

**EFFECTS OF COLLATERAL LEARNING ON ATTITUDE AND PERFORMANCE IN  
GENETICS AMONG CONVERGENT AND DIVERGENT SECONDARY SCHOOL  
STUDENTS OF SULEJA EDUCATIONAL ZONE, NIGERIA**

**BY**

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AHMADU BELLO UNIVERSITY,  
ZARIA, NIGERIA**

**JULY, 2017**

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**A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES,  
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**DEPARTMENT OF SCIENCE EDUCATION,  
FACULTY OF EDUCATION,  
AHMADU BELLO UNIVERSITY,  
ZARIA, NIGERIA**

**JULY, 2017**

## **DECLARATION**

I declared that the work in this dissertation entitled “Effects of Collateral Learning on Attitude and Performance in Genetics among Convergent and Divergent Secondary School Students of Suleja Education 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 reviewed were duly acknowledged in the text and list of references were provided. No part of this dissertation was previously presented for another degree or diploma at any institution.

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**Ado Mohammed SHUAIBU**

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Date

## CERTIFICATION

This dissertation entitled “Effect of Collateral Learning on Attitude and Performance in Genetics among Convergent and Divergent Secondary School Students of Suleja, Education Zone, Nigeria.” by Ado Mohammed SHUAIBU(P14EDSC8022) meets the regulations governing the award of degree of Masters in Biology Education of the Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

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## **DEDICATION**

This work is dedicated to my late father and mother Mallam Shuaibu Gani Baba'anya and Mallama Fatima Muhammad, may their souls rest in perfect peace Amen.

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whom I came across at various stages of my education. I say Al-Hamdullilah! “Getting education has played a tremendous role in raising my level of self-awareness, and confidence”.

## **ABBREVIATIONS USED**

ANCOVA	-	Analysis of Co-variance
CLS	-	Collateral Learning Strategy
MAN	-	Mathematical Association of Nigeria
NERDC	-	Nigerian Educational Research and Development Council
NPE	-	National Policy on Education
NECO	-	National Examinations Council
SSS2	-	Senior Secondary School Two
STAN	-	Science Teachers Association of Nigeria
STME	-	Science, Technology and Mathematics Education
WAEC	-	West African Examination Council
GCPT	-	Genetic Concepts Performance Test
GCAQ	-	Genetic Concepts Attitude Questionnaire
CDTT	-	Convergent and Divergent Thinker Test
UOTT	-	Uses of Objects and Things Test
C	-	Convergent
D	-	Divergent
PPMC	-	Pearson Product Moment Correlation
SROC	-	Spearman Rank Order Correlation

## OPERATIONAL DEFINITION OF TERMS

The following terms have been used to suit this study.

- Collateral Learning:** Collateral Learning Strategy is the cognitive explanation of cultural interaction that enables students to understand genetic concepts while maintaining their world view. The task of science teaching is to help all students acquire scientific knowledge, interest, skills, attitudes and ways of thinking without violating their personal and communal beliefs.
- Cognitive Styles:** A psychological construct that describes how individuals acquire knowledge, attitude and skill. It refers to mental behaviour which individuals apply habitually when they are solving problems. Cognitive styles is the mode by which individuals perceive information, synthesize and present the results in learning such as convergent and divergent.
- Convergent:** This refers to students that rely on facts, systematic and logical approach to solve a problems and make it easier to find a single correct answer or solution to a problem.
- Divergent:** This refers to students that rely on ideas and creativity to solve a problems and tends to be better at producing many correct solutions to an open-ended problems.
- Conception:** A body of beliefs held by an individual in exploring certain events. It is the formulation of general idea representing the common elements or attributes of a group or class.
- Genetics:** It is a branch of Biology concerned with heredity and variation.
- Learning:** This is any change in activities that is attributed to experience
- Lecture Method:** It is the conventional method of teaching/learning or expository method, where student were taught concepts in Biology.
- Performance:** A test to measure a student's knowledge and skills acquired in Biology.
- Attitude:** Is the behaviour towards the learning of genetics using Collateral Learning Strategy.
- Prior Knowledge:** The existing knowledge already acquired by a learner to which he/she can meaningfully relate new learning materials.

## LIST OF TABLES

Table	Page
1.1: WAEC Examination Result for Biology Students from 2010-2015	8
1.2: NECO Examination Result for Biology Students from 2010-2015	8
2.1: Definitions of Common Terms used in Genetics	43
2.2: Content on Genetics Topic	44
3.1: Population of the Study	67
3.2: Sample for the Study	69
3.3: Table of Specification for (GCPT) Based on the Topics Selected	71
4.1: Mean Scores and Standard Deviations of Students Performance of Experimental and Control Groups	81
4.2: Mean Rank Score of Attitude Change Among Convergent and Divergent Students	82
4.3: Post-test Mean Scores and Standard Deviation of Performance on Gender Among Convergent and Divergent Students	83
4.4: Post-test Mean Rank Scores of Attitude on Gender Among Convergent and Divergent Students	84
4.5: ANCOVA Result of Performance Among Convergent and Divergent Students of Experimental and Control Groups	85
4.6: Post-test Mann Whitney Result of Attitude Among Convergent and Divergent Students of Experimental Group	86
4.7: ANCOVA Result of Performance on Gender Among Convergent and Divergent Students of Experimental Group	87
4.8: Post-test Kruskal-Wallis Result of Attitude on Gender Among Convergent and Divergent Students of Experimental Group	88

## LIST OF FIGURES

Figure	Page
2.1 Flowchart of Collateral Learning Strategy Model.	36
3.1: Research Design	66
3.2: Flowchart of Adapted Collateral Learning Strategy Model.	77

## LIST OF APPENDICES

Appendix	Page
A: Genetic Concepts Performance Test (GCPT)	112
B: Marking Scheme of Genetic Concepts Performance Test (GCPT)	121
C: Answer Sheet for Genetics Concept Performance Test (GCPT)	122
D: Genetic Concepts Attitude Questionnaire (GCAQ)	123
E: Lesson Plan for Experimental Group	126
F: Lesson Plan for Control Group	144
G: Reliability of Genetic Concepts Performance Test (GCPT)	157
H: Reliability of Genetic Concepts Attitude Questionnaire (GCAQ)	159
I: Item Analysis of Genetic Concepts Performance Test (GCPT)	160
J: Convergent and Divergent Thinker Test (CDTT)	161
K: Convergent and Divergent Thinker Test (CDTT) Check-List	162
L: Sheet for Rough Record of Students Responses during the Class Activities	164
M: Letter for Validation of Instruments	166
N: ANOVA Result for Four Pretested Schools	171

## TABLE OF CONTENTS

Contents	Page
Title Page	i
Abbreviations Used	ii
Operational Definition of Terms	iii
List of Tables	iv
List of Figures	v
List of Appendices	vi
Table of Contents	vii
Abstract	xvi

