dayalı olarak geliştirilen etkinliklerin uygulanmasının etkililiğinin araştırılması. Türk Fen Eğitimi Dergisi, 1(1), 21-34.

Dewey, J. (1929). My pedagogic creed. *Journal of the National Education Association,* 18(9), 291-295.

Druger, A. (2002). It all depends. *Journal of College Science Teaching,* 31 (7): 493 –495.

Emabe, A.J. (2006). Mother-tongue education in Nigeria: A realistic approach. *Keffi Journal of Educational Studies,* Faculty of Education, Nasarawa State University, Keffi-Nigeria. *1(1):98-108.*

Erşahan, O. (2007). 6. Sınıf öğrencilerine madde ve değişim öğrenme alanındaki fen teknoloji toplum çevre kazanımlarının kazandırılmasında etkili ögretim yönteminin (rol oynama ve 5E öğretim yöntemi) belirlenmesi, Yayınlanmamış yüksek lisans tezi, Gazi Üniversitesi, Ankara, Türkiye.

Eze, C.U. (2002). Effect of Target Task Approach on Students' Achievement in Senior School Certificate Physical Chemistry. *Proceedings of the 43rd Annual Conference and Inaugural Conference of CASTME Africa,* Heinemann Educational Books, (Nigeria) PLC 259-262.

Federal Republic of Nigeria (2013). *National Policy on Education.* Lagos NERDC Press.

Fox, M. (2003). *Learning Design and e-Learning*. 1-44. An EPIC White Paper. EPIC Group, Plc. Brighton.

Fraenkel J.R, Wallen N.E. (2000). *How to Design and Evaluate Research in Education.* New York: McGraw-hill Companies Inc.

Friesen, S. (2010). Uncomfortable bedfellows: discipline-based inquiry and standardized examinations. *Teacher Librarian,* 37(6).

Fust, E.J.(1958),*Constructing Evaluation Instrument.* Longman Green Company .New York.

Garcia, C. M. (2005). Comparing the 5Es and traditional approach to teaching evolution in a hispanic middle school science classroom. Unpublished master thesis, California State University, USA.

Garcia, E. P. (2004). Using manipulatives and visual cues with explicit vocabulary enhancement for mathematics instruction with grade three and four low achievers in bilingual classrooms. Dissertation Abstracts International (UMI No. 3142085).

George, P.S., &Alexander, W. M. (2003). *The Exemplary Middle School (3rd* ed.). Belmont, CA: Wadsworth/Thomson.

Greenmiller D.K (2014) The Effect of Inquiry Based, Hands- on Labs on Achievement in Middle School Science. Dissertation Presented on Partial Fulfillment of the Requirement for the Degree Doctor of Education, Liberty University.

Gyuse, E.Y (2009). Moving Teaching and Science Education Forward. Diagnosing Science Teacher's Problem. Led Paper Presentation, Science Teacher Teachers Association of Nigeria (STAN) annual conference, Minna, Niger State.

Hattie, J. (2009). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*. London: Rutledge.

Hernandez-Ramos, P., & De La Paz, S. (2009). Learning history in middle school by designing multimedia in a project-based learning in a project-based learning experience. *Journal of Research on Technology in Education*, 42, 151-173.

Hiçcan, B. (2008). 5E öğrenme döngüsü modeline dayalı öğretim etkinliklerinin ilköğretim 7. sınıf öğrencilerinin matematik dersi birinci dereceden bir bilinmeyenli denklemler konusundaki akademik başarılarına etkisi, Yayınlanmamış yüksek lisans tezi, Gazi Üniversitesi, Ankara, Türkiye.

Hmelo, C., Holton, D., Kolodner, J. (2000). Designing to learn about complex systems. *Journal of the Learning Sciences,* 9(3), 247-298.

Hollifield, J. (1987). *Ability Grouping in Elementary Schools:* ERIC Clearing Housing on Elementary and Early Childhood Education, Urbana IL.

Hornby, A.S. (2010). *Oxford Advanced Learner's Dictionary:* International Student's Edition. New 8th Edition, Oxford University Press. Oxford New York.

Ibrahim S.T (2013) Effect of high level of teacher-students verbal interaction on students achievement in Biology: Implication for curriculum and new Science, Technology and Mathematic Teacher. Nigeria Educational Forum. *A Journal of Institute of Education ABU Zaria.* 22(2) 81-89.

Ibrahim, S.T. (2008). Effects on Teacher-Students Verbal Interaction on Biology Academic Achievements of Senior Secondary School Students of Sabon-Gari Zaria LGA of Kaduna State. Unpublished M.ed Thesis. Department of Education, ABU, Zaria.

Idris, I.O. (2012). Effect of Concept Mapping Strategy on Mathematics Achievement and Attitude among Students with varied Ability Levels in Senior Secondary Schools in Zaria Education Zone. A Postgraduate Research Seminar Paper (EDSE 805), Department of Science and Mathematics Education, Faculty of Education, Ahmadu Bello University, Zaria.

Igbojinwaekwu, P.C. (2012). Prior knowledge of study questions and students' Biology academic achievement at senior secondary school level. *Multidisciplinary journal of Nigeria academic forum.* 23 (1) 9-15.

Ihejirika, N.C. (2010). The impact of global economic crisis on students' performance in Biology in Senior Secondary School Certificate Examination (2005-2009) in some selected schools in Kano State. *STAN 2010, 51st Annual Conference Proceedings on the theme STEM Education and Global Economic Crisis.* HEBN Publishers, PLC, 39:239-243.

Itamah, D. (2007). A Keynote Address Delivered at the 2007 School of Science National Conference held at Federal College of Education, Zaria, April, 2-5.

James, T. (1991). Effectiveness of Inquiry Versus Lecture Methods of Teaching Biology in Secondary Schools in Niger State. Unpublished M.ed Thesis, Ahmadu Bello University, Zaria.

Jibrin, *A. G.* and Nuru, R.A. (2007). The Role of lCT in Teaching Science, Technology and Mathematics Education (SMTE) in Nigeria Instructions. A paper presented at the National Conference of Nigeria Primary and Teacher education Association, at University of Jos (July 31^{51}_ 3rd August).

Jiya, A. (2011). Effect of Teaching with Analogy on Academic Achievement Performance and Retention of Evolution Concept among NCE I Biology Students. Unpublished M.ed Thesis. Department of Education, ABU, Zaria.

John, W.B. and James V.K (2011). Research in education, tenth edition: PHI learning private limited, New Delhi-110001.

Kalia, K.A., (2005). Effectiveness of mastery learning strategy and inquiry training model on pupil's achievement in science. *Indian Educ. Rev*., 41(1).

Katcha, M.A. (2005). Effect of Vee-Diagram Instructional Strategy on Senior Secondary School Academic Achievement in and Attitude Change to Biology. Unpublished PhD (Science Education) Dissertation. Ahmadu Bello University Zaria, Nigeria.

Kaynar, D. (2007). The effect of 5E learning cycle approach on sixth grade students' understanding of cell concept, attitude toward science and scientific epistemological beliefs, Unpublished master's thesis, Middle East Technical University, Ankara, Turkey.

Kerlinger F. N. (2000). *Foundation of Behavioural Research*: Research Design in Occupational Education, Oklahoma State University 9. 72.

Kerlinger, F. N. and Leer, H. Z., (2005). Foundation of Behavioural Research. Forth Edition, New York: Harcourt Higher Learning Company.

Keskin, V. (2008). Yapılandırmacı 5E öğrenme modelinin lise öğrencilerinin basit sarkaç kavramları öğrenmelerine ve tutumlarına etkisi,Yayınlanmamış yüksek lisans tezi, Marmara Üniversitesi, İstanbul, Türkiye.

Ketim, Q. & Olowo, G.M. (2013) Academic performance of direct and pre-NCE students in Federal Colleges of Education (special, Oyo):implication for educational administrators. *Research journal in Organisational Psychology& Educational Studies.*2(4):218-223.

Lakpini (2012).Effect of a conceptual change instructional strategy on Biology performance of low and average secondary school students in Giwa Educational zone . *Journal of studies in science and mathematics Education,* Department of science Education ABU Zaria.2(1),47-56.

Lakpini, M. A. (2006). Effects of a Conceptual Change Instructional Strategy on the Achievement, Retention and Attitude of Secondary School Biology Students with Varied Ability. An Unpublished Ph.D Dissertation at the Department of Education, Ahmadu *Bello* University, Zaria.

Lawal, F. K. (2009). Effects of Conceptual Change Instructional Strategy in Remediating Identified Misconceptions Held by Students in Biology. Unpublished Ph.D (Science Education) Dissertation. Ahmadu Bello University Zaria, Nigeria.

Lawal, F.K. (2010). Relationship between Qualifying Examination (Q.E) and National Examination Council (NECO) result in Biology in selected schools of Kano metropolis. *Journal of Studies in Science and Mathematic Education*. Department of Education, ABU, Zaria. 1(1):42-46.

Lawal, T.E. (2005). Effect of Concept Mapping Strategies on Academic Achievement and Cognitive References of Undergraduate Students in Genetics. Ph.D Unpublished Disserted Department Scan Education, Faculty of Education A.B.U, Zaria.

Lawal, T.E., Obeka, S.S. and Mohammed, I. (2012). Effect of using conventional and improvised instructional materials on primary five pupils academic achievement in basic science concepts in Wase Local Government Area, Plateau State. *Journal of Studies in Science and Mathematics Education 2(1):72-80.* Department of Science Education, Ahmadu Bello University, Zaria.

Lee, C. A. (2003). A learning cycle inquiry into plant nutrition. The American Biology Teacher, 65(2), 136-144.

Llewellyn, D. (2005). *Teaching High School Through Inquiry. A Case Study Approach*. Thousand Oaks: Corwin Press.

Marx R.W., Blumenfeld P.C., Krajcik J.S., Fishman B., Soloway E., Geier R., Revital T.T. (2004). Inquiry-based science in the middle grades: assessment of learning in urban systemic reform. *Journal of Research in Science Teaching.* 41(10):1063-1080.

Mergendoller, J.R., Maxwell, N.L., & Bellisimo, Y. (2006). The effectiveness of problem-based instruction: A comparative study of instructional method and student characteristics. *Interdisciplinary Journal of Problem-Based Learning, 1*, 49-69.

Minner, D., Levy, A., & Century, J. (2010). Inquiry-based science instructions—what is it and does it matter? results from a research synthesis years 1984 to 2002. *Journal of Research in Science Teaching,* 47, 474 – 496.

Mohammed, B.H. (2009). Language as a tool for national rebirths: The case for Hausa language as a National Official Language. *Journal of Arts and Education (JOLAE)* A journal of Faculty of Education and Arts, Ibrahim Badamasi Babangida University, Lapai, Niger State 3 (1); 55-63.

Nagarjuna, G. and Meena, K. (2011). A proposal for developing a primer for constructing and analyzing conceptual structures. In S. Andrew, et al (eds.), lecture notes in artificial intelligence: conceptual structures – learning teaching and assessment. in international conference on conceptual structures: conceptual structures for discovering knowledge. Berlin, Germany: *Springer-Verlag.* 6828: (402-405).

National Commission of Colleges of Education (2009).*Minimum Standard for NCE Teacher Education*. Abuja: NCCE PR 8XS.

National Research Council NRC (2000), inquiry and the national science education standards; a guide for teaching and learning. Washington. D.C; national academy press.

Ndioho, O. F., (2007), Effect of Constructionists Based Instructional Model on Senior Secondary Students Achievement in Biology. In U. Nzewi (Ed), proceedings of the 5015 anniversary conference of STAW (Pp 98 - 101) Ibadan Nigeria, HEBN.

Ndrika, M. A. (2009), Effects of Teacher-Student Interaction on Academic Performance among Integrated Science Students of different Class Sizes and Ability Groups. Unpublished Ph.D Dissertation, ABU, Zaria.

Ndrika, M. A., Olorukooba, S. B., S. B. Usman, LA and Bichi S. S. (2010). Effect of different levels of teacher-students verbal interaction on academic performance of junior students in small class-sizes. *Journal of Studies in Science and Mathematics Education,* I (1): 98-102.

Nemati, A. (2009). Memory Vocabulary Learning Strategies and Long-Term Retention, *International Journal of Vocational and Technical Education;* Department of Studies in Linguistics, University of Mysore, Karnataka State, India.

NERDC (2007). *9 Years Basic Education Curriculum, Basic Science and Technology for Primary 4 -6:* Abuja, NERDC Press.

Njoku Z. C. (2004). Engendering Learning Equity in Science and Technology Classrooms for Sustainable Development: *50th Proceedings of the Science Teachers' Association of Nigeria,* HEBN Publisher, Plc.

Njoroge, U.N Changeiywo, J.M and Ndirangu M. (2014). Effect of inquiry-Based teaching approach on secondary school students achievement and motivation in physics in Nyeri Country, Kenya: *International Journal of Academic Research in Education and Review*. 2(1),1-16

Nnachi, O.R. (2002). Relationship of achievement, gender and science-self concept of students' attitude to science within South Eastern States of Nigeria. *Journal of the Nigerian Society for Educational Psychologists* (NISEP), 1(1):79-91.

Noddings, N. (2007). *Philosophy of Education* (2nd ed.). Boulder, CO: Westview Press.

Nwagbo, C. (2001). The relative efficacy of guided inquiry and expository method on the achievement in biology of students of different level of scientific literacy. *Science Teachers Association of Nigeria*, 36 (1&2), 43-5.

Nwagbo, C. (2007). Developing Observational and Drawing Skills in Teachers for Effective Conduct of Biology Practical: *STAN Proceedings, National Biology Panal Series.* Akins Press and Services, Jos, Plateau State, Nigeria.

Nwagbo, C.R. & Ovuve, A.D. (2011). Teachers' knowledge of the content and activities in the new basic science curriculum: Implications for the new science teacher. *Nigerian Journal of Curriculum Studies.18 (1):194-200.*

Nwagbo, C.R. (2002). "Level of Scientific Literacy of Secondary School Science Students": Implications for Sustainable Development in Nigeria. *43rd Annual Conference Proceedings of the Science Teachers' Association of Nigeria.* Heinemann Educational Books (Nig), Plc. 73-77.

Nwaiwu, N.E. and Audu, B. (2005) Influencing factor in female engineering and technical education in nigeria knowledge review. *A Multidisciplinary Journal* 10(1): 8-11

O.' Brien T. (2013) 5E (2) .*Guidelines for Designing Research – informed Science Lesson Sequences.* NSTA press. Arlington,Virginia.

Obeka, S.S., Bichi, S.S. and Yusuf, A. (2012). Effects of integrating instructional models with lecture lethod on academic performance of senior secondary school students of various class-sizes in environment concepts of Zaria Educational Zone. *Journal of Educational Research and Development.* 6(3), Ahmadu Bello University, Zaria.

Ogunboyede, M.O. (2003). Sex differences and students achievement at the primary school level. *The Nigerian academic forum.* 5(1), 152-155.

Ogunleye, A. O., (2000). An Introduction to Research Method in Educational and Social Sciences, Lagos. Sunshine International Publications (Nig). Ltd.