### CHAPTER ONE: THE PROBLEM

1.1	Introduction	1
1.1.1	Theoretical Framework of the Study	6
1.2	Statement of the Problem	7
1.3	Objectives of the Study	10
1.4	Research Questions	10
1.5	Null Hypotheses	11
1.6	Significance of the Study	11
1.7	Scope of the Study	12
1.8	Basic Assumptions of the Study	13

## **CHAPTER TWO: LITERATURE REVIEW**

2.1	Introduction	14
2.2	Biology as a Teaching Subject at Senior Secondary School Level in Nigeria	15
2.2.1	The Role of the Teacher in Teaching Biology	17
2.2.2	Students Factor in the Learning of Biology	19
2.2.3	Teaching Strategies in the Learning of Biology	23
2.3	Concepts of Collateral Learning	27
2.3.1	Collateral Learning and Academic Performance in Biology	29
2.3.2	Processes of Collateral Learning	30
2.3.3	Models of Collateral Learning	34
2.4	Concepts of Genetics in Senior Secondary Schools Biology Syllabus	39
2.5	Concepts of Cognitive Styles	45
2.5.1	Convergent and Divergent Thinking and Academic Performance in Science	47
2.5.2	Personal Characteristics of Convergent and Divergent Thinkers	50
2.5.3	Identification of Convergent and Divergent Thinker	51
2.6	Gender and Academic Performance in Biology	53
2.7	Attitude and Academic Performance in Biology	55
2.8	Overview of Similar Studies	56
2.9	Implication of Literature Review for the Present Study	63

## **CHAPTER THREE: METHODOLOGY**

3.1	Introduction	65
3.2	Research Design	65
3.3	Population of the Study	67
3.4	Sample and Sampling Technique	67
3.5	Instrumentation	69

3.5.1	Convergent and Divergent Thinkers Test (CDTT)	69
3.5.2.	Genetic Concepts Performance Test (GCPT)	70
3.5.3.	Genetic Concepts Attitude Questionnaire (GCAQ).	71
3.5.4	Validation of the Instruments	72
3.6	Pilot Testing	73
3.6.1	Reliability of the Instruments	74
3.6.2	Items Analysis	74
3.7	Administration of Treatment	75
3.8	Procedure for Data Collection	78
3.9	Procedure for Data Analysis	79
<b>CHAPTER FOUR: DATA ANALYSIS RESULTS AND DISCUSSION</b>		
4.1	Introduction	80
4.2	Data Analysis and Result Presentation	80
4.2.1	Answer to Research Questions	80
4.2.2	Hypotheses Testing	84
4.3	Summary of Major Findings	89
4.4	Discussion of the Results	90
<b>CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS</b>		
5.1	Introduction	93
5.2	Summary	93
5.3	Major Findings of the Study	95
5.4	Conclusion	96

5.5	Contributions to Knowledge	98
5.6	Recommendations	99
5.7	Limitation of the Study	100
5.8	Suggestions for Further Studies	100
	References	102
	Appendices	112

## ABSTRACT

This study investigated the Effects of Collateral Learning on Attitude and Performance in Genetics Among Convergent and Divergent Secondary School Students of Suleja Education Zone, Nigeria. The research design used was pre-test, post-test Quasi-experimental control group design. The population of this study covered all the eight (8) public Senior Secondary Schools (SSSII) offering Biology with total enrolment of two thousand two hundred and sixtythree (2263) as at 2015/2016 academic session. One hundred and seventy five (175) students were sampled from two co-educational schools using simple random sampling technique involving balloting. Four objectives were stated with their corresponding research questions and null hypotheses. Two validated instruments namely; GCPT and GCAQ were used for data collection with reliability coefficients of 0.89 and 0.71 using PPMC and SROC respectively. Research questions raised were answered using mean and standard deviation while null hypotheses were tested using ANCOVA, Mann Whitney and Kruskal Wallis test at 0.05 level of significant. Results of the findings showed that there was significant difference between the performance mean scores of convergent and divergent students taught genetic concepts using Collateral Learning Strategy and those taught using Lecture Method, in favour of experimental group. Also, there was no significant difference between the attitude change of convergent and divergent students taught genetic concepts using Collateral Learning Strategy. Similarly, the finding shows that there was no significant difference between the performance mean scores and attitude change of male and female convergent and divergent students exposed to Collateral Learning Strategy. From the findings of the study, recommendations were made which include among others that teacher should be motivated and encouraged by State Ministry of Education and Science Teacher's Association of Nigeria (STAN) to attend seminars and workshops on the effective use of Collateral Learning Strategy in the teaching and learning of science in general and Biology concepts in particular.

## **CHAPTER ONE**

### **THE PROBLEM**

#### **1.1 Introduction**

Science has contributed in no small measure to the development and comfort of the modern world. Belzewki (2009) stated that for any nation to attain the status of self-reliance, science must be an important component of the knowledge to be given to all citizens of that nation irrespective of race, creed or sex. Indeed, science is recognized as the foundation upon which the bulk of the present day technological breakthrough is built. Shaibu (2008) expressed the opinion that Nigerian citizens should pursue science, technology and mathematics education (STME) to prevent Nigeria from being perpetual slave to the developed world. The prestige and political power of any nation also resides largely in its level of scientific performance.

Consequently, the pursuit of science as an imperative endeavour for achieving prosperity and advancement is conspicuous in the national development plans of many developed and developing nations. According to Aliyu (2014) one of the aims of the National Policy on Education (FME, 2009) is to equip students to live effectively in modern age of Science and Technology. This underscores the importance to our economic life and explain why the government through the ministry of education is showing much concern for science education through making good policies that will promote the teaching and learning of science.

Science education researchers like Lawal (2011) and Ajaja (2013) pointed out that the performance of science students in Nigerian schools still leaves much to be desired right from the primary school through secondary school to the tertiary level of education. A general review of Nigerian students' performances in Biology in the West African Examination Council (WAEC) and National Examination Council (NECO) from 2010 to 2015 revealed fluctuations and down-ward trends in students' performance (Table 1.1 and 1.2).

Biology as one of the science subjects taught in Nigeria senior secondary schools, is a popular science subject of choice among students. According to Bichi (2008), the popular nature of Biology among the science subjects at Senior Secondary Certificate Examination (SSCE) is attributed to it being softer and relatively easier to learn than chemistry or physics. The word biology is of Greek origin, coined from 'bios', meaning 'life' and 'logos' meaning 'the study of life'. Biology is conceptualized as a unique life subject, which deals with animate and inanimate objects, including their structures, functions, growth, origin, evolution and distribution. According to Ahmed and Akinbobola (2011), Biology is designed ultimately to educate individuals who may or may not pursue biological related careers, but could at least acquire the knowledge as prerequisite for pursuing careers in science related disciplines. This includes medicines, pharmacy, nursing, agriculture, forestry, biotechnology, nanotechnology, aquaculture, genetic engineering and many other areas.

Academic performance was defined by Oludipe and Oludipe, (2010) as the exhibition of knowledge attained or skills developed by students in a subject designed by test scores assigned by teachers. However, science education researchers like Lawal, (2009) and Lakpini, (2013) found that the persistent low academic performance in Biology at Secondary School Certificate Examination (SSCE) is attributed to teachers instructional strategy among others. Thus, instructional strategies used by teachers in teaching-learning process have significant influence on learners' academic performance. Paul and Dantani (2008) observed that the present method of teaching biology whereby teachers use lecture method does not in any way provide for sequence of learning experiences. Usman (2010) opines that lecture method is teacher-centered with little or no participation of students, consequently, they remain passive listeners. Therefore, in this study Lecture Method was used as a control variable to be compared with Collateral Learning Strategy on Attitude and Performance in Genetics among Convergent and Divergent Senior Secondary School II Biology Students of Suleja, Niger State.

Genetics is a branch of Biology that studies the function and behavior of genes. Genes influence many aspects of our daily life from the food we eat to identification of criminals, and treatment of diseases. In agriculture, genetics advances have enabled scientists to alter a plant or an animal structure to make it more useful. For instance, food crops such as oranges, potatoes, wheat, soyabean and rice have been genetically altered to make them withstand insect pests and harsh weather conditions. According to Sorajin (2015), tomato and apple have been genetically modified, so that they can withstand discoloration and bruising on their way to market, thus enhancing their appeal on supermarket shelves. The study of genetics today is important and as such considered as crucial to the scientific and technological development of the society. Fakunle (2012) opined that understanding of the concepts of genetics and its mode of operation appears to be more difficult than any other topic in Biology. This evidence is showed in the WAEC and NECO Chief Examiners Report(2010 – 2015). This study therefore, find out the effect of Collateral Learning Strategy (CLS), which is learnercentred in its characteristics,on genetic concepts for better understanding among Senior Secondary School II Biology Students.

According to Ogawa (2012), Collateral Learning Strategy is the cognitive explanation of cultural interaction that enables learners to understand science concepts while maintaining their world view. The task of science teaching is to help all children acquire scientific knowledge, interest, skills, attitudes and ways of thinking without violating their cultural belief and experiences. Umar (2011) delineated Ogawa idea by proposing three types of science;personal belief, communal belief and modern science.

Ajaja (2013) argued that teaching modern science is enhanced when students become aware of their personal belief and communal belief in a classroom. He referred to this as “Collateral Learning”. Learning science (Biology) meaningfully according to Herbert (2008) often involves cognitive conflicts of some kinds. In Collateral Learning, students achieve meaningful learning as it takes account of the multidimensional cultural world of the learner and helps learner to resolve existing conflict from different cultures. This study find out the effect of Collateral

## Learning Strategy on Attitude and Performance in Genetic Concepts among Convergent and Divergent Senior Secondary School II Biology Students.

Nwagbo and Aham (2015) observed that the population of students in most cases is made up of students of varying intellects, learning styles and attitudes which has to a large extent affected students' academic performance in Biology. Witkin (2011) reported that individuals differ in their characteristic ways of dealing with problems of different sorts, thereby resulting in individual differences in approach to problems-solving otherwise known as cognitive styles or learning styles. Gray (2009) defined learning styles to include student variations in modes of perceiving, comprehending, storing, transferring and utilizing information. Fakunle (2012) mentioned that one of the major difficulties in educating students is the inability of the teacher to be able to diagnose and adapt to the different learning styles of the students. It is expected therefore, that the teacher should be familiar with the students learning abilities and be able to devise the appropriate instructional strategy that can address such individual differences in the students. Adamu (2010) stated some of the common cognitive styles capable of affecting students attitude and performance in Biology to include field dependence and field independence, reflective and impulsive, convergent and divergent. According to Akbari (2011), convergent and divergent students can be identified easily by their areas of interest. That convergent students rely heavily on reading and experiment to process information while divergent students rely heavily on listening and watching to process information. Kolb (2008) stated that convergent and divergent students are very different in their learning styles but they can both benefit greatly from working with one another. Therefore, this study was focused on how the students irrespective of their cognitive styles can learn the concept of genetics effectively in order to improve their academic performance as well as motivate more positive attitude towards Biology subject using Collateral Learning Strategy (CLS) which is a student learning style centered in its characteristics.

Nwagbo, and Ugwuanyi, (2015) opined that stereotype in gender by different cultures also might have some effects on students performance especially in science. Findings on the influence of gender on the performance of students in biology have not been conclusive. Researches on the influence of gender on Attitude and Performance of the Students in Genetic Concepts have been of great concern to science educators. Therefore, in this study the researcher investigate the effects of gender on Attitude and Academic Performance of Senior Secondary School Students taught Genetic Concepts using Collateral Learning Strategy.

Baum (2005) defined attitude as the favorable or unfavorable response to things, places, people, events or ideas while Bichi, (2008) described attitude as tendency for individuals to organize thought, emotions and behaviors towards psychological object. Human beings are not born with the attitudes they learn afterwards. As such, attitudes are based on peoples own experience, knowledge and skills and some are gained from other sources like interaction with peer groups etc. Ogawa, (2012) reported that collateral learning not only led to more positive attitudes in science but that this positive attitudes persisted long after Collateral Learning intervention was over. The inappropriate use of teaching method as opined by Obeka, (2013) leads to the decline in students' attitude to science. Therefore, this study investigate the effect of Collateral Learning Strategy on Attitude and Academic Performance in Genetic Concepts among Convergent and Divergent Senior Secondary Schools II Biology Students of Suleja, Niger State, Nigeria.

### **1.1.1 Theoretical Framework**

The theoretical basis for this research is meaningful learning proposed by Ausubel (1963). This theory emphasizes the importance of subsumers as basic for further learning. Ausubel formulated subsumption learning which is based on prior knowledge and is used for the interpretation of new information to be learned. Thus, Ausubel proposed the idea that meaningful learning take place when a general subsuming concept or idea is available in students cognitive structures. If science teachers are aware of Ausubel recommendations, then learning of science can likely improve. Medenajereze (2008) opined that learning science meaningfully often involves cognitive conflicts of some kinds, that this conflicts is captured by the Collateral Learning Strategy. In Collateral Learning, students achieved meaningful learning as it takes into account of their personal and communal beliefs and helps to resolve existing conflicts between students communal culture and modern science culture irrespective of cognitive thinking (convergent and divergent). According to Jegede (2004), Collateral Learning Strategy generally postulates a spectrum of cognitive experiences (parallel, dependent, secured and simultaneous Collateral Learning) to explain cultural interaction. These four types of Collateral Learning are not separate categories but point along a spectrum depicting degrees of interaction resolution.