Okafor. E.N. & Okeke, O.C. (2006) Concept Mapping as Effective Technique for Teaching Difficult Concept in Biology. In N. Uchenna (ED). Proceedings of the 47th Annual Conference of STAN, 122-127.

Okebukola, P.A. (2002). Beyond the Stereotypes to New Trajectories in Science teaching. Special Lecture Presentation at the *43th Annual Conference of STAN and CASTME* August.

Okeke, E.A.C. (2001). Women in Science/Technology and Mathematics Education in Nigeria. *Keynote Address at the 42nd Annual Conference of STAN*.

Okeke, E.A.C. (2008). Clarification and analysis of gender concepts. *Education Series*, No. 2, 5-8.

Olorukooba, S.B Lawal, F.K and Jiya, A. (2012), Effects of teaching with analogy on academic achievement and retention of evolution concepts among male and female NCE Biology students. *Journal of Studies in Science and Mathematic Education*,2(1):81-91 Department of Science Education, ABU, Zaria.

Oludipe, D. (2012). Gender differences in Nigerian Junior Secondary School students' academic achievement in basic science, integrated science department, school of science, Tai Solarin College of Education, Nigeria. *Journal of Educational and Social Research, 2(1):93.*

Oluwatoyin, A.J. (2007). Gender and subject choice effects on students psycho-cognitive outcomes in Mathematics. *Journal of Arts and Education* JOLAE), 1(1): 1-12.

Opara,A.J.(2011).Inquiry method and students academic deferent in Biology: Lesson and policy implication: *American-urasian journal of scientific research* 6(1) 28-31.

Orgill, M., & Thomas, M. (2007). Analogies and the 5E model: Suggestions for using analogies in each phase of the 5E Model. The Science Teacher, 40-45.

Ortlieb, E. T., & Lu, L. (2011). Improving teacher education through inquiry-based learning. *Journal International Education Studies*, 4(3), 41-46. doi: 10.5539/ies.v4n3p41.

Orukotan, A.F. and Balogun, E.M. (2000). Implementing Conceptual Change: a Strategy of Enriching Science Teaching in Schools. *Proceeding of the 41st Annual STAN Conference*, 65-68.

Osborne, I. (2003). attitudes towards science: a review of the literature and its implication, international *Journal of Science and Education,* 25(9), 1049-1079. http://www.tandfco.uk/ Journal. Retrieved on 10/4/2010.

Özdal, J., Ünlü, K., Çatak, M. & Sarı, S. (2006). A mathematics lesson designed using 5E learning cycle model. VI. Uluslararası Eğitim Teknolojileri 74 Konferansı, 19-20-20 Nisan 2006, Doğu Akdeniz Universitesi, Magosa-K.K.T.C.

Özlem , S. and Jale, Ç. (2010) Effects of 5E Learning Cycle on Students' Human Circulatory System Achievement. Journal of Applied Biological Sciences 4 (3): 63-67, 2010 ISSN: 1307-1130, E-ISSN: 2146-0108 www.nobel.gen.tr.

Ozmon, H. A. & Carver, S. M. (2008). *Philosophical Foundations of Education (8*th ed.). Upper Saddle River, NJ: Pearson/Merrill Prentice Hall.

Özsevgeç, T. (2006). Kuvvet ve hareket ünitesine yönelik 5E modeline göre geliştirilen öğrenci rehber materyalinin etkililiğinin degerlendirilmesi, Türk Fen Eğitimi Dergisi, 3(2), 36–48.

Özsevgeç, T., Çepni, S. & Bayri, N. (2007). Kalıcı kavramsal değişimde 5E modelinin etkililiği. EDU 7, 2(2), 1-12.

Pabuçcu, A. (2008). Improving 11th grade students' understanding of acid-base concepts by using 5E learning cycle model. Unpublished Doctor of Philosophy Dissertation, Middle East Technical University, Ankara, Turkey.

Patrick, M., 2000. *Enhancing Learning and Styles of Students. University News,* 38(1).

Pearson Education (2003). *Longman Dictionary of Contemporary English.* (New Edition), Essex: Pearson Education Limited.

Peni, H.Y. (2008). Effects of an Improvised Volumetric Analysis apparatus on Students' Academic Achievement in Chemistry. Unpublished M.ED Thesis, Ahmadu Bello University, Zaria.

Philips, K.A.; Chandrasekher, M. Barrow, L. and Litherland, R. (2000). Physical Science Interest and Inventory Profiles of Female in a Residential Summer Programme. A Paper Presented at the Annual Meeting of the National Association of Research in Science Teaching, New Orleans, L.A. April, 30. http://epic.physics,missouri.edu. Accessed on 12/4/2010.

Poderoso, C. (2013). The Science Experience: The relationship Between an Inquiry-Based Science Program and Student Outcomes. Retrieved from Liberty University website:http://search.proquest.com.ezproxy.liberty.edu:2048/pqdtft/docview/1318596989/487E9985B3E425FPQ/2?accountid=12085.

Pulat, S.(2009) Impact Of 5e Learning Cycle On Sixth Grade Students' Mathematics Achievement On And Attitudes Toward Mathematics . A Thesis Submitted To The Graduate School Of Social Sciences Of Middle East Technical University In Partial Fulfillment Of The Requirements For The Degree Of Master Of Science In The Department Of Elementary Science And Mathematics Education.

Rao, V.K. (2007). *Science Education:* APH Publishing Cooperation, 4435-36/7, ANSARI Road, DARYA GANJ, New Delhi-110002.

Ridgeway, V.G. (2004). One teacher journey. *Journal of Adolescent and Adult Literacy, 47(5):364-368.*

Rotbain, Y. Marbach-Ad, G. & Satvy, R. (2006). Effect of bead and illustrations model on high school students achievement in molecular genetics. *Journal of Research in Science Teaching 43(5) 500-529.*

Rubin, B.C. (2006). Tracking and detracking: debates, evidence, and best practices for a heterogeneous world. *Theory into Practice,* 45(1):4-14.

Rubin, B.C., & Noguera, P. A. (2004).Tracking detracking: sorting through the dilemmas and possibilities of detracking in practice. *Equity and Excellence in Education*, 37:92-101.

Sambo, A.A.(2008).*Statistical Principles for research in Education and Social sciences.* S. Asekome Publishing Company Samaru Zaria, Nigeria.

Saygın, O., Atılboz, N. G., & Salman, S. (2006). Yapılandırmacı öğretim yaklaşımının biyoloji dersi konularını öğrenme basarısı üzerine etkisi: canlılığın temel birimi-Hücre. Gazi Üniversitesi Eğitim Fakültesi Dergisi. 26(1), 51-64.

Schiller, S. Z. (2009). Practicing learner-centered teaching, pedagogical design and assessment of a second life project: *Journal of Information Systems Education,* 20, 369-381.

Seyhan, H. & Morgil, I. (2007). The effect of 5E learning model on teaching of asid- base topic in chemistry education. Journal *of Science Education*, 8(2), 120-123.

Shitu,S.(2013).Effects of Guided Inquiry Strategy on Learning Outcome of low Achieving Secondary School Physics Students in Kaduna Metropolis, Nigeria. Unpublished M.ED Thesis, Ahmadu Bello University, Zaria.

Silvia, S., and Michael, W. (2010). *Biology Dictionary.* 11th Edition. McGraw, Hill Companies.

Sjoberg, S. (2002). *Science for Children.* Department of Teacher Education and Science Department, University of Oslo.

Slavin, R. E. (1993). Ability grouping in middle grades: achievement effects and alternatives. *Elementary School Journal,* 93 (5): 535 – 552.

Slavin, R.E. (1986). *Ability Grouping on Students Achievement in Elementary Schools:* A Best-Evidence Synthesis. Baltmore, MD: Centre for Research on Elementary and Middle Schools.

Taylor, J. and Bilbrey, J. (2014), Effectiveness of inquiry based and teacher directed instruction in an Alabama elementary School. *Journal of Instructional Pedagogies*. http://www.abri.com/copyright.html.

Thompson, C. J. (2006).Preparation, practice, and performance: An empirical examination of the impact of standards based instruction on secondary students' math and science achievement. *Journal* of *Research in Education,* 81(1): 53-62.

Tuckman B.W. (1975) .*Measuring Educational Outcomes.* Harcourt Brace, Hangwick, New York.

Tuna, A. and Kacar , A. (2013) The Effect Of 5e Learning Cycle Model In Teaching Trigonometry On Students' Academic Achievement And The Permanence Of Their Knowledge :International Journal on New Trends in Education and Their Implications : 4 (1) Article: 07 ISSN 1309-6249 . Copyright © International Journal on New Trends in Education and Their Implications / www.ijonte.org

Umar, S. (2012). Utilization of Instructional Materials and its Effects on Academic Performance of Gender among Secondary School Biology Students of Kura Education Zone, Kano State- Nigeria. *Research Seminar Paper Presentation at the Department of Science of Science and Mathematics Education,* Faculty of Education, Ahmadu Bello University, Zaria.1(1):163-167.

Umeh, M.O. (2006). Availability and use of Human and Material Resources in the Teaching of Ecology in Senior Secondary School in Anambra State Nigeria. In .U. Njew, (ED) *Proceedings of the 47th Annual Conference of STAN* , 128-133.

Usman, I. A. (2000). The Relationship between Students Performance in Practical Activities and their Academic Achievement in Integrated Science using NITEP Mode of Teaching. *Ph.D Dissertation,* ABU, Zaria, Nigeria.

Usman, I. A. (2007). Relationship between students performance in L/Practical activities and their academic achievement in Senior Secondary School Biology using NISTEF mode of teaching. *Journal of Educational Research and Development,* 2(3):240-244. Faculty of Education, ABU, Zaria.

Usman, I.A. (2010). The effect of indoor and outdoor laboratory instructional method on academic achievement of junior secondary school integrated science students in zaria local government area of kaduna state. *Journal of Studies in Science and Mathematics Education,* 1(1): 66-73.

Vamadevappa, H.V. (2002). Causative factors for underachievement in Biology. *Perspectives in Education,* 18 (3):171-178.

Vanosdall R, Klentschy M, Hedges LV, Weisbaum KS (2007). A Randomized Study of the Effects of Scaffolded Guided-Inquiry Instruction on Student Achievement in Science. Paper Presented at the Annual Meeting of the American Educational Research Association april, 2007 Chicago, Illinois.

Varnado, J. (2011). An Analysis of Didactic and Inquiry-Based Teaching and Learning on Student Achievement in Urban Elementary Schools. Retrieved from Liberty University. website: http://search.proquest.com.ezproxy.liberty.edu:2048/pqdtft/docview/867672849/216922C375C749AFPQ/1?accountid=12085

Vee, V. (2013). *Grouping Students by Ability Regains Favour in Classroom*, Chyl Centre for the New York Times.

Vygotsky, L.S. (1986). *Mind in Society: The Development of Higher Psychological Processes.* Cambridge, MA: Harvard University Press.

Watanabe, M. (2006). "Some people think this school is tracked and some people don't": using inquiry groups to unpack teachers' perspectives on detracking. *Theory into Practice,* 4.5(1) 24-31.

West African Examinations Council (WAEC) (2005). Senior School Certificate Examination. Chief Examiners Report.

West African Examinations Council (WAEC) (2010). Senior School Certificate Examination. Chief Examiners Report.

West African Examinations Council (WAEC) (2012). Senior School Certificate Examination. Chief Examiners Report.

West African Examinations Council (WAEC) (2014). Senior School Certificate Examination. Chief Examiners Report.

Wilder, M., & Shuttleworth, P. (2004). Cell inquiry: A 5E learning cycle lesson. Science Activities, 41(1), 25-31.

Yara, P.O. (2009). Students' attitude towards mathematics and academic achievement in some selected secondary schools in south-western Nigeria. *European Journal of Scientific Research, 36(3)336-341.*

Yıldırım, N., Er Nas, S., Şenel, T. & Ayas, A. (2007). Ögrencilerin kavram yanılgılarını gidermeye yönelik örnek bir etkinlik geliştirilmesi, uygulanması ve değerlendirilmesi. EDU 7, 2 (2), 1-22.

Yonazawa, S., & Jones, M. (2006). Students' perspectives on tracking and detracking. *Theory into Practice,* 4.5(1)15-23.

APPENDIX 1
GENETICS ACADAMIC PERFORMANCE TEST

School: _____

Group No.: _____ Sex: _____

Instruction: Circle the Correct Answer.

1. Which of the statements below is true about heredity?
   A. Transmission of characters from grandparents to offspring.
   B. Characters transmitted cannot be controlled by genes.
   C. Environmental factors cannot change genotype
   D. Brings about only differences between parents and offspring.

2. An organism with two sets of chromosomes is said to be
   A. polyploid
   B. diploid
   C. haploid
   D. hybrid

3. DNA molecules form the foundation for heredity because
   A. they are found in the cytoplasm of a cell.
   B. of the ability to replicate and make exact copies of themselves.
   C. they are needed during reproduction and pregnancy.
   D. they are the same as chromosomes.

4. Identical twins inherit their genes from
   A. the same ovum and different sperms.
   B. the same sperm and different ova.
   C. different sperms and many ova.
   D. the same ovum and the same sperm.

5. Which of the following best describes homologous chromosomes? They are
   A. a product of the division of a chromosome.
   B. two identical chromosomes from each parent.
   C. Chromosomes arranged on spindle fibres during cell division.
   D. Arrangement of daughter chromatides.

6. The haploid number of chromosomes in man is
   A. 48 B. 46 C. 24 D. 23

7. If a cross is made between a pure breeding red flower plant and a pure breeding white flowered plants where ‘R’ is dominant for red flower and ‘r’ is recessive for white, the most likely F_1 generation will be
   A. 75% red flowers and 25% white flowers.
   B. 100% all red flowers.
   C. 50% red flowers and 50% white flowers.
   D. 75% white flowers and 25% red flowers.