At one extreme of Collateral Learning, the conflicting schemata do not interact at all. Obiekwe (2009) stressed that this is parallel Collateral Learning. Students will access one schema or the other depending upon the context. For example, students will use a scientific concept of genetics only in school, never in their everyday world where common sense concept of genetics prevail. At the opposite extreme of Collateral Learning, conflicting schemata consciously interact and the conflict is resolved in some manner. This is secured Collateral Learning. Kesamang (2002) reported that the person will have developed a satisfactory reason for holding on to both schemata even though the schemata may appear to conflict, or else the person will have achieved a convergence toward commonality by one schema reinforcing the

other, resulting in a new conception in long term memory. Between these two extremes of parallel and secured Collateral Learning, we find varying degrees and types of interaction between conflicting schemata and we detect various forms of conflict resolution. In this context it will be convenient to designate points in between the two extremes, one of which is called dependent Collateral Learning. Therefore, meaningful learning often results in parallel dependent or secured Collateral Learning. Simultaneous Collateral Learning ensues when ideas from two world views about a particular concept learned at the same time. A student, who needs to move into the culture of modern science, requires an effective use of Collateral Learning with a heavy reliance on successful cultural interaction into school sciences. Based on these facts, the researcher investigated effects of Collateral Learning Strategy on the Attitude and Academic Performance in Genetic Concepts among Convergent and Divergent Senior Secondary School II Biology Students.

## **1.2 Statement of the Problem**

The National Policy on Education (FME, 2013) stated in its objectives that students be helped to become effective teachers with good mastery of content and strategy for effective teaching of Biology in Senior Secondary Schools and Colleges of Education. However, the WAEC and NECO Chief Examiners Report of 2010 to 2015 revealed that only between 34% to 49% of the students pass Biology annually. This shows that the understanding of the subject appears to be difficult. Table 1.1 and 1.2 show students performance from 2010-2015 for both WAEC and NECO in Nigeria.

**Table 1.1 WAEC Examination Result for Biology Students from 2010-2015.**

Years	Number of students with A1-C6	(%) of student with A1-C6	Number of students with D7-F9	(%) of students with D7-F9	Total number of students sat for the examination
2010	501, 755,38	34.20	965, 365,62	65.80	1,467,121
2011	489, 960,43	33.90	955, 350,57	66.10	1,445,311
2012	698, 952,44	43.38	912, 279,56	56.62	1,611,232
2013	767, 247,42	48.62	810, 801,58	50.38	1,578,049
2014	736, 171,14	46.09	861, 075,86	53.91	1,597,247
2015	713, 981,61	45.70	848, 341,39	54.30	1,562,323
<b>Total</b>	<b>3,908,068,42</b>	<b>42.20</b>	<b>5,353,214,58</b>	<b>57.80</b>	<b>9,261,283</b>

Source: West African Examination Council 2010-2015 Annual Report (2015)

It could be deduced from Table 1.1 that students performance in Biology from 2010-2015 was not impressive, over 50% of the students had D7 – F9 in the years indicated. This is an indication of poor performance in the subject among the students.

**Table 1.2 NECO Examination Result for Biology Students from 2010-2015.**

Years	Number of students with A1-C6	(%) of students with A1-C6	Number of students with D7-F9	(%) of students with D7-F9	Total number of students sat for the examination
2010	596, 161,06	47.73	652, 866,94	52.27	1,249,028
2011	596, 567,40	47.04	671, 645,60	52.96	1,268,213
2012	565, 707,50	41.95	782, 820,50	58.05	1,348,528
2013	561, 548,74	42.98	744, 986,26	57.02	1,306,535
2014	721, 737,96	47.83	787, 227,04	52.17	1,508,965
2015	686, 43,18	48.10	740, 662,82	51.90	1,427,096
<b>Total</b>	<b>3,728,155,84</b>	<b>45.98</b>	<b>4,380,209,16</b>	<b>54.02</b>	<b>8,108,365</b>

Source: National Examination Council 2010-2015 Annual Report (2015)

In Table 1.2 the trend for poor performance can also be observed over the years indicated. Over 50% of the number of students who registered for Biology failed yearly. Both the WAEC and NECO Chief Examiners Report for 2010 – 2015 attributed this poor performance in Biology to poor understanding of some concepts in Biology including genetic concepts. The situation appears to still remain the same till date. In addition the observed failure rate according to Usman (2010) is mostly attributed to improper exposure to laboratory

activities, poor science background at junior secondary school and lack of problem solving ability which affect students attitude towards the subject, while Lawal (2009) stated part of the problems leading to this failure rate in genetics to include poor method of instruction. This is supported by the assertion of Nsofor and Ala (2013) who attributed the deterioration in students performance in genetics to ineffective strategy of teaching Biology as well as lack of recognition of students cognitive style.

According to Obiekwe (2009) based on this deplorable trend of poor performance at SSCE Biology, educators have designed instructional strategies over the years to curb the problem of under performance in the subject as well as achieve the aims and objectives of teaching Biology. For instance, Ajaja (2013) proposed concept mapping and co-operative learning for better performance in Biology. Bichi, (2002) recommended the use of Problem-solving strategies and enriched curriculum to improve Attitude and Performance in Biology While Jacinta (2017) recommend student centered strategy such as Collateral Learning Strategy. Adajoh and Ityokyaa (2012) stressed that lack of attention by science teachers in handling students of varying learning styles like convergent and divergent have been implicated as some key factors responsible for students poor performance and negative attitude towards Biology subjects. Given this scenario, this study used Collateral Learning Strategy (CLS) to determine its effects on Attitude and Academic performance among Convergent and Divergent Secondary School II Biology Students in Genetic Concepts from Selected Senior Secondary School of Suleja, Niger State, Nigeria.

### **1.3 Objectives of the Study**

This study was guided by the following objectives to:

1. investigate the effects of Collateral Learning Strategy on the academic performance of convergent and divergent Senior Secondary School II Biology Students in genetic concepts;
2. find out the effects of Collateral Learning Strategy on the attitude of convergent and divergent Senior Secondary School II Biology Students in genetic concepts;
3. examine gender related effects of Collateral Learning Strategy on the academic Performance of convergent and divergent Senior Secondary School II Biology Students in genetic concepts; and
4. determine the gender related effect of Collateral Learning Strategy on the attitude of convergent and divergent Senior Secondary School II Biology Students in genetic concepts;

### **1.4 Research Questions**

This study answers the following research questions:

1. What is the difference in the mean academic performance scores of convergent and divergent students taught genetic concepts using Collateral Learning Strategy and those taught using lecture method?
2. What is the difference in the mean attitude scores of convergent and divergent students taught genetic concepts using Collateral Learning Strategy?
3. What is the effect of Collateral Learning Strategy on the mean academic performance scores of convergent male and female and divergent male and female students taught genetic concepts?
4. What is the effect of Collateral Learning Strategy on the mean attitude scores of convergent male and female and divergent male and female students taught genetic concepts?

## 1.5 Null Hypotheses

Based on the research questions, the following null hypotheses were tested at  $P \leq 0.05$  level of significance.

**H<sub>01</sub>:** There is no significant difference between the mean academic performance scores of convergent and divergent Students taught genetic concepts using Collateral Learning Strategy and those taught using lecture method.

**H<sub>02</sub>:** There is no significant difference between the mean attitude scores of convergent and divergent students taught genetic concepts using Collateral Learning Strategy.

**H<sub>03</sub>:** There is no significant difference in the mean academic performance scores of convergent male and female and divergent male and female students taught genetic concepts using Collateral Learning Strategy.

**H<sub>04</sub>:** There is no significant difference between the mean attitude scores of convergent male and female and divergent male and female students taught genetic concepts using Collateral Learning Strategy.

## 1.6 Significance of the Study

It is hoped that the findings of this study would uplift the standard of Biology education at Senior Secondary Schools level in the following ways:

To Biology Curriculum Planners: Motivation in emphasizing the use of Collateral Learning Strategy in teaching various concepts in Biology. This may help to enhance the performance of students in Biology, thereby reducing the rate of failure in the subject at SSCE level.

To Biology Teachers: Provision of additional teaching strategy for teaching Biology in order to inculcate in students the skills of diligent search and enhance positive attitude and performance in Biology.

To Biology Students: Benefiting from awareness of the factors that affect their performance and attitude in science, knowing such factors could help them identify their strength and weaknesses.

To Biology Teachers Trainers Tertiary Institutions: Benefiting from awareness of the utility value of the strategy which would enable them in producing more effective teachers who would encourage Senior Secondary School Students to construct knowledge on their own, most especially in teaching of genetic concept.

To Researchers: This study would be a foundation for other researchers in Biology education who may develop interest in investigating the effect of Collateral Learning Strategy on attitude and performance of Students in other concepts of Biology and science subjects in general, it could also serve as source of literature review in related fields.

To Professional Bodies like STAN, MAN etc; making use of the findings to organize workshops or seminars for Biology teachers and other science teachers, especially on how to improve teacher-student interaction such that students performance could be enhanced and that their attitude can be aroused and sustained.

## **1.7 Scope of the Study**

This study examines the effects of Collateral Learning Strategy on attitude and performance in genetic concepts among convergent and divergent students. It is limited to public Senior Secondary School two (SS II) students in Suleja Educational Zone, Niger State Nigeria. The schools are owned by the government, and the same ministry of education supervises teaching learning processes in the schools. According to Suleja educational zone (2016), there are eight Public Senior Secondary Schools with population of 2263 Senior Secondary Schools II Biology students in the study area. From this figure, 1180 were male while 883 were female. SS II students are used because they were stable, unlike SS I students who are not fully settled for the study, nor SS III students who were facing their final year examination. They were also familiar with genetic concepts which fell within the SS II scheme of work.

The subtopics chosen under genetics includes: genetics terminologies, transmission and expression of characteristics in organisms and chromosomes the basis of heredity, probability in genetics, sex determination and sex linked characters. These topics have been identified as difficult for students to learn by WAEC and NECO Chief Examiners Report (2010 – 2015).

### **1.8 Basic Assumptions of the Study**

For the purpose of this study, the following assumptions were made:

- i. The use of Collateral Learning Strategy as learner centered could improve the teaching and learning of genetic concepts;
- ii. All students in Senior Secondary Two (SS 2) have been exposed to the Biology syllabus on genetics and evolution;
- iii. The use of Collateral Learning Strategy is Measurable; and
- iv. Determination of effects of Collateral Learning Strategy on Attitude and Performance among Convergent and Divergent Students is possible.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

This study has investigated the effects of Collateral Learning Strategy on attitude and performance in Genetic Concepts among Convergent and Divergent Senior Secondary School II Biology Students. The chapter reviews some literature related to the study under the following sub-headings:

2.2 Biology as a Teaching Subject at Senior Secondary Schools Level in Nigeria;

2.2.1 The Role of the Teacher in Biology Teaching;

2.2.2 Students Factors in the Learning of Biology;

2.2.3 Teaching Strategies in the Learning of Biology;

2.3 Concepts of Collateral Learning ;

2.3.1 Collateral Learning and Academic Performance in Biology;

2.4 .Concept of Genetics at Senior Secondary School Biology Syllabus;

2.5 Concept of Cognitive Style;

2.5.1 Convergent and Divergent Thinking and Academic Performance in Science;

2.6 Gender and Academic Performance in Biology;

2.7 Attitude and Academic Performance in Biology;

2.8 Overview of Similar Studies; and

2.9 Implication of the Literature Reviewed on the Present Study.

## **2.2 Biology as a Teaching Subject at Senior Secondary Schools Level in Nigeria**

As a science subject, Biology at senior secondary school level is often regarded as a "soft" option, which has led to the explanation of the relatively enrolment in Biology. According to Ahmed (2012) Biology is the study of plants and animals as a core subject for many science disciplines in post primary institution in Nigeria; it is designed ultimately to produce educated individuals some of whom may take to biological studies in science professional pursuit. Lawal (2011) opined that the concepts of Biology is related to both biotic and abiotic environment comprising elements such as water, nutrient, light, temperature and later comprising animals, plants and microorganisms.

Sorajini (2015) mentioned that, Biology as an important discipline has contributed tremendously to financial, physical and aesthetic benefit to man and to the nation building. The areas of contribution of Biology include the following:

- **Medicine:** Most of the major discoveries in medicine have been developed from practical study of physiological processes.
- **Fisheries:** The propagation management and conservation offish and aquatic animal for food, sports and other non-edible products.
- **Apiculture:** The breeding of honey bees for production of honey wax and pollination of crops.
- **Parasitology:** The investigation and control of parasite of man, domestic and wild animals.
- **Forestry:** Planting, culture and development of forest tree for timber, wood, pulps, poles, food and raw material.
- **Crime detection:** The knowledge of genetics helps to detect crime using fingerprint as well as using insect to detect crime (forensic entomology).

From the above mentioned a good knowledge of these benefits will be of utmost importance to students and create interest of learning in them. Hence, the need for effective study of biology subject at senior secondary schools level is emphasized.

Biology curriculum was adapted and revised from 1985 edition. Developed by Comparatives Education Study and Adaptation Centre (CESAC). The objectives of this Curriculum have been derived from the National Policy on Education (2009) and the main objectives are to prepare student to acquire:

- Adequate laboratory and field skills in Biology.
- Meaningful and relevant knowledge in Biology.
- Ability to apply scientific knowledge to everyday life in matter of personal community health and agriculture,
- Reasonable and functional scientific attitude.

Yunusa (2008) maintained that in pursuance of the stated objectives, the content and context of the curriculum places emphasizes on field studies, guided discovery, laboratory activities/techniques and skills along with conceptual thinking (e.g. Collateral Learning). The curriculum intended to provide a modern Biology course as well as meet the needs of the learner and the society through relevant and functionality in its contents, methods, processes and applications. It covers the major themes, these themes are of direct relevance to the society and the learner the themes are as follows:

- Organization of life.
- Organisms at work.
- The organisms and its Environment.
- Continuity of Life.