8. Which of the following represents the phenotypic ratio when a plant Rr is crossed with another plant Rr, assuming that the gene 'R' for round seed is dominant and wrinkled 'r' is recessive.
   A. 1:2:1 B. 2:2:1 C. 2:2 D. 3:1

9. All hereditary characters in a cell are passed on from parent-cell to daughter-cell through the process of
   A. mitosis B. meiosis C. fertilization D. gestation

10. when gametes from pure breeding parents with contrasting features such as tallness and shortness are involved in monohybrid cross, the offspring in the first filial generation are usually
   A. pure bred
   B. heterozygous
   C. homozygous
   D. co-dominance

11. A pair of genes which controls a trait are described as
   A. dominant B. recessive C. alleles D. chromosomes

12. The genetic make-up of an organism is known as the
   A. phenotype B. genotype C. character D. gene

13. Which of these is not hereditary?
   A. Poliomylietis
   B. Blood group
   C. Sickle cell anaemia
   D. Shape of face and nose

14. An individual with blood group AB can receive blood from those in blood group(s)
   A. AB only B. A and B only C. AB and O only D. A, B, AB and O

15. Which of the following is the unit of transmission of hereditary traits in living organisms?
   A. Nucleus B. Nucleolus C. Gene D. Chromosome

16. Blood group and tongue rolling are examples of
   A. Continuous variation
   B. Discontinuous variation
   C. Variation due to environment
   D. Adaptive variation

17. Which of the following statements is correct about sex-determination?
    A. If the female chromosome is stronger the child will be a girl
    B. If the male chromosome is stronger the child will be a boy
    C. Female X-chromosome and male X-chromosome result in a female
    D. Female gametes carried both the X-chromosome and Y-chromosome

18. Which of the following is the precise location of the gene?
    A. Chromosome
    B. Centrosome
    C. Cytoplasm
    D. Protoplasm

19. If a black guinea pig of genotype 'BB' is crossed with a white guinea pig of genotype 'bb'; what will be the phenotype of the F_1 generation?
    A. Half of the offspring would be black while the other half would be white
    B. All the offspring would be black
    C. All the offspring will be grey
    D. One-third of the offspring would be black while two-third would be white

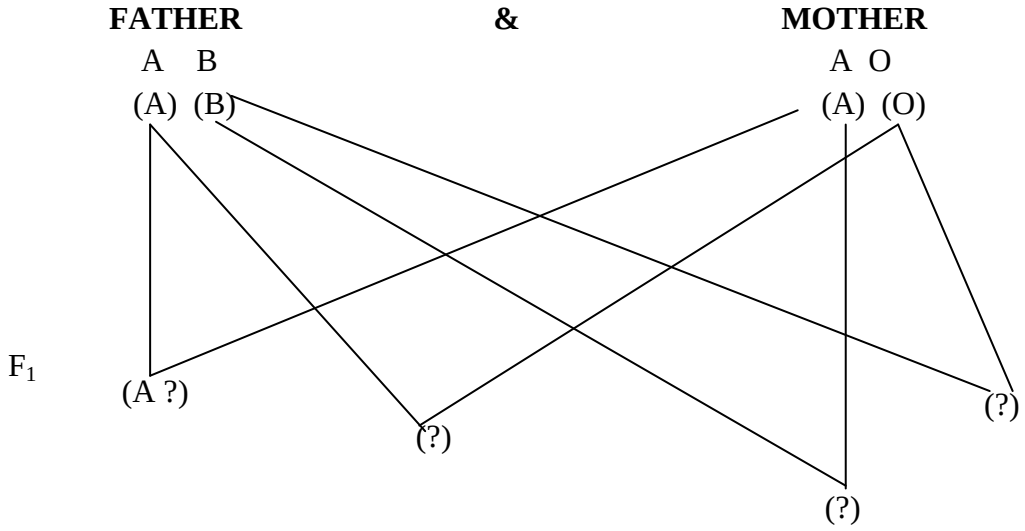
20. How many chromosomes are found in the human ovum?
    A. 46 B. 23 C. 33 D. 13

21. Heterozygous individuals are said to be
    A. Different individuals in the society ding different things
    B. Individual with different characters which can be seen
    C. Individuals with two different alleles of a gene
    D. Individuals with different looks or appearances

22. The process that results in gamete formation is
    A. Mitosis
    B. Fertilization
    C. Pregnancy
    D. Meiosis

23. Continuous variation is determined by
    A. long genes
    B. no gene
    C. polygene
    D. one gene

24. Complete the genetic cross below showing the inheritance of blood groups:



From the cross above, which of the following F_1 offspring does NOT belong to the father?

A. AA B. AO C. OB D. OO

25. Which of the following is NOT an example of continuous variation?
    A. Height of plant
    B. Ability to roll tongue
    C. Skin colour
    D. Length of fingers

26. In human beings gene for haemogblin-s is recessive while that for haemoglobin-A is dominant. The chance of parents that are heterozygous (AS) having a child suffering from sickle cell anaemia is

A. ¼ B. ½ C. $^1/_3$ D. $^2/_3$

27. In one of Mendel's experiments, a red variety of pepper crossed with a yellow variety produced all red offspring. The red offspring were then self pollinated and these produced both red and yellow pepper. The yellow colour can be said to be
    A. dominant to red
    B. recessive to red
    C. homozygous
    D. heterozygous

28. Morphological variation deals with
    A. organism's genotype
    B. organism's phenotype
    C. organism's Chromosome numbers
    D. organism's skin colour

29. The paternity of a child, which is in dispute, can be ascertained by comparing the child's
    A. phenotype with that of the father and mother
    B. genotype with that of the father alone
    C. genotype with that of the mother and father
    D. genotype with that of his grand parents
30. Variation is the study of:
    A. differences in height and weight of organisms
    B. differences in the number of males and females
    C. the observable differences between parents and offspring
    D. the observable differences in the rich and the poor

APPENDIX 2

MARKING SCHEME OF GENETIC ACADEMIC PERFROAMNCE TEST (GAPT)

1. C
2. B
3. B
4. D
5. B
6. D
7. B
8. D
9. B
10. B
11. C
12. B
13. A
14. D
15. C
16. B
17. C
18. A
19. B
20. B
21. C
22. D
23. C
24. D
25. B
26. A
27. B
28. B
29. C
30. C

Total: 1 mark x 30 = 30 marks.

APPENDIX 3
STUDENTS' ATTITUDE TO GENETICS QUESTIONNAIRE (SAGQ)

Dear Respondents,

Tick the appropriate option in the following:

Section A

Candidate's Number: _____

Sex: Male _____ Female _____

Name of School: _____

Section B: Items on Attitude to Genetics Questionnaire

Instructions:

Each of the statements of this questionnaire expresses a feeling towards Genetics. Against each statement, there are five items.

SD - Strongly Disagree
D - Disagree
U - Undecided
A - Agree
SA - Strongly Agree

Please, draw a circle around the letter or tick against each statement that best represents your personal feeling.

		Strongly Disagree (SD)	Disagree (D)	Undecided (U)	Agree (A)	Strongly Agree (SA)
1	I am always under a terrible strain when confronted with Genetics in Biology class.					
2	I do not like Genetics as it scare me from learning Biology.					
3	Genetics is very interesting and I enjoy it.					
4	Genetics is fascinating and self inspiring to me.					
5	I am unable to think clearly and logically when learning Genetics.					
6	Genetics is stimulating to me.					
7	Learning Genetics make me uncomfortable, restless, irritable and impatient.					
8	I feel so good whenever I learn Genetics in Biology class.					
9	I never like Genetics because it is dreadful to me.					
10	Learning Genetics is very important in everyday life.					
11	I like Genetics because it always leads me to the correct answer.					
12	It makes me nervous to even think of learning Genetics.					
13	Genetics helps me in learning other school subjects.					
14	I do not feel at ease in Biology class because it involves Genetics.					
15	All students should be required to understand Genetics in Biology class.					
16	I approach Genetics with a feeling of hesitation, resulting from fear of not being able to understand its concepts..					
17	Biology is a course in school that I enjoy most because it contains Genetics.					
18	I feel being lost in a jungle whenever I learning Genetic.					
19	Learning Genetics is not important in everyday life.					
20	I am happier in a Biology class than in any other class because Genetics give me a feeling of satisfaction.					

APPENDIX 4
LETTER TO VALIDATORS OF THE INSTRUMENTS
DEPARTMENT OF SCIENCE AND MATHEMATICS EDUCATION
FACULTY OF EDUCATION
AHMADU BELLO UNIVERSITY, ZARIA

13th October, 2014.

Dear Sir/Ma,

VALIDATION OF INSTRUMENTS

I am a Ph.D student in the above mentioned Department working on "Impact of 5E Teaching Cycle on Attitudes, Retention and Performance, of pre-NCE Biology students with Varied Abilities in North-West, Zone". I have three instruments for use in the research and they are as follows:

(i) Genetics Academic Performance Test (GAPT).
(ii) Students Attitude to Genetics Questionnaire (SAGQ).

Sir/Ma kindly validates the instrument applicable to you as is related to your field.

Yours faithfully,

Sukola Tambaya IBRAHIM
Ph.D/EDUC/14403/2010-2011

APPENDIX 5
LESSON NOTES FOR THE EXPERIMENTAL GROUP EXPOSED TO 5E TEACHING CYCLE.

Lesson 1	-	WEEK 1
Group	-	Experimental
Class Level	-	Pre-NCE
Subject	-	Biology
Course	-	Genetic
TOPIC:	-	Morphological Variation In Appearances of Individuals.
Duration	-	2 hours
Instructional Materials	-	Tape rule, paper students in the class, Diagram showing major types of finger prints and scale.

SPECIFIC OBJECTTIVES: At the end of the lesson students should be able to:

1. Explain what is variation;
2. Explain what is morphological variation;
3. Give examples of morphological variation;
4. Explain what is continuous variation;
5. Make your finger prints on a paper and classify them into the major types;.

PREVIOUS KNOWLEDGE: Students are familiar with variation in the physical appearances within families and between individuals.

PRESENTATION: Presentation of lesson to the experimental group with 5E Model is as follows:

PHASE 1: ENGAGEMENT PHASE: The teacher starts the lesson by asking some questions

You have the following pictures on table:

A. A family picture.(appendix 11)
B. Picture showing a group of children of the same age standing. (Appendix 12)
C. Picture showing major types of fingerprints.(Appendix 13)

Look at the picture carefully and answer the following questions in your answer sheet:

1. Do all the children in the family picture look exactly identical since they have the same parents? Why
2. Is there any child who does not look like either of the parents?
3. From pictures B what features can you observe that makes one individual different from the other one slightly? Name four of such features that you can notice.
4. Look at the tip of your finger; can you see patterns on them? What are the patterns called?

PHASE 2: **EXPLORATION PHASE**: Here the teacher give student an activity to carried out on the topic.

Activity 1: To demonstrate variation using height.

Materials: Measuring tape, recording sheet

Procedure

1) Each group member should stand against the wall.
2) Another member of group should place a ruler on his/her head horizontally to mark the point showing the height.
3) The tape rule should be used to measure the height of the student from the floor to the point where the ruler is.
4) The measurement should be done in metre and centimeter.
5) The height should be recorded in the recording sheet.
6) Collect the height of the students from the other groups.
7) Make a table showing height and the frequency of occurrence.

Questions

1. From the data collected. What type of variation is height?
2. Give a reason for your answer.

PHASE 3: EXPLANATION PHASE: The teacher explains some concepts about the topic.

What is variation? It is the set of observable differences that exist between parents and offspring and among individuals of the same species.

Types of Variation: The study of the phenotype (physical appearance) differences in any large population shows that two forms of variations occur: morphological variation and physiological variation. These variations may be continuous or discontinuous.

Morphological Variation: This has to have to do with observable differences which occur in form and structure of an organism. It determines the physical appearance of an individual and helps to identify the individual. Examples of features that show morphological variation are sizes in terms of length. Weight and width. Colour of hair, eye, skin, shape of nose, nose, face, ears, fingers, mouth etc.

Continuous Variation: These are the types of variations found in features, they vary gradually from one extreme form to the other with several intermediates. Characteristics exhibiting continuous variation are produced by combined effect of many genes (polygene) and environmental factors. The frequency distribution for a characteristics exhibiting continuous fall in the middle of the range with approximately equal number showing the two extreme forms.

Finger Prints

Prints are a form of variation, which cannot be sorted into continuous, or discontinuous variations. They are impressions of the ridges on the ends of our fingers and thumbs. These ridges form patterns that can be sorted into various distinctive groups. However, everyone has a set of fingerprints that is uniquely theirs.

Discontinuous Variation

Features which show no intermediate form but exhibit a limited form of variation are said to show discontinuous variation. Type of variation shows a sharp difference or clear cut difference between the various forms of a given features. Characteristics which show discontinuous variation are usually controlled by one or two major genes which

may have two or more allelic forms and their phenotypic expression is relatively unaffected by environment.

Examples are: Blood group, sex, ability to roll tongue, hand clasping, and tasting phenylthiocarbamide.

PHASE 4: ELABORATION PHASE: The teacher further gives students another activity to buttress more understanding of concepts.

Activity 2: To observe fingerprints

Materials: Stamp pad with ink, Plain paper, Hand lens.

Procedure

1. Touch the stamp pad with your thumb; press your thumb on the plain paper.
2. Each member of the group should make his/her fingerprints.
3. Compare the different fingerprints one with another and also with the main group of fingerprints provided using a hand lens.

Question:

1. Do you all have the same fingerprints?

PHASE 5: EVALUATON: The teacher evaluates the lesson by asking students questions based on the topic learned:

(1) What is variation?
(2) What do you understand by morphological variation?
(3) Give 4 examples of morphological variations?
(4) Explain continuous and discontinuous variations.
(5) Under which of the main groups of fingerprints can you classify your fingerprints?

Lesson 2 - WEEK 2
Group - Experimental
Class Level - Pre-NCE
Subject - Biology
Course - Genetic
Topic: - PHYSIOLOGICAL VARIATION AND APPLICATION OF VARIATION
Duration - 2 hours
Instructional Materials - Chart, diagrams
Behavioural Objective: At the end of the lesson students should be able to:

(1) Explain physiological variation
(2) Give examples of physiological variation
(3) Explain the importance of physiological variation in the following:
  (a) Crime detection
  (b) Blood transfusion
  (c) Determination of paternity.

Materials: Students in the class, Chart showing antigen-antibody reaction between donor and recipient.

Previous Knowledge: Students have been taught what variation means and they have studied morphological variation.

Presentation: Presentation of lesson to the experimental group with 5E Model is as follows:

PHASE 1: ENGAGEMENT PHASE: The teacher starts the lesson by asking some questions:

(1) Name different behavioral patterns exhibited by students in your class.
(2) What is your blood group?
(3) Are there characters, which you inherited from your parents which are not visible except you perform some acts? Name two of them.
(4) Why is it important for you to know your blood group and your genotype?

PHASE 2: EXPLORATION PHASE: Here the teacher give student an activity to carried out on the topic.

Activity 1: Determination of blood group and Rhesus factor by agglutination materials required per student:
- sterile disposable bloodletting lancet
- a clean tile.
- a 70% alcohol bottle per table
- surgical cotton wool
- Blood grouping anti-a scrum, anti-b serum, and anti-D serum.

Procedure
1. Mark the tile provided with the marker as shown below.
2. Each student in the group should be given a number.
3. Write the number of each group member on the spaces under **name.**

NAME OF STUDENT-	ANTI-a	ANTI-b	ANTI-D	BLOOD GROUP
1				

4. Mark off 3 circular area each 1 cm in diameter in the spaces against your number.

5. Clean the tip of your thumb with cotton wool soaked in 70% alcohol. Allow to dry and jab once with a sterile lancet or pin.

6. Press the finger to facilitate obtaining some droplets of blood and let in 2 or 3 drops in each of the circular area under different anti sera.

7. Add 1 drop of Anti-a serum to the blood under anti-a, 1 drop of Anti-b to the blood under anti b. One drop of Anti-D to the blood under anti-D.