In planning the new Biology curriculum, the spiral approach to sequencing a science course was adapted. In the approach, the concepts to be taught are arranged in such a way they run

throughout the three-year post basic course, with the concept being discussed in greater depth as the course progresses. The curriculum is organized into six sections:

- Topic
- Performance Objectives.
- Content.
- Activities - Teacher and Students.
- Teaching and Learning Materials.
- Evaluation Guide.

According to Erinosh (2008) such organization provide maximum guide to the teacher. Teachers should, however, note that the performance objectives presented in the curriculum are not exhaustive as need arise, especially in the higher cognitive level and psychomotor and affective domains. The curriculum provides a logical and psychological follow up to the 9 - year's Basic Science Core Curriculum.

### **2.2.1 The Role of the Teacher in Teaching Biology**

Usman (2010) ascertained that teaching is a systematic presentation of facts, ideas, skills, and techniques to students. Although human beings have survived and evolved as a species partly because of a capacity to share knowledge, teaching as a profession did not emerge until relatively recently. However, a major challenge for the educational system in contemporary Nigeria is the production of qualified teachers to teach at various levels of the educational system in sufficient numbers. Bichi (2002) expressed that this situation has arisen as a result of a combination of factor including relative by low remuneration and recognition for teachers, and the cumulative effect of several years of neglect of the educational system prior to 1999, as indicated in reduced funding. This had adverse, effects on the facilities and equipment for teaching at all levels, which also had effects on the quality of the products of the educational institutions, including the teachers.

Ultherland and Henning (2009) mentioned that the quality of education at any level depends largely on the qualification and commitment of the teacher. In Science teaching and learning, the role of the science teacher cannot be over-emphasized. The science teacher is an engineer in the teaching and learning of science as he selects the instructional objectives, contents, methods, learning experiences, organizes the experiences and evaluates the outcome of instruction with respect to the stated objectives. The personality, behavior and attitude of the science teacher therefore cast too important an impression on the students mind.

Teachers' knowledge of Biology subject and attitude to teaching are other factor that might cause student under performance in Biology. Imhanlahimi and Anguele (2010) stated that the biology teacher can neither be dispensed with, nor can he be totally replaced by the use of modern electronic equipment in teaching. The professional background and commitment of the biology teacher determines to some extent the quality of performance of students in the subject. Teacher effectiveness therefore, could reasonably be assessed by the degree to which he has produced the desired behavior in his students. Besides teacher effectiveness is assessed in terms of teaching experience, knowledge of subject matter, favourable attitudes towards teaching and adequate knowledge of teaching methodologies.

Katcha (2005) opined that biology teaching and learning in senior secondary school includes many factors which are determinants of learning quality. These can be classified as affective and cognitive factor. For the cognitive domain, reasoning ability, information processing and academic performance are among the most studied constructs. Those among the most frequently emphasized factors of the affective domain in the science and Biology education literature are attitude, self-efficacy, anxiety and motivation. As an affective factor, giving more importance of attitude for Biology education over the other affective factors in Biology education was suggested by some science education researcher like Muraya and Kinamo (2011) attributed students poor performance in Biology to students negative attitude toward the subject.

Adajoh and Ityokyaa (2012) opined that attitudinal preparedness of prospective teachers as mediators of curriculum to teach and learn any subject matter of a curriculum and related perceptions on the subject matter are of learning as it has been found that learning through memorization and reproduction does not result in knowledge that can be used to reason and to solve problems in new situations. He further noted that what the student does is more important in determining what is learned than what the teacher does. Thus, teacher's role is not to lecture in an exclusively transmissive way, but to encourage active participation, dialogue and interaction by students with course materials and with each other. Students learn by interacting with and transforming received information so as to own it and make it personally meaningful which leads to powerful understanding and useful knowledge. Ahmed and Akinbobola (2011) have noted that teachers should have the knowledge of how students learn Biology and how best to teach and that effort should be taken now to direct the presentation of Biology lessons away from the Lecture Methods to a more student centered approach. Similarly Kopksal and Cimen (2008) note that the teaching approach that a teacher adopts is one factor that may affect student performance and therefore, use of an appropriate teaching strategy is critical to the successful teaching and learning of Biology. Learning is facilitated by a range of tasks that involve students in active processing, such as questioning, explaining and discussion.

### **2.2.2 Students Factor in the Learning of Biology**

A number of studies like Usman (2010) have shown that students attitude triggered learning activity and leads to a higher degree of deep - level learning. Obiekwe (2009) defined attitude as a relationship between individual and an object. Most researchers differentiate between individual and situational attitude. According to Mangal (2010) individual attitude is understood to develop gradually and affect one's knowledge and values over time, while situational attitude appears suddenly as a response to something in the environment and is more emotional in nature. Situational attitude according to Afolabi and Akinbobola (2009) is thought to have only short - term impact whereas individual attitude is believed to be more stable.

More research in science education has revealed that students are usually more interested in Biology than other science subjects and this explains why a larger population of students choose Biology as one of the science subjects.

Students' difficulties in learning genetics have been studied by Biology education researchers, like Nwagbo (2005) and Abdulrahman (2010) found that hormones, genes, chromosomes, mitosis, meiosis, and Mendelian genetics were considered difficult concepts by secondary school students. Experiencing difficulty in so many subtopics in genetics negatively affects students' attitude and performance. Students' difficulties with genetics concept topics in Biology have stimulated researchers to investigate why students experience such difficulties and how to overcome these difficulties.

There are many reasons why students have difficulties in learning genetics and some Biology concepts. Cimer (2012) described the nature of Biology itself and its teaching methods among the reasons for the difficulties in learning Biology, while Nsofor (2010) observed that the biological level of organization and the abstract level of some Biology concepts like genetics, respiratory system, nervous system make learning Biology difficult. Overloaded Biology curricula and interdisciplinary nature of biological concepts are the other factors preventing students from learning Biology effectively. Okebukola (2004) revealed that designing learning environments while ignoring students' attitudes and expectations causes several learning problems as well as decreasing their interest in Biology. That there is a close relationship between students' perceptions of their classroom learning environment and their success. Mark (2002) also reported that students' diminishing interest in learning Biology was due to the curriculum content being overloaded and not generally related to working life, the lack of discussion of topics of interest, the absence of creative expression opportunities, the alienation of science from society and the prevalence of isolated science subjects.

Trumper (2006) opined that teaching methods and techniques may also be factors that affect students' learning in Biology. If students are not happy with the way that Biology is taught,

they may show no interest and negative attitudes towards Biology and its teaching. Muraya and Kinamo (2011) stated that the investigation of students' attitudes towards studying Biology has been a substantive feature of the work of the Biology education research community for the past 30 - 40 years.

According to Nwagbo (2005), anxiety and negative attitude of students towards the learning of scientific concepts and particularly, Biology concepts has continued to exist in secondary schools despite all effort to make the learning of Biology more effective. Uitto and Meisolo (2006) described that students' religious belief is in conflict with some Biology topics such as evolution, genetics and reproduction. This is another factor that affects the teaching and learning of Biology topics. Available literature like Achifusi, Umeh and Ezenduka (2011) show that most science students begin their career with a desire to learn and with an intrinsic approach to performance, which later switches to a more extrinsic orientation as students increase in age. Moreover, Sutherland (2008), revealed that, the home environment is important as what goes on in the school. In the home important factors include parental involvement in their children's education, how much television the children watch and the number of children in the home i.e. the family size. Parental influence has been identified as an important factor affecting student performance. Ogawa (2012) investigated that parent education and encouragement are strongly related to improved students performance. Again Ogunkola and Olatoye (2010) also found that parental education and socio-economic status have an impact on student performance.

Ogonnaya (2011) stressed that, one of the overriding objectives of Biology teaching is to ensure that students learn Biology concepts meaningfully. Meaningful learning as explained by Ausubel (1963) results when a learner consciously and explicitly relates new knowledge to relevant concepts or propositions, which he/she already possesses. Meaningful learning therefore, provides evidence that an individual has been able to internalize in his ability to apply the new knowledge to other situations. Lawal (2011) stated that meaningful learning is active,

constructive, intentional, authentic, and cooperative. Eniayeju (2001) also observed that compounding the problems associated with effective program delivery in indigenous communities are the more acute epistemological issues cited in the literature. As an example of school science improvement literature has been criticized for universalizing schools and students, paying insufficient attention to context, especially in terms of racial, class and gender differences. Biology curricula, in particular, tend to focus on modern science and in so doing ignore communal epistemologies and aspirations. As suggested by Aikenhead (2006), science instruction often fails to give priority to harmonizing the science being learned by students life - world culture, including their native language and culturally appropriate learning strategies. Ogawa (2012) observed that mandated science curricula are largely expressions of the dominant modern science and neglect communal and personal beliefs. Sillitoe (2007) goes further to explained that the lack of inclusion of communal and personal beliefs in modern science curricula and teaching is a reflection of science improvement initiatives as being nationalizing in aspirations for economic and technological gain. By being so, government of many countries of the world including Nigeria fail to acknowledge the aspirations of communal and personal beliefs in it modern science curricula which lead to students negative attitude toward science subject in general and Biology in particular. Medinagerez (2008) opined that science curricula and teaching that ignores communal and personal beliefs will fail most students. Ndirika (2015) maintains that every effort has to be made to harmonize the modern science being taught with aboriginal students' life-world culture, including their first languages. Such thinking underlies cross-cultural strategies to science teaching which referred to as "two - way" learning or "both - ways education" (Collateral Learning Strategy). Therefore, this present study intends to investigate what will be the effect of Collateral Learning Strategy on attitude and performance in genetics among convergent and divergent senior secondary school II Biology students in Suleja Niger State.

### 2.2.3 Teaching Strategies in the Learning of Biology

Teaching method was described by Biology education researcher like Ajaja (2013) as the means of transmitting subject content to students. Various teaching methods have been developed and were available for use by the teachers of various subjects. It was often said that good teaching was not always tied to any particular method. This implied that, teachers should vary their teaching methods or techniques for effective teaching and learning. Biology teachers are therefore at liberty to use whichever methods they considered suitable to serve their purpose. Adajoh and Ityokyaa (2012) opined that the effective teaching of Biology could be measured by examining the methods of teaching applied in school and performance of students in school examinations. As such, the methods teachers can employ to teach Biology are numerous. The most frequently used teaching methods for Biology teaching include the following:

- Lecture method
  - Excursion method (Learning through fieldwork)
  - Demonstration method
  - Inquiry method
  - Project method
  - Discussion method
  - Collateral Learning Strategy
- Lecture Method: This is a widely used method for the teaching of Biology. In this method the teacher presents the lesson to students verbally while the students listen and write down the key points of the lesson, hence it was described as "talk and the listen" approach to teaching. As a teaching technique, lecture method is teacher-centered because a lot of telling is done by the teacher while the learners act as passive recipients of the information. Unlike other teaching strategies, the lecture deprives the learner of the opportunity to participate fully in the learning process for which reason the method has been criticized for developing passivity in the classroom.

The use of lecture method as instructional strategy for teaching Biology, particularly at secondary school level, has raised a number of questions among researchers and educationists. Ajaja (2013) investigated the use of lecture method in Biology to teach genetics and concluded that the poor academic performance of students in genetics was due to the use of lecture method as instructional strategy. Secondary school teachers were usually cautioned over the use of lecture method at this level not only in Biology but virtually in all the subjects.

In spite of the above, the lecture has its strengths as teaching technique. Olorukooba (2001) gave some of these strengths, namely: it helps teachers cover vast area at a limited time as it dealt with lengthy explanations. Also it is cheap and less expensive as it did not demand any significant financial expenditure, it helped the students to cultivate the skills of note-taking and it is good for adult classes and people of higher mental ability. Some of the limitations of lecture method include are that it makes the learner passive recipient of information/knowledge, it is didactic and teacher-centered, it is boring particularly in large-size classes and where it was lengthy, it does not promote positive student-teacher relationship, and it does not provide accurate means of checking students' progress. Moreover, Nsofor (2013) postulated that, the objectives of teaching Biology were include to acquire the knowledge of Biology, to acquire the processes of developing Biology skills, and acquisition of Biology attitudes. Also, opined that Lecture Method is not the best way to achieve the objectives of teaching biology.

- Demonstration Method is another method of teaching Biology. The method allowed the students to see the teacher actively engaged as a model rather than merely telling the information. Students learn mental or physical skills by performing those skills under supervision. Demonstration is therefore an instructional strategy in which the teacher did a lot of "showing and doing" activities while the students listen and observe the teacher. After the teacher has finished the act of a particular activity, the students might be required to

perform same activity in order to test their understanding. Where the teacher showed a particular process, act of skills or technique with no explanation accompanying it, this is known as "pure demonstration". Demonstration with commentary occurs if demonstration was accompanied with verbal explanation. In participative form of demonstration, students participate in the demonstration given by the teacher.

Paul and Dantani (2008) observed that lecture method made appeal to the sense of hearing, demonstration implied making appeal to the sense of sight and sense of hearing too. In Biology classrooms, Biology teachers use demonstration method to teach ecological concept as well as diffusion and osmosis. In each of these areas, the teacher showed and or explained to students a particular process involving the use of some instruments/tools or identification of certain ecological features. Demonstration aroused students' attitude and make learning more meaningful and memorable to students. Some of the limitations of this method are that it is risky especially where students are required to make use of dangerous equipment or chemicals; it is time-consuming and its success depends upon the availability of instructional materials.