8. Stir the mixture in each circle with an injection needle and allow to settle.

9. Observe and determine your blood group and Rhesus factor by comparing it with the chart provided.

10. After determining your own blood group, record the blood group of your group members.

Chart 3: Determination of Blood Group and Rhesus Factor

Blood Group	Anti-a	Anti-b	Anti-D	Blood Group/ Rhesus factor
Group A	Clumping	No Clumping	Clumping No Clumping	A+ A-
Group B	No Clumping •'	Clumping	Clumping No Clumping	B+ B-
Group AB	Clumping	Clumping	Clumping No Clumping	AB+ AB-
Group O	No Clumping	No Clumping	Clumping No Clumping	O+ O-

Question

(1) Now that you know your blood group and Rhesus factor, of what advantage is it to you? Give your answer in just two sentences.

PHASE 3: EXPLANATION PHASE: The teacher explains some concepts about the topic.

Physiological Variation

Physiological variations are variations, which occur in the function and activities living organism or one of its parts. It is not as obvious as morphological variation, Becomes evident when the individual acts.

Examples of Physiological Variation are:

1. Behavioral patterns such as:
   - (i) Aggression (hostile, easily angered) or non-aggression (not hostile and not easily angered)
   - (ii) Excitable (easily stimulated to action) or calm (quiet)
   - (iii) Timid (easily frightened or afraid) or brave (able to face danger)
   - (iv) Caring (kind, shows concern) or non-caring (do not show concern).
   - (v) Intelligent (quickness in understanding) or stupid (unintelligent).

2. Blood Groups:

Humans can be placed in four distinct blood groups, which are A, B, AB, and O. These blood groups are placed in the various distinct groups according to the antigens and antibodies that are found in the blood. Antigens are found on the surface of red blood cells while antibodies are found in the plasma (liquid part of blood). One method that is commonly used for identifying and measuring antigens and antibodies is by agglutination. Agglutination or clumping (forms cluster) occurs when a specific antibody and its antigen are mixed. The procedure is applied in identification of human blood groups.

The knowledge of the blood group of an individual is very important in case an individual needs blood in an emergency or wishes to donate blood. Blood groups can be identified by mixing a drop of blood with serum containing cither Anti-b antibody and -b antibody. The Anti a- serum would cause blood containing red blood cells with antigen A to clump, while Anti-b serum would cause blood containing red blood cell with antigen B to clump. The clumping of red blood cells is called agglutination.

CHART 1: Showing Antigen and Antibodies in Different Blood Groups

BLOOD GROUP	ANTIGEN ON RED BLOOD CELL	ANTIBODY IN PLASMA
A	A	B
B	0	A
AB	AB	-
O	-	ANTI-a ANTI-b

CHART 2: Showing How Different Blood Groups Can Be Identified.

BLOOD GROUP	ANTf-a SERUM	ANTI-b SERUM
A	Clumping	no clumping
B	no clumping	Clumping
AB	Clumping	Clumping
O	no clumping	no clumping

CHART 3: Showing Antigen - Antibody Reactions between Donor and Recipient Blood

Antigen on Donors Red Blood Cells

RECIPIENT	A (GROUP A)	B(GROUP B)	AB(GROUP AB)	(GROUP 0
• Anti-b (Group A)	No clumping	Clumping	Clumping	No clumping
: Anti-a (Group B)	Clumping	No clumping	Clumping	No clumping
(Group AB)	No clumping	No clumping	No clumping	No clumping
Anti-a and Anti-b (Group 0)	Clumping	Clumping	Clumping	No clumping

From the Table it can be seen that

A can receive Blood from A and 0 and give to only A & AB
B can receive Blood from B and O and give to only B & AB
AB can receive from all groups and give to only AB
O can receive from only O and give to all other groups.

Rhesus factor:

It is an antigen found in the cell surface membrane of red blood cells. 85% of people possess the factor and are described as rhesus positive. Those who lack rhesus antigen are described as rhesus negative. Presence of rhesus antigen is genetically determined. If a rhesus negative person receives rhesus positive blood, agglutination occurs. The immune system of the rhesus negative person will produce anti-rhesus bodies that will react with the antigen of the donor causing agglutination.

Additionally, when rhesus negative mother is carrying a rhesus positive foetus, some foetal red blood cells will enter the maternal circulation especially during birth. Her body recognizes the foreign foetal (D) antigen, which causes her to produce anti-rhesus (anti-D) antibodies against them. This can cause massive destruction of the baby's red blood cells, which can result in the death of the baby or miscarriage.

How to identify the Rhesus Factors

Blood group (Rhesus system)	Anti-Rhesus serum
Rhesus positive (Rh+)	Clumping
Rhesus negative (Rh-)	No clumping

Applications of Variation:

Knowledge of variation has helped to solve many medical and criminal problems. Knowledge of variation has been used in the following ways such as crime detection, blood transfusion, detection of paternity and genetic counseling.

Crime Detection

Fingerprints are commonly used as an identification feature. It has been used by the police to detect criminals. This is because criminals usually leave their fingerprints at the scene of their crimes. The police collect these fingerprints and compare them with those of potential suspects and past criminals.

Blood Transfusion

During blood transfusion, blood from a healthy donor is fed into one of the veins in the body of the patient or recipient. The knowledge of an individual's blood group is very important here. For blood transfusion to be successful the blood*group of the donor must be compatible with that of the recipient. If the blood is not compatible the donor's red blood cell will clump in the recipient's blood vessels, causing serious harm to the recipient. For example group A blood which contains Antigen-A clumps in the presence of anti-a antibody. Blood with Antigen A must never be given to a patient with plasma containing antibody A. Usually, blood used in blood transfusion contains very little of the donors' plasma. It is the antigens on the red blood cell of the donor's blood that must be compatible with the antibodies in the recipient's plasma.

Detection of Paternity:

The knowledge of variation helps to determine the paternity of a child in dispute. Features showing discontinuous variations such as blood groups, ability to roll the tongue or to taste Phynelthiocarbamide (PTC) are used for this purpose. For example a group A or O man and a group A or O woman cannot produce a group AB child. Likewise a man and a woman who cannot roll their tongue usually cannot produce an offspring who can. Examination of the genotype (genetic make-up) of the child, the father and mother will help to resolve the dispute.

Genetic Counselling

This deals with giving, information and advice about the risk of genetic diseases and their outcomes. Doctors have an important role to play in alerting patients of possible risks before problems arise. For example, knowledge of Rhesus blood systems will also determine who can receive blood from whom and who can marry who.

If a Rhesus negative person receives Rhesus positive blood, agglutination occurs. The immune system of the Rhesus negative person will produce anti-Rhesus antibodies that will react with the antigen on the donor's red blood cells causing these cells to agglutinate.

It is also important for individuals to know their genotype so as to guide against the choice of life partner. For example it is not advisable for two individuals who are

carrier of sickle cell trait to marry because they have a high chance of having offspring who is/are suffering from sickle cell anemia.

Question

Of what importance is the knowledge of variation to you? Give your answer in only three sentences.

PHASE 4: ELABORATION PHASE:- The teacher further give students another activity to buttress more understanding of concepts.

Activity 2: Behavioural Pattern

Instruction*:* Look round the class and try to identify 2 students each with the following behavioural patterns. On a sheet of paper, write the names of students against their appropriate behavioural pattern.

Count the number of students for each behavioural pattern and write the number of students who possess each of the following behavioural patterns.

Behavioural Pattern	**Number of Students**
Aggressive	
Not aggressive	
Excitable	
Calm	
Timid	
Brave	
Caring	
Not caring	

Question:

(1) Can these behavioral patterns be noticed in a person who is sitting down quietly?

(2) How do you know a person has any of these traits?

(3) What type of variation is behavioral pattern is it morphological or physiological?

PHASE 5: EVALUATON: The teacher evaluates the lesson by asking students questions based on the topic learned:

(1) Explain what you understand by physiological variation

(2) Give 5 examples of physiological variation

(3) Explain the importance of physiological variation in:

(a) crime detection

(b) blood transfusion

(c) determination of paternity.

LESSON: **3**
Group - Experimental
Class Level - Pre-NCE
Subject - Biology
Course - Genetic
Topic: - Causes of variation
Duration - 2 hours

Previous knowledge: Students have learnt the meaning of variation and types of variation (inherited, acquired, continuous and discontinuous)

Instructional Materials: Cardboard sheets, makers.

Behavioural Objectives: By the end of the lesson, students should be able to: carry out activities on causes of variation, Identify and discuss the factors that cause variation, categorize the factors into genetic and environmental. explain how sexual reproduction causes variation. Explain how mutation causes variation. Explain how environment causes variation.

Presentation: Presentation of lesson to the experimental group with 5E Model is as follows:

PHASE 1: ENGAGEMENT PHASE: The teacher starts the lesson by asking some questions:

I: What did you think are the causes of variation?

II Categorize the factors that cause variation in to two.

PHASE 2: EXPLORATION PHASE: Here the teacher give student an activity to carried out on the topic.

Activity 1: Demonstration of effect of environment on phenotype

Materials: Tomatoes planted in humus soil (A), Tomatoes planted in sandy soil (B). The tomatoes seeds planted in both pots were very healthy and were planted the same day.

Instructions:

- Looking at the poned plants A and B, measure the diameter of the stem of each plant and record.
- Measure the length and the width of one leaf of each and record.
- Measure the height of both plants.

Record as follows:

Plant Part	**Plant A**	**Plant B**
Diameter of Stem		
Length of leaf		
Width of leaf		
Height of plant		

Question:

1. Explain what accounted for the differences noticed in the two plants.

PHASE 3: EXPLANATION PHASE: The teacher explains some concepts about the topic. Genetic causes of variation are: cell division, sexual reproduction and mutation.

(i) Sexual reproduction

The production of sperms and eggs by meiosis causes reshuffling of genes and chromosomes. The reshuffling causes change in the arrangements of genes and chromosomes which cause variation.

The union of sperm and egg (fertilization) brings about different arrangements of genes and chromosomes which causes variation in organisms.

(ii) Genes and chromosomes mutation.

Mutation is any heritable change in the structure of genes and chromosomes and they way they work. If the change affects only genes, it is referred to as genes mutation. If it affects chromosome, it is known as chromosomes mutation.

Mutation is caused by the following;

Cell division (meiosis)

Chemicals

Radiation

Variation that is caused by genetically factors like cell division, sexual reproduction and mutation is referred to as "hereditary variation". Such variations are passed from parents to children. In other words, they are inherited (e.g. sickle cell, blood group etc).

(iii) Environmental Factors

Genes and chromosomes determine the characteristics and behavior of an organism. The expression of the characteristics and behavior is controlled by the environment. If the environment is favorable for a given characteristics it will be expressed fully. If not, that characteristic will either completely not be expressed or partially expressed. Environment could also cause certain variations in an organism. Variations that are caused by the effect of environment are referred to as acquired or non-hereditary variations, such variations are not pass from parents to children, another words,' they are not inherited (e.g. skin bleaching, infant paralysis).

Influence of Environment:

The ultimate factor determining a phenotypic characteristic is the genotype (genetic make up). At the moment of fertilization the genotype of the organism is determined, but the subsequent degree of expression allowed to this genetic potential is influenced greatly by the action of environmental factors during development of the organism. For example Mendel's tall variety of garden pea normally attained a height of six feet. However, it would normally do so if provided with adequate light, water and soil conditions. A reduction in the supply of any of these factors would prevent the gene for height from exerting its full effect.

PHASE 4: ELABORATION PHASE: The teacher further gives students another activity to buttress more understanding of concepts.

Activity 2

Step I: (a) In your group, categorize the following into hereditary and non-hereditary (acquired) variation.

Sex:	(v) Skin colour
(ii) Race	(vi) Ability to swim
Muscularity	(vii) Polio disease
(iv) Hand writing	(viii) Sickle cell

In your group, classify the following into continuous and discontinuous variation

Sex	(v) blood group
Height	(vi) blood pressure
Weight	(vii) heart beat
Skin colour	(viii) ability to drive

Discuss and argue your reasons

Step II: It has been observed that most children these days grow taller than their parents. Do you think this is caused by genetically or environmental factor? Discuss and argue your reasons in your group.

PHASE 5: EVALUATON: The teacher evaluates the lesson by asking students questions based on the topic learned:

1. Identify and explain the genetic causes of variation.
2. Explain how sexual reproduction causes variation.

Lesson 4 - WEEK 4
Group - Experimental
Class Level - Pre-NCE
Subject - Biology
Course - Genetic
Topic: - Chromosome: the Basis of Heredity
Duration - 2 hours
Instructional Materials - Chart, diagrams
Behavioural Objective: - At the end of the lesson should be able to:

1. Explain terms such as a alleles, chromosomes, genotype, phenotype, haploid, diploid, recessive, dominant, homozygous and heterozygous.
2. Define heredity.
3. Give examples of characters, which can be transmitted, from parents to offspring.
4. Explain how characters are transmitted from parents to offspring.

Materials

Diagrams showing how characters are transmitted.

Previous Knowledge: The students already have the knowledge of meiosis and mitosis which is needed in genetics.

PHASE 1: ENGAGEMENT PHASE: The teacher starts the lesson by asking some questions

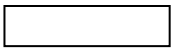
Look at the family picture provided and answer the following questions in your sheet.

1. Are these similarities between children and parent?
2. Are there differences between children and parent?
3. Do all the children alike?
4. What do you think is responsible for the similarities and differences between parents and offspring?
5. What do you understand by the term genetics?
6. What do you understand by heredity?
7. When you hear that two organisms are crossed, what does that mean?
8. What is the difference between diploid and a haploid cell?
9. What are genes and chromosomes?
10. What does homologous chromosome mean?

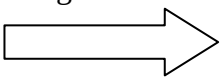
PHASE 2: **EXPLORATION PHASE:** Here the teacher give student an activity to carried out on the topic.

Activity 1: to determine what genes and chromosomes are:

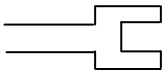
The following are structures representing the nitrogenous bases



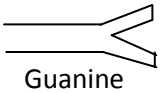
Thymine



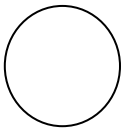
Cytosine



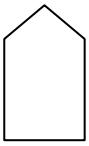
Adenine



Guanine

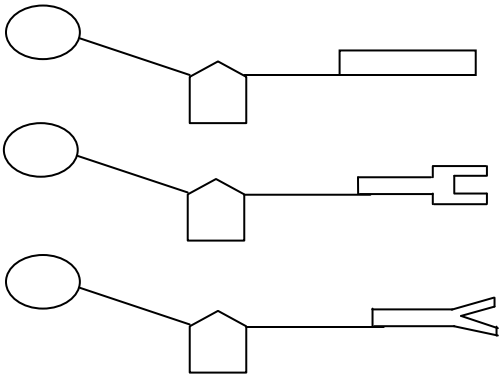


Phosphate molecule



Deoxyribose sugar

The following is a strand or chain of DNA Molecule.
Make a complementary one



Using the piece of paper provided, draw two strands of DNA.

Questions

1. What have you formed?
2. Name the component of each of DNA molecule.
3. Why is it very easy for two strands to break up?
4. Why is the ability of the DNA to replicate important?
5. According to what you have read about genes and chromosomes, use the biro provided and the double helix structure that you formed to show the relationship between genes and chromosomes.

PHASE 3: EXPLANATION PHASE: The teacher explains some concepts about the topic.

What is heredity?

It is the transmission of inherited characters from parents to offspring through genes. Heredity is responsible for the similarities and differences between parents/offspring. The similarities are due to the genes an organism/offspring inherits from the parents, while the differences are due to a new combination of genes during meiosis.

What are Genes?

Genes are the basic units of heredity. A gene is a segment of deoxyribonucleic acid (DNA) molecule that usually codes for the synthesis of a polypeptide chain, which eventually determine the nature of an inherited character (traits or observable features). They are discrete (separate) unit of inheritance, which determine hereditary characteristics. They are found on chromosomes in the nuclei of all cells. All the information for the inheritable characteristics of an individual is contained in the genes. When a cell divides, the genes duplicate themselves so that each daughter cell has an identical set of genes as the original parent cell. Genes are passed on from parents to offspring in the gametes (eggs in females, sperm in males) of the parents.

Structure of DNA Molecule

The DNA molecule consists of two strands of nucleotide curved spirally or twisted into each other form a double helix structure. Each nucleotide is made up of a phosphate group altering with sugar molecule which in this case a pentose sugar is called adenine guanine and thymine.

The nitrogenous base from one chain or strand links up with a compatible base of the opposite chain. Adenine with thymine, guanine with cytosine. These bases are held together by hydrogen bond which is very weak and can easily break readily, causing a DNA to separate into half strands. Free nucleotides present in the nuclei material then arrange themselves along each half strand. Hydrogen bond forms between the complementary bases resulting in two identical DNA strands. This process requires enzymes and energy.

DNA molecules (gene) are capable of replicating itself or making exact copies of itself. The ability to replicate itself makes it important in the transmission of hereditary materials from parents of offspring.

What are Chromosomes?

They are the dark strained structures which are seen in the nucleus of a cell. Just before cell division chromosomes appear as thin threads. Each chromosome is seen to be made up of two threads called chromatids joined at a point called centromere. Chromosomes are made of protein and form the frame work on which genes or DNA double helixes are wound round.

Transmitted Characters

These are characters that can be transmitted from parents to offspring. Characters which are not controlled by genes, cannot be transmitted from parents of offspring. Examples of inherited characters include the following: height, colour, shape of nose, mouth, length and shape of fingers, eye colour, blood group, behavioral pattern etc.

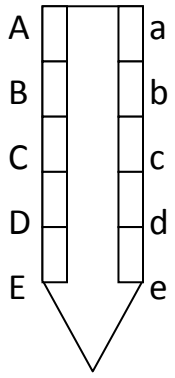
Example of characters which are not controlled by genes are ability to play football, basket ball, do high jump, boxing, wrestling are all acquired through training. Also becoming dark coloured as a result of exposure to sun light or have patched skin as a

result of disease are all acquired characteristics and cannot be inherited or transmitted from generation to generation.

How Characters are Transmitted

A diploid organism has two sets of chromosomes, which are said to be homologous (have the same length or size, have the same shape). Such chromosomes have two copies of each gene with copies occupying identical locations or loci in each homologous pair. Homologous chromosomes are derived from each parent of the organism. They are identical, containing the same type of genes located at the same point. Each paired genes control the same way or in contrasting form. Diploid organisms produce gametes by meiosis in their reproductive organs. A male and a female individual form the parent (P) generation they produce gametes in form of sperms and eggs respectively which are both haploid having half the number of chromosomes as the parents cells. The sexual union or mating of the male and female organism is termed a cross (X). During sexual reproduction the gametes of male and that of a female individual fuse to form a zygote. Each zygote is diploid as it gets one set of chromosomes and one copy of each gene from parents gamete of each parent. Characters that are determined by genes are transmitted from parents to offspring through gametes. A gene for a particular character may have alternative forms which express the character in different ways. Each alternative form of gene is known as an allele. For example, a pair of genes controlling the height of pea plant expresses the character in two contrasting ways-tall or dwarf. Such a pair of genes is known as allelic pair or just "alleles". Most characters have more than one form of expression. Alleles arise as a result of mutation (sudden change in the chemical structure of a gene). During sexual reproduction, parents pass on thousands of genes that determine various characters of an offspring.

Fig 1: A Pair of Homologous Chromosomes.
Homologous chromosomes showing the position allelic pairs.



Alleles

Activity 2: To show homologous

Materials

- Beads (white, pink, blue and green)
- Thread (2 pieces, 2 inches long)

Method

(1) Cut equal pieces of thread about 2 inches long.
(2) Arrange the heads given above in the order of the colours specified.
(3) Repeat the arrangement as in 2 above for the other thread.
(4) Make sure that the same colour of beads occupy the same position on two thread,
(5) Place the two threads (with beads arranged on them) side by side with beads of the same colour at the same loci/position.

Questions:

1. The set up produced in 5 above represent what type of chromosome?
2. Give reasons for your answer.
3. Make a drawing of the set up in your answer sheet and label your drawing.

Sex Determination in Man

The factor that distinguish a boy from a girl or a man from a woman can be traced lo the difference in just one pair of chromosomes found in the nucleus of every human cell. The human species has 23 pairs of chromosome of each pair (homologous pair) are equal in size and have (he same shape for 22 of the pairs.

The chromosomes of the 23" pair are equal in size and shape in a woman but are different in a man. The 23" pair of chromosomes are referred to as the sex chromosomes. In a woman/girl where the two sex chromosomes are the same, they arc both called X-Chromosome. In a man/boy, one of the chromosomes is an X-Chromosome pairs while the other is called a Y-Chromosome. The Y-Chromosome is smaller and shorter than the X-Chromosome. Females are therefore regarded as XX individuals, while males are regarded as XY individuals.

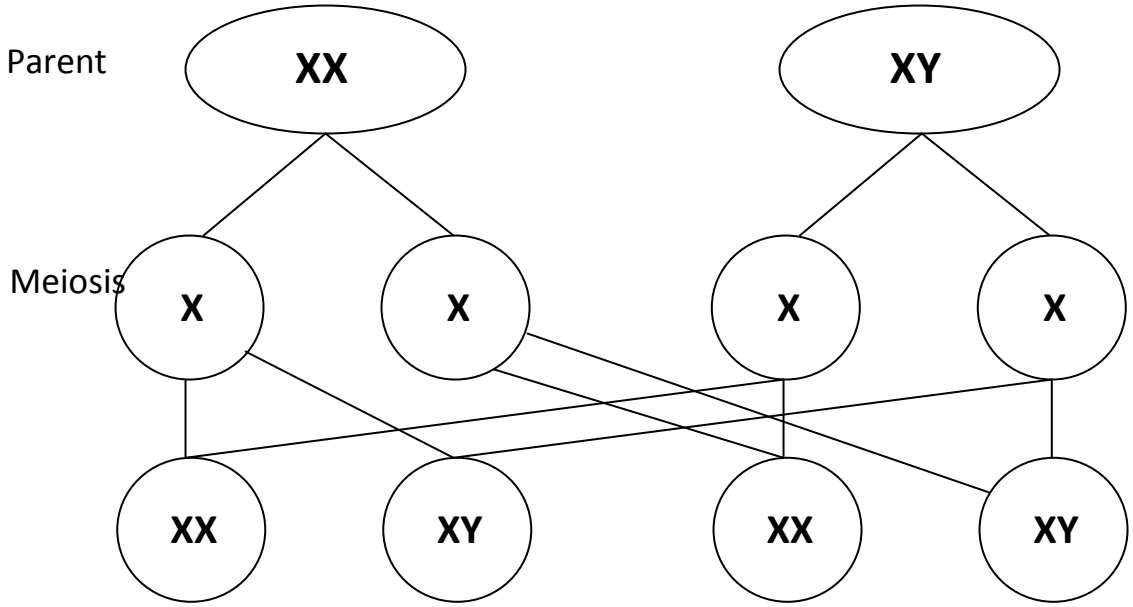
What happens during gamete formation?

During formation of gametes or reproductive cells, just as every other chromosome pairs (homologous chromosomes) separate into individual reproductive cells, the sex chromosomes also separate into individual reproductive cells. In the ease of females every reproductive cell or egg carries an X-Chromosome. In the case of the male reproductive cells or sperm, half carry's an X-Chromosome and half carry's a Y-Chromosome.

Fertilization

When a female and a male mate or cross, if an egg with X chromosome is fertilized by a X-carrying sperm, the resulting offspring will be female carrying XX Chromosomes. If however, an egg is fertilized by a sperm carrying a Y-Chromosome, the resulting offspring is a male. Each fertilization or conception is a matter of chance, the sex of the child cannot be determined before fertilization or conception naturally. Theoretically the chances of having a girl or a boy is equal at each conception, since the male who determines the sex of a child produces the X-Chromosome and the Y-Chromosome bearing sperms in equal numbers. Thus, the chance of having a girl boy is equal at each conception.

Fig. 2: Showing Sex Determination



PHASE 4: ELABORATION PHASE: The teacher further gives students another activity to buttress more understanding of concepts.

Activity 3: To demonstrate sex determination

Materials

- Markers (1 red, 1 blue)
- Cardboard paper
- Biro

Instruction

Look at figure 2 above and using two markers given to you produce diagrammatic representation of how sex is determined.

Note: That you are using the coloured markers to represent the chromosomes of the parents, the gametes and the offspring.

Questions

(1) The first two individuals you started with represents the _____ and the _____

(2) Are they diploid or haploid?

(3) Give reasons for which over answer you have given for 2.

(4) What process brought about the production of the two gametes you have under each of the initial two individuals?

(5) How many chromosomes does each gamete have?

(6) From your cross, how many of the offspring are boy and how many are girls?

PHASE 5: EVALUATON: The teacher evaluates the lesson by asking students questions based on the topic learned:

Go back to the question at the beginning of this lesson and answer the questions again. If there are areas of discrepancies, identify them. Discuss with the teacher and go through such area again in your instructional package to help resolve the differences.
Should the mother be driven out of the house for having only female children?

1. Explain and support your answer using genetic cross diagram.
2. What is heredity?
3. Give examples of characters that can be transmitted from parents to offspring.
4. (4)Explain how characters are transmitted from parents to offspring.

Lesson 5	-	WEEK 5
Group	-	Experimental
Class Level	-	Pre-NCE
Subject	-	Biology
Course	-	Genetic
Topic:	-	Transmission and Expression of characteristics in Organisms(monohybrid inheritance)
Duration	-	2 hours
Instructional Materials	-	Chart, diagrams

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

(1) Explain the following terms – pure breed, hybrid, homozygous, heterozygous, phenotype and genotype.
(2) Describe Mendel's experiment.
(3) State Mendel's laws of inheritance.

Materials – Diagrams showing how characters are transmitted.

Previous knowledge:

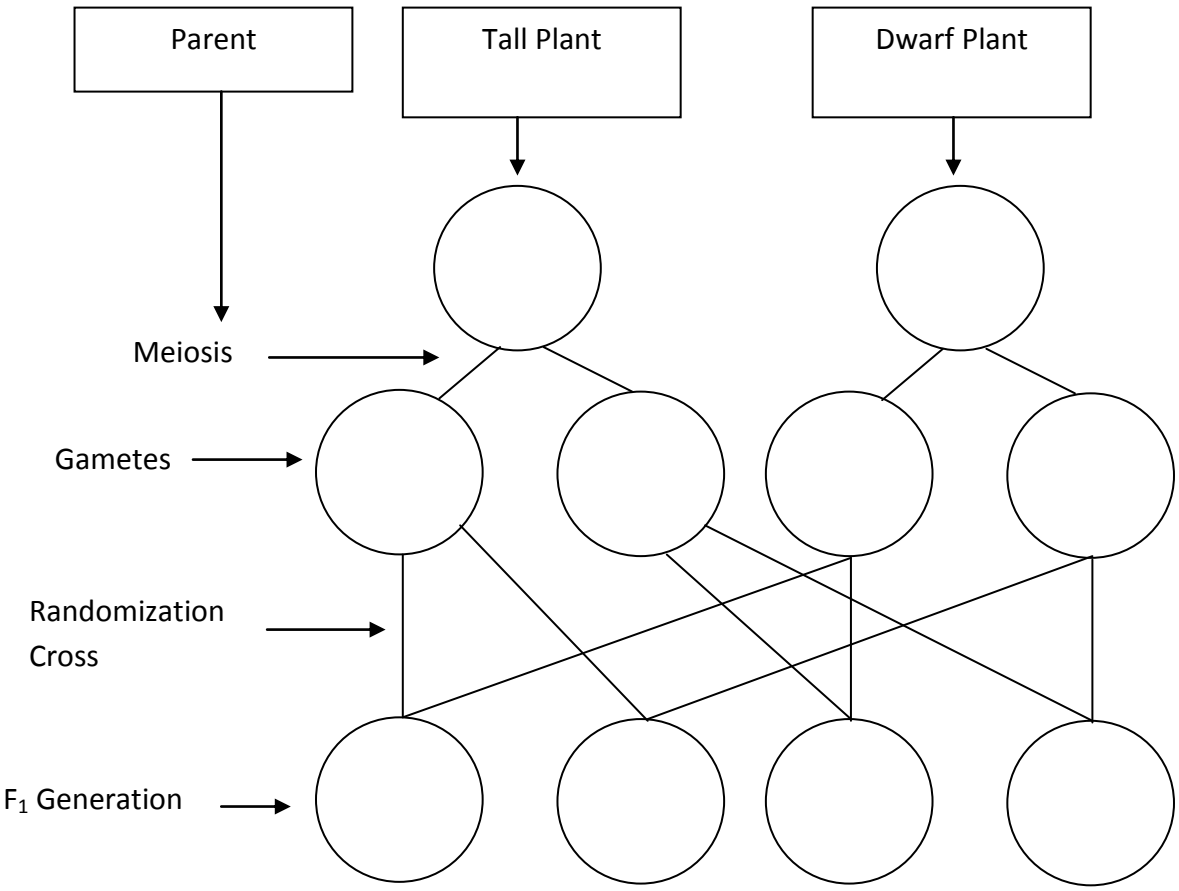
Students already have the knowledge of how characters are transmitted from parents to offspring.

PHASE 1: ENGAGEMENT PHASE: The teacher starts the lesson by asking some questions

1. How are characters transmitted from parent to offspring?
2. What is the difference between homozygous and heterozygote?
3. What is the difference between genotype and phenotype?
4. If to light-skimmed parents give birth to dark skinned baby can you explain what probably must have happened?
5. Explain what dominant and recessive mean in genetic.
6. What does pure bred mean?

PHASE 2 : EXPLORATION PHASE: Here the teacher give student an activity to carried out on the topic.

Activity 1: To Demonstrate Monohybrid Inheritance:
Materials: Red and NIK- marker, plain paper.
Problem: at tall homozygous plant (TT) is crossed with a dwarf homozygous plant (tt). What will be the genotype of the F1 generation? Note that the gene for tallness is dominant over the dwarf gene.



Question

1. What is the phenotype of each offspring of the F1generation?
2. Give the genotype of the F1 plant?
3. Is there a **dwarf offspring among** the F1plants? Give reason for your answer.

PHASE 3: EXPLANATION PHASE: The teacher explains some concepts about the topic.

Mendel's Work in Genetics

Gregor Mendel born in Moravia in 1822, joined the Augustinian Monastery at Brunn in Austria in 1843. He went to the University of Vienna where he spent two years studying natural History and Mathematics before returning in the monastery in 1853. His choice of subject had a significant influence on his subsequent work on inheritance in pea

plants. While he was in Vienna he became interested in the Process of hybridization in plants (crossing plants with contrasting characteristics). This formed the basis of Mendel's scientific investigations in inheritance, which he began in summer 1956. Mendel's success was due in part, to his careful choice of experimental organism, the garden pea, Pisum sativum. He chose to use the garden pen because it bad a number of advantages over other species, which are:

1. Several varieties are available with distinct characteristics.
2. They were easy to cultivate.
3. The reproductive structure', were completely enclosed by the petals. This allowed for only self-pollination. This led to the varieties producing the same characteristics generation after generation.
4. Artificial cross-breeding between varieties was possible and resulting hybrid were completely fertile.

Mendel's Experiment:

Mendel first established true breeding (Possession of homozygote genotype) stocks of peas for a given expression of a trait. He did this by allowing the plants to self-pollinate for several generations. He then crossed true bleeding sets of plants showing the alternate forms of a trail. For example, he crossed a pure stock of plant showing green pod colour with that showing yellow pod colour. He was able to do this by removing immature anther from the flower of a plant with green pod; he pollinated this flower by dusting its stigma with pollen from the mature anther of a flower from a plant with yellow pods. He covered the pollinated flower with a paper bag to prevent pollen from other sources falling on its stigma. He also reversed the process by doing a reciprocal crossing.

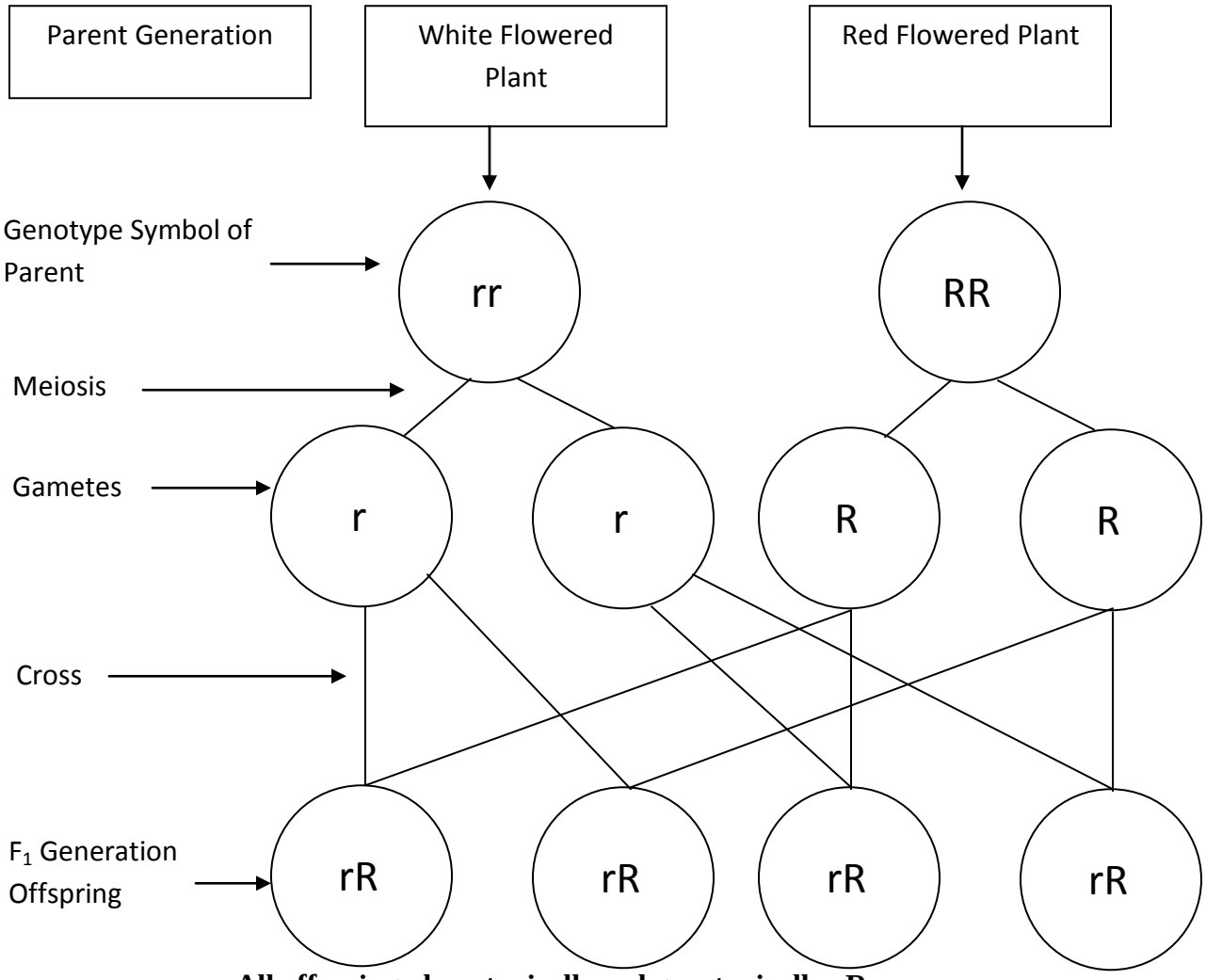
Finally, he allowed the hybrid offspring (F_1) to self-pollinate to produce offspring (F2) generation, lie counted the number of the offspring of each type in the F, and F_2 generations. The F, plants all produced yellow pods. The F_2 generation produced both yellow and green pod plants in the ratio 3: 1.

Single - Factor Inheritance or Monohybrid Cross

If a pure stock of white flowered pea plant represented by genotype(rr) is crossed with pure stock of red flowered(RR) one, this is called monohybrid cross since only the alleles of one specific character (flower colour) are involved. The offspring of this cross are all red flowered pea plant. All the plants produced in the F, generation ore all red flowered colour. Red colour is said to be dominant. While colour which does not show up in F_1 generation is said to be recessive form of the character.

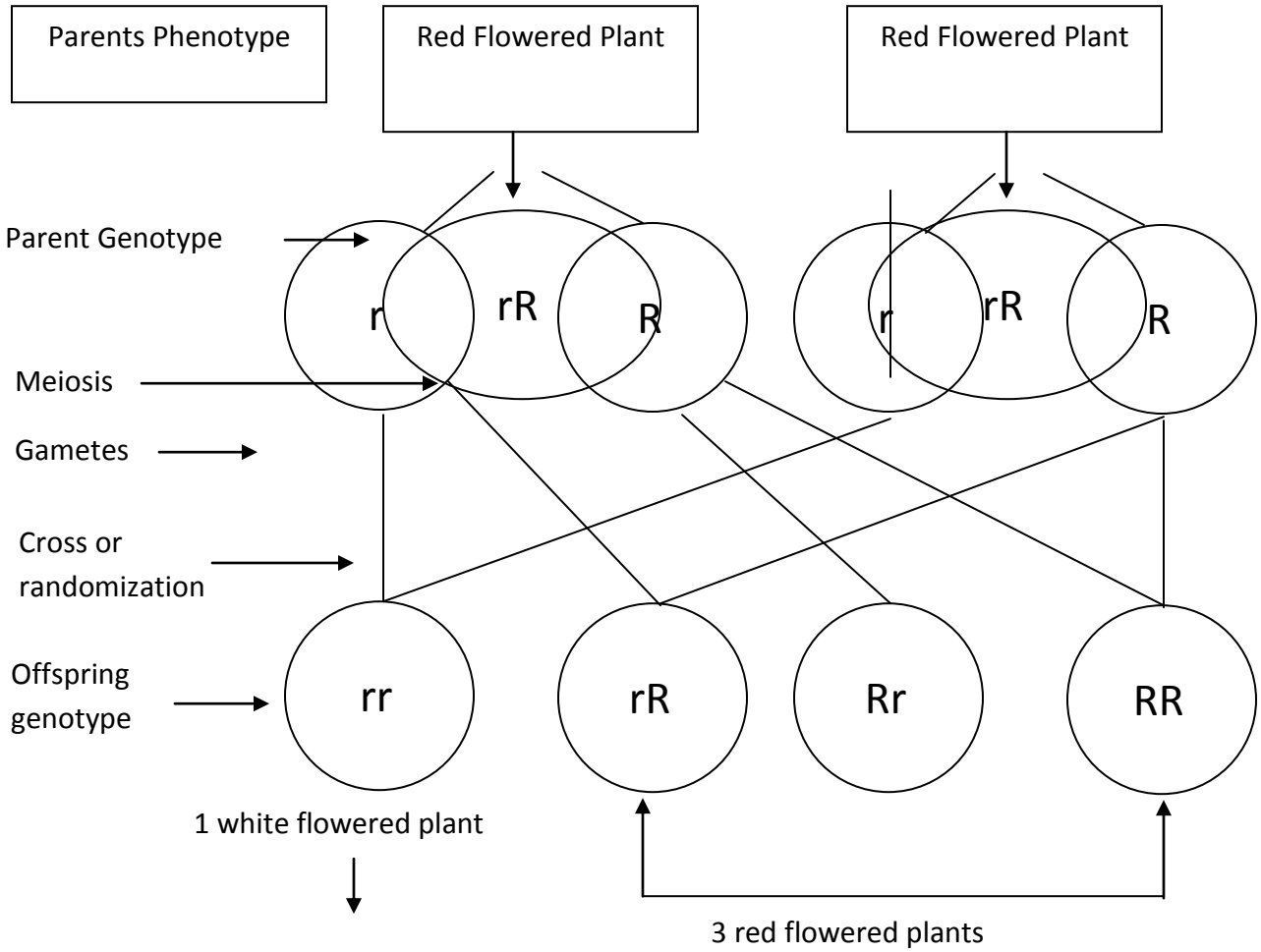
There are two type of red flowered plants. One with identical alleles (genes) referred lo as homozygous and one with two alleles (genes), which arc different and referred to as heterozygous. The homozygous and heterozygous form arc said to have the same phenotype (visible red appearance) but different genotype (genetic make up) Heterozygous organisms are said to be hybrid organism. This can be illustrated through the Cross below:

Fig. 3: Showing Single Factor Inheritance or Monohybrid



All offspring phenotypically red genotypically rR

If for example two individuals of F1 having eR genotype and are phenotypically red are crossed



The resulting offspring from the cross of 2 phenotypically red flowered parent heterozygous plants produced 3 red flowered plants and one white flowered plant.

Question

If what happened in the case of these red flowered parent plants had happened in a family having mother and father light coloured and producing all light coloured children except one, can ii lie said that the dark coloured child docs not belong to that family? Explain your answer.

PHASE 4: ELABORATION PHASE: The teacher further gives students another activity to buttress more understanding of concepts.

Activity 2a: To Demonstrate Mendel's Monohybrid Inheritance

In your answer shed, using the experimental procedure described **above** in the investigation of the inheritance of a single pair of contrasting characteristics which is an example of monohybrid cross, draw a genetic cross between a green pod plant and a yellow pod plant from parent to F2-generation. Note that the yellow colour is dominant while the green colour is recessive. By convention, (capital form) is used as the symbol for the gene (the dominant allele) while the lower case represents the **recessive allele.** In xYiis case, since yellow colour is dominant the gene for yellow **colour** should be represented by capital (Y) and the recessive form represented by the lower case (y).

Mendel's Laws:

From the result of his experiments Mendel came to certain conclusions, which are referred, to as the principles of Mendelian inheritance in Mendel's Laws of Inheritance.

Law of Segregation:

States that characteristics of an organism are determine by the internal factors which occur in pair. Only one of a pair of such factors can be represented in a single gamete.

Activity 2b: To Demonstrate Law of Segregation

Materials: **8** beads (4 red. 4 white)

Instruction:

Using the beads red representing the male and white representing the female arrange the beads to show the genotype of the parents and the gamete produce by each,

Question

1. How many beads represent the genotype of each parent?
2. How many beads represent the genotype of the gamete produced by each parent?
3. In your own words state the law of segregation.

PHASE 5: EVALUATON: The teacher evaluates the lesson by asking students questions based on the topic learned:

Describe the structures of a gene and a chromosome

Lesson 6	-	Week 6
Group	-	Experimental
Class Level	-	Pre-NCE
Subject	-	Biology
Course	-	Genetic
Topic:		Mendel's Dihybrid inheritance
Duration:		2hours
PREVIOUS KNOWLEDGE:		Students have learnt Mendel's monohybrid inheritance.

INSTRUCTIONAL MATERIALS: Cardboard sheets, markers, photocopies of dihybrid inheritance.

BEHAVIOURAL OBJECTIVES: By the end of the lesson, students should be able to:

1. Carryout activities on Mendel's dihybrid inheritance.
2. State and explain Mendel's second law of inheritance.

PHASE 1: ENGAGEMENT PHASE: The teacher starts the lesson by asking some questions. Study and discuss the following:

- Mendel studied the inheritance of two pairs of inheritance (tall and coloured, dwarf and white) in plants.
- He cross fertilized a tall and coloured (TTCC) plant with dwarf white (ttcc) plant.
- The seeds resulting from the cross were collected and sown. All the seeds gave rise to tall and coloured plants, no dwarf and white plants.
- Two of the tall and coloured plants were self-fertilized.
- The resulting seeds from the self fertilization were sown.
- The sown seeds gave rise to four different kinds of plants: (1). Tall with coloured flowers (ii). Tall with white flowers (iii). Short with coloured flowers (iv) short with white flower in ratio of 9:3:3:1.

Answer and explain the following:

- Why it is that all the seeds resulting from the cross when sown gave rise to all tall and coloured plants?
- When the resulting seeds from self fertilization of two tall and coloured plants were sown they gave rise to four different plants. Explain this result.
- What will be the genotype of (i) the tall and coloured plant? (ii). Short and white plant? {iii) Short and coloured (iv) Tall and white?.

PHASE 2: EXPLORATION PHASE: Here the teacher give student an activity to carried out on the topic.

- Each individual of the groups is asked to represent Mendel's dihybrid inheritance diagrammatically and by punnette square. They should compare their individual diagrams and punnette squares and come - up with group agreed diagram and punnette square.
- Each group is asked to study the photocopy Fl and F2 on Mendel's, dihybrid inheritance and to compare it with their groups diagram and punnette square.

- Each group is asked to explain the assortment and the transmission of pairs of *1* genes from parent to offspring as seen from Mendel's dihybrid inheritance, photocopy I. Fl and F2.

PHASE 3: EXPLANATION PHASE: The teacher explains some concepts about the topic.

Being pure breeding, Mendel's dihybrid inheritance of a cross between tall and coloured plant with short and white plant, their genotype will therefore be TTCC for tall and coloured plant, ttcc for short and white plant.

The Fl generation were all tall and coloured because the tall and colour characteristics are dominant. The short and white characters did not appear in the Fl generation because they are recessive.

From the activities conducted on dihybrid inheritance, it could be seen that pairs of genes assort themselves freely and are transmitted independently from parents to offspring. This led to the development of Mendel's second law of inheritance. From the observations of F2 plants, Mendel's arrived at his second law of heredity on the principle of independent assortment.

The law state that "genes on different chromosomes assort independently of each other during gamate (egg and sperm) formation.

Each group is asked to study the photocopy (G) on the assortment of genes in meiosis and compare it with the explanations of Mendel's second law of heredity.

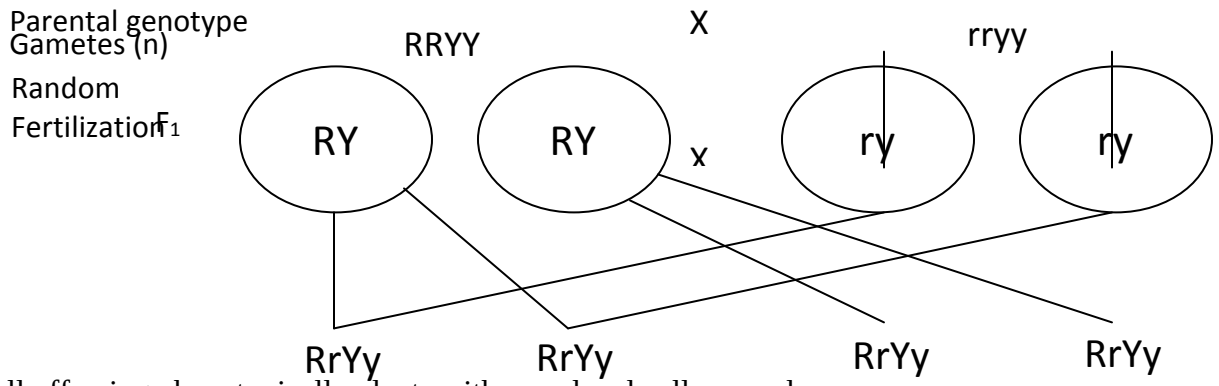
Dihybrid Inheritance

Mendel went further to study the inheritance of two pair- of contrasting characteristics. Such as seed coat and seed colour. He crossed pure breeding homozygous plants having round and yellow peas RRYy: with pure-breeding plants having wrinkled and green peas. The F1generation seeds were round and yellow. Mendel knew that round and yellow characteristics were dominant. He crossed the F1 generation and got the following characteristics for the F2 generation

1. Round and yellow
2. Wrinkled and yellow
3. Round and green
4. Wrinkled and green

The proportion of each phenotype approximated to a ratio of 9: 3: 3: I. This is known as the dihybrid ratio.

Round and Yellow Seeds Plants Wrinkled and Green Seeds Plants



All offspring phenotypically plants with round and yellow seed

Round and Yellow Seeds Plant **Wrinkle and Green Seeds Plant**

Parental Genotype (2n) RrYy X RrYy

Gametes (n) Ry Ry rY ry RY Ry rY ry

Randomization

	RY	**Ry**	**rY**	**Rr**
RY	RRYY	RRYy	RrYY	ReYy
RyrrYy	RrYY	RRyy	RryY	Rryy
Ry	rRYY	RRYy	rrYY	rrYy
Ry	rRyY	RRyy	rryY	Rryy
	9	3	3	1
	Round And Yellow	Round And Green	Wrinkled And Yellow	Wrinkled And Green

This led to the law of independent Assortment

Law of Independent Assortment:

It states that one of a pair of character may combine with either one another pair.

PHASE 4: ELABORATION PHASE: The teacher further gives students another activity to buttress more understanding of concepts.

Activity 2a

If a pure strain of mice with brown-coloured fur (BB) are allowed to breed with a pure strain with grey-coloured fur (bb). If the F1 mice are allowed to interbreed they **produce** an F2 generation with fur colour in the proportion of three brown-coloured to one grey.

a) Explain this result.
b) What would be the result of mating a brown coloured heterozygote from the F1 generation with the original grey-coloured parent?

Activity 2b: To demonstrate the Law of Independent Assortment

A short black-haired guinea pig (SSBB) was crossed with a long-white-haired **guinea** pig (ssbb). Using your knowledge of independent assortment, write the possible **genotypes** for the gametes that can be produced by the two parents in both the K, and F_2 generations.

Question

State this law in your own words.

Activity 2c: A haemophilia and sickle cell man (hhss) marries a normal non haemophilian and sickle cell woman (HHAA). What is?

(i) The genotype of the man and the woman?
(ii) If they give birth to children how many will be haemophilia? .How many will be sicklers? How many will be normal?

If two of their children are to be married, how many of their grand children:

(i) Will be both haemorphilia and sicklers?
(ii) Will be sicklers only?
(iii) Will be haemophilia only?
(iv) Will be normal?

Work out the dihybrid inheritance of a haemophilia and sickle cell man who marries a normal woman diagrammatically and by punnette square.

PHASE 5: EVALUATION: State and explain Mendel's second law of inheritance.

APPENDIX 6

LESSON PLAN FOR CONTROL GROUP EXPOSED TO LECTURE METHOD

Traditional Instructional Method

Lesson 1 - WEEK 1
Group - Control
Class Level - Pre-NCE
Subject - Biology
Course - Genetic
Topic: - Morphological Variation in Physical Appearance of Individuals:
Duration - 2 hours
Instructional Materials - Chart, diagrams

Behavioural objectives: At the end of the lesson students should be able to:

(1) explain what variation is
(2) explain what morphological variation means
(3) gives examples of morphological variation.
(4) explain what continuous and discontinuous variations mean
(5) plot graphs of frequency distribution of height and weight.
(6) Make fingerprints and classify them into the major types.
(7) explain the influence of environment on genetics.

Materials: Tape rule, paper, students in the class, diagram showing major types of fingerprints and scale.

Previous Knowledge: Students are familiar with variation in the physical appearances within families and between individuals.

Presentation of Lesson:

Step 1. The teacher introduces the lesson by asking subjects to classify the students in their class into various groups using different criteria.
Step 2. The teacher explains what variation means.
Step 3. The teacher gives the types of variation.
Step 4. The teacher gives examples of the different types of morphological variation.
Step 5. The teacher explains how a frequency graph can be plotted.
Step 6. The teacher describes the major types of fingerprints.
Step 7. The teacher leads the subjects to observe their own fingerprints.

Evaluation of Lesson

1. what is variation?
2. What do you understand by morphological variation?
3. Give 4 examples of morphological variations?
4. Explain continuous and discontinuous variations.
5. Under which of the main groups of fingerprints can you classify your fingerprints?

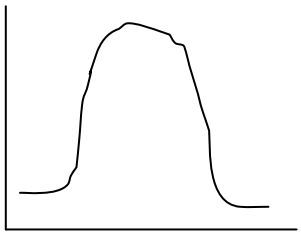
Assignment: Using the data obtained from the measurement of length and weigh, plot a graph of frequency distribution.

Blackboard Summary:

This section incorporates the main points, which emerged from the lesson.

- Variation is the observable differences that exist between parents and offspring and among individuals of the same species.
- Morphological variation has to do with differences, which occur in the form and structure of an organism.
- Examples of morphological variations are size, skin colour, height, fingerprints, ear lobes, and fur colour in animals, weight.
- Continuous variation: These are the types of variations found in features, which vary gradually from one extreme to the other e.g. length, weight size. They are controlled by many genes.
- Discontinuous variation: These are features which show no intermediate, forms e.g. ear lobes, tongue rolling, blood group, sex, hand clasping. They are controlled by two or more allelic forms of genes.

Frequency distribution curve: f



Characteristics in cm.

Fingerprints: These are impressions of the ridges on the end of the fingers and thumbs. These ridges form patterns that can be sorted out into several distinctive groups. Every individual has a set of prints that is unique to him/her and this can be used to differentiate one individual from another. The main groups are: arches, loop, whorl and double whorl or compound.

The ultimate factor determining a phenotypic characteristic is the genotype. At conception the genotype of an organism is determined but the degree of expression of the genetic potential is influenced greatly by environmental factors, such as food, weather, disease, application of chemicals

Lesson 2 - WEEK 2
Group - Control
Class Level - Pre-NCE
Subject - Biology
Course - Genetic
Topic: - PHYSIOLOGICAL VARIATION AND APPLICATION OF VARIATION
Duration - 2 hours
Instructional Materials - Chart, diagrams

Behavioural Objective: At the end of the lesson students should be able to:

(4) Explain physiological variation
(5) Give examples of physiological variation
(6) Explain the importance of physiological variation in the following:
  (d) Crime detection
  (e) Blood transfusion
  (f) Determination of paternity.

Materials: Students in the class
Chart showing antigen-antibody reaction
Between donor and recipient.

Previous Knowledge:

Students have been taught what variation means and they have studied morphological variation.

Presentation:

Step 1: The teacher reviews the previews lesson by asking question based on the previous lesson e.g. give examples of morphological variation, distinguish between continuous and discontinuous variation.
Step 2: The teacher explains physiological variation.
Step 3: The teacher gives examples of physiological variation by making the student to act.
Step 4: Teacher tests the blood and rhesus factors of few students through demonstration.
Step 5: Teacher explains the importance of physiological variation in the following:
  (i) determination of paternity
  (ii) crime detection
  (iii) blood transfusion

Evaluation:

(1) Explain what you understand by physiological variation
(2) Give 5 examples of physiological variation
(3) Explain the importance of physiological variation in:
a. crime detection
b. blood transfusion
c. determination of paternity.

Assignment:

Look around the class and identify other physiology variations, which we have not studied and write them down.

Summary:

The paragraphs below give the highlight of the lesson:

- physiological variation are variations, which occur in the function and activities of a living organism or one of its parts.
- They are not externally manifested as morphological variation but become evidence when the individual acts.

Examples of physiological variations include the following:

Behaviour patterns such as:

(a)	Aggressive	-	hostile, easily provoked (or)
	non-aggressive	-	not hostile, not easily provoke
(b)	Excitable	-	stimulated to action (or)
	calm	-	quiet
(c)	timid	-	easily frightened
	brave	-	able to face danger
(d)	Caring	-	kind, concerned (or)
	Uncaring	-	not kind
(e)	Intelligent	-	quickness in understanding (or)
	Stupid	-	unintelligent

Other examples are tongue rolling, tasting phenylthiocarbamide, blood groups and rhesus factor.

Applications of Variation:

Knowledge of variation has helped to solve many medical and criminal problems. The knowledge of variation has been used in the following ways:

1. **Crime detection:** Fingerprints are commonly used as an identification feature. It has been used by police to detect criminals. This is because criminals usually leave their fingerprints at the scene of the crimes.
2. **Blood transfusion:** During blood transfusion, blood from a healthy donor is fed into one of the veins in the body of the patient or recipient. The knowledge of an individual's blood group is very important. For blood transition to be successful, the blood group of the donor must be compatible with that of he recipient. If the blood is not compatible, the donor's red cell will clump in the recipient's blood vessel, causing serious harm to the recipient.
3. If a Rhesus negative person receives Rhesus positive blood, agglutination occurs. The immune system of the Rhesus negative person will produce anti-Rhesus antibodies that will react with the antigen on the donor's red blood cells causing these cells to agglutinate.
4. Draw the chart showing antigen-antibody reaction between donor and recipient.

Detection of Paternity

The knowledge of variation helps to determine the paternity of a child in dispute. Features showing discontinues variation such as blood group, eye colour, ability to roll tongue, to taste PTC are used for this purpose. The genotype of the child and that of the father and mother can also be compared in order to detect the paternity of a child in dispute.

Genetic Counselling

This deals with giving information and advice about the risk of genetic diseases and their outcomes. Examples of genetic diseases are sickle cell anemia, Down ’s syndrome, hemophilia. Doctors also have an important role to play in alerting patients to possible risks before the problem arises. For example knowledge in Rhesus blood system will also determine who can receive blood from whom and who can marry whom.

Lesson 3 - WEEK 3
Group - Control
Class Level - Pre-NCE
Subject - Biology
Course - Genetic
Subject: Biology
Topic: - Causes of variation

INSTRUCTIONAL MATERIALS: Board Chalk, duster, Teacher, students.

BEHAVIOURAL OBJECTIVES: By the end of the lesson, students should be able to:

1. List and explain the factors that causes variation
2. Define mutation
3. List the factors that causes mutation
4. Give examples of hereditary and acquired variation.

PRESENTATION

Step 1: The teacher explains the factors that cause variation as follows:

factors that cause variation in organism population are

(i) Sexual reproduction

The production of sperms and eggs by meiosis causes reshuffling of genes and chromosomes which cause changes in the structure of genes and chromosomes, this brings about variations.

The union of sperm and egg (fertilization) causes different combinations of genes and chromosomes which causes variation.

(ii) Genes and chromosomes mutation

Mutation is any heritable change in the structure of genes and chromosomes and they way they work.

It is caused by:

- Cell division (Meiosis)
- Chemicals
- Radiation

Variation, that is caused by genetic factors like cell division sexual, reproduction and mutation is referred to as "hereditary variation" such variations are pass from parents to children in another words, they are inherited (e.g. sickle cell blood group).

Genes and chromosomes determine the characteristics and behavior of an organism. The expression of the characteristics and behavior is control by the environment. If the environment is favorable for a given characteristic it will be expressed. If not, it will not be expressed. On the other hand, environment could cause certain variation in an organism.

Variations that are caused by the effect of environment are referred to as acquired or non-hereditary variation; such variations are not passed from parents to children (.e.g skin bleaching, infant paralysis).

Step II: class what are the factors that causes variation in organism population? Yes
Gbanga - sexual reproduction.
Good. Yes , Blessing- Mutation
Good. Yes, Samira-
Environment. Good.

Step III: How does sexual reproduction mutation and environment causes variation?
Yes Bamaiyi Good. Yes. Mainasara. Good
Step IV: Class, variations that are caused by genetical factors are called what?
Yes, Bassey. Good Can such variation be passed from parents to children?
Those variation that are caused by environment are called what? Give me example. Can such variation be passed from parents to children?

EVALUATION:

1. Identify and explain the genetic causes of variation.
2. Explain how sexual reproduction causes variation

Lesson 4 - WEEK 4
Group - Control
Class Level - Pre-NCE
Subject - Biology
Course - Genetic
Topic: - Chromosome: the Basis of Heredity
Duration - 2 hours
Instructional Materials - Chart, diagrams

Behavioural Objective: *At the end of the lesson should be able to:*

1. Explain terms such as a alleles, chromosomes, genotype, phenotype, haploid, diploid, recessive, dominant, homozygous and heterozygous.
2. Define heredity.
3. Give examples of characters, which can be transmitted, from parents to offspring.
4. Explain how characters are transmitted from parents to offspring.

Materials

Diagrams showing how characters are transmitted.

Previous knowledge :The students already have the knowledge of meiosis and mitosis which is needed in genetics.

Presentation

Step 1. The teacher reviews the previous lessons and asks questions on the previous lesson

Step 2. The teacher explains what genes, chromosomes and DNA mean.

Step 3. The teacher defines heredity.

Step 4. The teacher gives examples of characters which can be transmitted from parents to offspring.

Step 5. The teacher explains sex determination in humans

Step 6. The teacher explains how characters are transmitted from parents to offspring.

Evaluation

1 What is heredity?

2 Give examples of characters that can be transmitted from parents to offspring.

3 Explain how characters are transmitted from parents to offspring.

Assignment: Read Mendel's work in genetics.

Summary

In the following paragraphs the major highlights of the lesson have been articulated.

Heredity

Heredity is the transmission of inherited from parents to offspring through genes. It is responsible for the similarities and differences between parents and offspring.

What are genes?

Genes are the basic units of heredity. A gene is segment of deoxyribonucleic acid (DNA) molecule that usually codes for the synthesis of a polypeptide chain, which eventually determines the nature of an inherited character (traits or observable features). They are discrete (separate) unit of inheritance, which determine hereditary characteristics. They are found on chromosomes in the nuclei of all cells. All the information for the inheritable characteristics of an individual is contained in the genes. When a cell divides, the genes duplicate themselves so that each daughter cell has an

identical set of genes as the original parent cell. Genes are passed on from parents to offspring in the gametes (eggs in females, sperm in male) of the parents.

Structure of DNA Molecule

The DNA molecule consists of two strands of nucleotide curved spirally or twisted into each other to form a double helix structure. Each nucleotide is made up of a phosphate group altering with sugar molecule which in this case is a pentose sugar called deoxyribose and a nitrogenous base, which can be any of the following: cytosine, adenine guanine and thymine.

The nitrogenous base from one chain or strand links up with a compatible base of the opposite chain. Adenine with thymine, guanine with cytosine. These bases are held together by hydrogen bond which is very weak and can easily break readily, causing a DNA to separate into two half strands. Hydrogen bond forms between the complementary bases resulting in two identical DNA strands. This process requires enzymes and energy.

DNA molecules (gene) is capable of replicating itself or making exact copies of itself. The ability to replicate itself makes it important in the transmission of hereditary materials from parents of offspring.

What are chromosomes?

They are the dark strained structure, which are seen in the nucleus of a cell. Just before cell division chromosomes appear as thin threads. Each chromosome is seen to be made up of two threads called chromatids joined at a point called centromere.

Chromosomes are made of protein and form the frame work on which genes or DNA molecule helix are wound round.

Transmitted Characters

Characters that can be transmitted are characters, which are controlled by genes.

How Characters Get Transmitted:

A diploid organism has two sets of chromosomes, which are said to be identical locations or loci. Diploid organisms produce gemetes by meiosis in their reproductive organism. A male and female individual produces gametes from the Parent (P) generation. The sex determination or mating termed a cross (X). A gene for a particular character may have alternative form which express the character in different ways. Each alternative form of a gene is known as allele. For example a pair of genes controlling newer colour in pea plant expresses the character in two contrasting ways or forms which are red and white. Such a pair of genes is known as the allelic pair or just "alleles."

Sex Determination in Man

During formation of gametes or reproduction cells, just as every other chromosome pairs separate into individual reproductive cells, the sex chromosomes also separate into individual reproductive cells. In the case of females every reproductive cell or egg carries an X-Chromosome. In the case of the male reproductive cells of sperm, half will carry X-Chromosome and half will carry a Y-Chromosome.

When a female and a mates or crosses, if an egg with X-Chromosome is fertilized by a X carrying sperm, the resulting offspring will be a female carrying XX – Chromosomes; if however, an egg is fertilized by a sperm carrying a Y-Chromosome, the resulting offspring is a male carrying XY-chromosomes. The sex of the child cannot be determine conception. The chances of having a girl or a boy are equal at each concept.

Lesson 5	-	WEEK 5
Group	-	Control
Class Level	-	Pre-NCE
Subject	-	Biology
Course	-	Genetic
Subject:		Biology
Topic:	-	Transmission of hereditary materials (Mendel's works in Genetics monohybrid inheritance
Duration:	-	2hours

PREVIOUS KNOWELDGE: Students have learnt about the nature of chromosomes and genes.

INSTRUCTIONAL MATERIALS: Black board, chalk and duster

BEHAVIOURAL OBJECTIVES: By the end of the lesson, students should be able to:

1. Explain Mendel's monohybrid inheritance
2. Recognize that Mendes's works on inheritance led to the discovery of genes and chromosomes.
3. Recognize that Mendel's works on inheritance led to discovery and formulation of genetical terms and concepts.

PRESENTATION

Step I: The teacher explains Mendel's works on monohybrid inheritance as follows:

- Mendel studied the inheritance of one pair of inheritance (tallness and dwarfness) in plants.
- He crossed fertilized a tall plant with a dwarf plant.
- The seeds resulting from the cross were collected and sown.
- All the sown seeds gave rise to tall plants, no dwarf plants.
- (15^{th} filial generation).
- Two of this tall plant was self fertilized.
- The resulting seeds from the self - fertilization were sown.
- The sown seeds gave rise to a mixture of tall and dwarf plants in ratio of 3 tall plants and I dwarf plant. There were no medium size plants.
- The findings from his works form the foundations on which the study of heredity is built. His findings led to the discovery of genes and chromosomes, formulation of genetic concept and laws.

The First law of inheritance discovered by Mendel was on the segregation of hereditary factors, particles or genes during gametes formation. The law state that "Genes and chromosomes occur in pairs. They separate (Segregate) independently during gamete (Sperm and egg) formation. Thus, a gamete received only one gene and chromosome pair.

Pure breeding is the breeding of organisms with the same characteristics. Hybrid breeding is the breeding of organism with different characteristics.

Contrasting characteristics are characteristics between two or more organisms that are different (tall e.g. and short).

Cross-fertilization is the fusion of gametes of two organisms with contrasting characters.

Self - fertilization is the fusion of gametes of two organisms with the same characteristics.

Monohybrid inheritance, is the study of inheritance of one characteristics at a time Genes A tall plant was cross - fertilized with dwarf plant occur in pairs. The genes for tallness and dwarfness could be represented as follows:

Tall Dwarf

X

TT tt

When organism contains identical genes like TT or tt, it is said to be homozygous. During gamete formation the gene pairs go to separate gametes. TT x tt during fertilization, gamete fussed randomly. Thus, the seed from cross - fertilization will have two pairs of dissimilar genes like this

t x T = tT

When organism contains unidentical genes like tT, it is said to be heterozygous. When the seeds resulting from the cross of tall and dwarf plants were sown, they all gave rise to tall plants, no dwarf plant, despite that they contain 'genes for dwarfness. In this case, the gene for tallness is said to be dominant and the gene for dwarfness is said to be recessive. A recessive gene is a gene that does not expressed its characteristics to be seen in a heterozygous state. A dominant gene is the gene that expressed its characteristics outwardly to be seen in a heterozygous state.

Two or more genes that determined and control a particular character are called "Alleles". The genes T and 't' controls height, so they are alleles.

The First offspring from cross - fertilization are referred to as First Filial generation or Fl. The second offspring from-the self - fertilization/are referred to as second filial generation or F2.

Inheritance can be represented or summarized diagrammatically or by using a chequer board or punnette square. In punnette square the gametes of one parent are written along the top of a series of boxes, and the gamete of the other parent is written by the left side. The products of the various fusions are written in the appropriate boxes and their relative number can be counted.

EVALUATION:

Describe the structures of a gene and a chromosome

Lesson 6	-	WEEK 6
Group	-	Control
Class Level	-	Pre-NCE
Subject	-	Biology
Course	-	Genetic
Topic:	-	Transmission and Expression of characteristics in Organisms(Dihybrid inheritance)
Duration	-	2 hours

PREVIOUS KNOWELDGE: Students have learnt about the nature of chromosomes and genes,

INSTRUCTIONAL MTAERIALS: Black board, chalk and duster

BEHAVIOURAL OBJECTIVES: By the end of the lesson, students should be able to:

1. State and explain Mendel's First Law of inheritance.
2. Identify and explain the meaning of I^{5t} and 2^{nd} filial generation.

PRESENTATION

The teacher explains Mendel's works on dihybrid inheritance to the students as follows:

- Mendel studied the inheritance of two pairs of inheritance (tall and coloured, dwarf and white) in plants.
- He cross fertilized a tall and colour (TTCC) plant with dwarf white (ttcc) plant.
- The seeds resulting from the cross were collected and sown. All the seeds gave rise to tall and colour plants, no dwarf and white plants.
- Two of the tall and coloured plants were self - fertilized.
- The resulting seeds from the self fertilization were sown.
- The sown seeds gave rise to four different kinds of plants: (!}-. Tall with coloured flowers (ii). tall with white flowers (iii). short with coloured flowers (iv) short with white flower in ratio of 9:3:3:1. Respectively.

Being pure breeding, Mendel's dihybrid inheritance of a cross between tall and coloured plant with short and white plant, their genotype will therefore be TTCC for tall and coloured plant, ttcc for short and white plant.

The Fl generation were all tall and coloured because the tall and colour characteristics are, the short and white characters did not appear in the Fl generation because they are recessive.

Pairs of genes assort themselves freely and are transmitted independently from parents to offspring. This led to the development of Mendel's second law of inheritance. From the observations of F2 plants, Mendel's arrived at his second law of heredity on the principle of independent assortment. The law that "genes on different chromosomes assort independently of each other during gamete (egg and sperm) formation.

EVALUATION:

Explain Mendel's monohybrid inheritance.

.

APPENDIX 7

Facility Index and discriminating index for GAPT

S/NO	(a) $F = \frac{RU+RL}{N\ X100}$	(b) $D=RU-\frac{RI}{\frac{1}{2}N}$
1.	0.30	0.65
2.	0.40	0.70
3.	0.50	0.62
4.	*-0.11	*0.95
5.	0.50	0.65
6.	*-0.12	*0.20
7.	0.60	0.70
8.	0.50	0.62
9.	0.70	0.70
10.	0.40	0.60
11.	0.35	*0.86
12.	0.35	0.55
13.	0.50	0.70
14.	0.50	0.65
15.	0.60	0.67
16.	0.50	0.45
17.	*-0.9	*0.94
18.	0.60	0.70
19.	0.70	0.70
20.	*0.85	0.68
21.	*-0.8	*0.94
22.	0.33	0.47
23.	*-0.9	*0.96
24.	0.35	0.68
25.	0.40	0.60
26.	*0.9	*0.92
27.	0.70	0.70
28.	0.75	0.60
29.	0.32	0.70
30.	0.70	0.60
31.	0.60	0.69
32.	0.50	RR 0.70
33.	0.40	*0.99
34.	0.30	RR 0.50
35.	*-0.11	*0.90
36.	0.50	RR 0.70
37.	0.60	RR 0.62
38.	*-0.12	*0.91
39.	0.70	RR 0.60
40.	*0.75	RR 0.65

Appendix 8
Scores of Pilot Testing
For High Ability Group

S/No	Gender	Pretest	Post test	Post post test
01	Male	12	27	25
02	Male	15	25	26
03	Female	16	26	27
04	Male	16	26	25
05	Female	16	26	20
		For Average Ability		
01	Male	14	24	25
02	Female	12	22	24
03	Female	13	23	22
04	Female	12	22	20
05	Male	12	22	24
06	Male	14	24	25
07	Female	10	10	23
08	Male	13	20	20
09	Male	11	21	20
10	Male	14	24	25
11	Male	12	22	25
12	Male	13	24	27
13	Male	13	25	28
14	Female	13	24	23
15	Male	13	22	20
16	Female	10	18	22
17	Female	12	22	25
		For Low Ability		
01	Male	5	10	11
02	Male	8	12	10
03	Male	7	13	13
04	Male	6	10	12
05	Female	8	13	11
06	Female	8	13	10
07	Female	6	12	13
08	Female	7	13	11
09	Male	7	10	9

Appendix 9

Scores of Experimental Group

For High Ability Group

S/No	Gender	Pretest	Posttest	Post posttest
1	Male	14	28	27
2	Female	13	25	24
3	Male	15	28	26
4	Female	13	26	29
5	Male	14	28	27
6	Male	11	24	24
7	Male	12	25	27
8	Male	14	28	26
9	Male	10	29	27
10	Female	16	29	28
11	Female	13	25	24
12	Male	16	29	28
13.	Male	14	28	27
14	Male	15	29	27
15	Male	10	25	26
		For Average Ability		
1	Male	11	27	28
2.	Male	9	20	22
3	Male	8	25	23
4	Female	7	22	22
5	Male	8	20	23
6	Female	10	25	24
7	Female	9	23	21
8	Male	11	25	24
9	Male	9	22	23
10	Female	8	23	20
11	Male	9	22	23
12	Male	7	19	18
13	Female	8	20	22
14	Male	10	23	24
15	Female	10	22	25
16	Male	11	20	21
17	Female	10	23	20
18	Male	9	22	22
19	Female	9	19	20
20	Male	5	20	19
21	Female	10	22	25
22	Female	9	19	20
23	Male	7	19	18
24	Male	10	23	24
25	Male	9	22	22
26	Male	5	20	19
27	Male	11	27	28

28	Male	8	25	23
29	Male	8	20	23
30	Male	5	20	19

For Low Ability

1.	Female	5	19	22
2.	Male	4	20	21
3.	Female	5	18	19
4.	Female	4	22	17
5.	Male	5	20	19
6.	Male	3	18	21
7.	Male	3	21	19
8.	Male	3	19	20
9.	Male	5	18	19
10.	Male	3	19	20

Appendix 10

Scores of Control Group

For High Ability Group

S/No	Gender	Pretest	Posttest	Post posttest
S/No	**Gender**	**Pretest**	**Posttest**	**Post posttest**
1	Female	13	25	24
2	Female	12	24	23
3	Male	10	22	21
4	Male	12	24	20
5	Female	12	24	23
6	Male	10	22	15
7	Male	11	23	19
8	Male	10	22	21
9	Male	11	23	20
10	Female	12	24	22
11	Male	13	25	24
12	Male	10	22	15
13.	Male	12	24	23
14	Male	11	23	20
15	Male	10	22	21
		For Average Ability		
1	Male	7	20	20
2.	Female	9	19	18
3	Male	6	16	20
4	Male	8	21	20
5	Female	8	20	21
6	Male	6	16	15
7	Female	6	20	19
8	Female	7	18	19
9	Female	6	20	18
10	Female	8	16	17
11	Male	6	18	15
12	Male	6	19	20
13	Male	7	22	19
14	Male	6	20	19
15	Male	9	22	20
16	Female	7	19	22
17	Female	9	20	21
18	Male	9	22	16
19	Female	9	20	18
20	Male	8	16	15
21	Female	7	19	20
22	Male	6	18	17
23	Male	7	19	20
24	Male	9	20	19
25	Male	8	16	15
26	Male	7	20	20

27	Male	6	16	18
28	Male	7	18	19
29	Male	7	16	17
30	Male	6	18	19

For Low Ability

1.	Male	3	8	7
2.	Male	5	10	11
3	Male	5	13	12
4	Female	5	12	11
5	Male	5	11	10
6	Male	3	7	6
7	Male	4	6	8
8	Female	3	7	8
9	Female	5	10	11
10	Male	5	12	9