- Excursion Method: This is another method teachers of Biology use to teach Biology. The importance of excursion as instructional strategy has been recognized by Biology teachers at all levels. Field work or excursion, as it was also called, is one of the teaching procedures that make instruction real and memorable, Excursion referred to an organized visit to a place of interest outside the school in order to allow the students see and do things for themselves. Trumper (2006) defined excursion as teaching and learning outside the classroom for the purpose of making relevant observations and also for obtaining specific information. This method (excursion) fostered good teacher-students relationship, makes learning more realistic and memorable and allows students to see the ways in which economic, social physical processes were integrated and interact in a particular place. However, excursion is

said to be time-consuming, expensive to organize and during trip it is difficult to maintain good conduct among students.

- Project Method: This method is also used for teaching Biology. According to Ajewole (2001) the method refers to any individual or group activity involving the investigation and solution of problem planned and carried out to a conclusion by student or students under the guidance of the teacher. The project starts with problem identification and the identified problem could be of interest to student(s). The teachers' role is to guide the students. Where the investigation is being carried out by a group of students, there is no guarantee that all the students in the group will participate.
- Discussion Method: This method employed in Biology classrooms to present lessons. In discussion method, the teacher divides the class into small group, large group or whole class group for the purpose of teaching and learning. The teacher usually gives the topic(s) of discussion to students in advance so that they could seek for information, organize it and present it during the discussion. The teacher also ensure that all group members follow the discussion and concludes the findings after all group leaders have finished their presentations. The success of this method depends upon the teachers' ability to select relevant and real problem, guide the group in the course of discussion and treat everyone impartially.

The bulk of advantages of this method were that, it developed communication skills among learners, the students learn to share and respect other people's view points and develops confidence in the students. Some of the disadvantages of discussion method are that brighter students tend to monopolize the discussion at the expense of less bright ones, if not well-organized the discussion might degenerate into trivial issues and above all the method does not allow for wider coverage of syllabus.

- Inquiry Method: This is also called problem-solving, it involves seeking or asking for information about something. Nwagbo (2005) stressed that inquiry-based teaching approach

provide useful platform for engaging students in practical, hand-on science investigation that can bring them in interaction with living and non-living aspect of the environment. Bichi (2002) opined that this method is a very potent instructional strategy for Biology teachers in the teaching of their subject particularly where the real answer to the problem is not known.

Adajoh and Ityokyaa (2012) opine that other methods of teaching Biology are Question and Answer method, experimentation, laboratory method, Dramatization and expository method. It should be noted at this juncture that most of the teaching methods described above, have been criticized by some Biology education researcher like Okebukola (2004) for being ineffective in teaching genetics concept at senior secondary school. There is therefore an urgent need to search for alternative instructional methods that would enhance the teaching and learning of genetics ideas, fact, information and knowledge which in turn improve students' academic performance. In this study, the instructional method proposed for teaching genetics in order to improve students performance is the Collateral Learning Strategy.

### **2.3 Concepts of Collateral Learning**

According to Ogawa (2012), collateral learning is the cognitive explanation of cultural interaction that enables learners to understand science concepts while maintaining their world view. The task of science teaching is to help all children acquire scientific knowledge, interest, skills, attitudes and ways of thinking without violating their communal believes and experiences. Ogonnaya (2014) cited Ogawa (2012) idea by proposing three types of science namely, personal beliefs, communal belief and modern science. Ogbu (2012) argued that teaching modern science is enhanced when students become aware of their personal and communal science in a classroom. He referred to this as "multi science teaching".

Medinajerez (2008) opined that learning science meaningfully often involves cognitive conflicts of some kinds. In collateral learning, students achieve meaningful learning as it takes the account of the multidimensional cultural world of the leaner and helps him/her to resolve

existing conflicts from the different cultures. Alkenhead and Lima (2009) mentioned that one major influence of Science Education identified from students in developing countries is their feeling that school science is like a foreign culture to them. Their feeling stems from the fundamental differences between the culture of modern science and their communal cultures. Cultural clashes between students life-worlds and the world of modern science challenge science educators who embrace science for all, and the clashes define an emerging priority for the 21<sup>st</sup> century to develop culturally sensitive curricula and teaching methods that reduce the foreignness felt by students. The capacity to think differently in diverse cultures and the capacity to resolve conflicting beliefs between these cultures are familiar human traits. Nielsen and Nashon (2007) discovered when they investigated student's movement between the worlds (micro cultures) of families, peer groups, school, and classroom: many adolescents are left to investigate transitions without direct assistance from person in any of their contexts, mostly notably the school. Further, young people's success in managing these transitions varies widely.

Sutherland (2008) studied students varied success at moving between the communal cultures and the cultures of their science classroom. She confirmed Nielsen and Nashon finding, that transitions are smooth when the cultures of communal and science are congruent, transitions are manageable whenever the cultures are somewhat different, transition tend to be hazardous when the cultures are diverse, and transition are virtually impossible when the cultured are highly discordant. In other words, success in science course depend on the degree of culture difference that students perceive between their life-world culture and their science classroom, how effectively student move between their life-world cultures and the culture of science or school science and the assistance students receive in making those transitions easier. Two major points arise from this brief analysis. The transition from a student's life-world into science classroom is a cross-cultural experience for most students. This point was explored by Cobern (2006) who recognized the transition as "cultural border crossings". Second, cognitive conflicts

arising from different cultural settings needs to be addressed and resolved. This second point was explained by Jegede (2004) in terms of his "collateral Learning theory".

Obiekwe (2009) ascertained that cultural border crossing and collateral learning are constructs grounded in empirical research and warranted in anthropological and psychological paradigms respectively. The phenomenon to which collateral learning refers is universal and well-known worldwide. An implication for science teaching for the 21<sup>st</sup> Century is clear. Herbert (2008) reported that effective Collateral learning in science classrooms will rely on successful cultural border crossing into School Science. Collateral learning and border crossings are fundamentally interrelated. Collateral learning was proposed to explain why many students, Non-western and western, experienced culturally related cognitive dissonance in their classes.

### **2.3.1 Collateral Learning and Academic Performance in Biology**

In school Science, from the viewpoint of cultural anthropology, to learn Science is to acquire the culture of Science. To acquire the culture of science, students must travel from their everyday life world of science found in their science classroom. Student's flexibility, playfulness, and feelings of ease in the world of science will help determine the smoothness with which students cross the border into the culture of science. This smoothness will likely affect the degree of culture acquisition that takes place. Baker and Taylor (2005) observed that different cultural processes are involved in the acquisition of science culture. When the culture of science generally harmonizes with a student's life-world culture, science instruction will tend to support the students view of the world, and the process of enculturation tends to occur. This process is characterized by smooth border crossings and is experienced by the type of student Costa (2005) called potential Scientists.

Collateral learning generally involves two or more conflicting schemata held simultaneously in long term memory. There are variations in the degree to which the conflicting ideas interact with each other and the degree to which conflicts are resolved. Basically, there are four (4) types of collateral learning acknowledged, are introduced here and then are clarified by examples that

show what role they play in learning science and Biology in particular. These four types of collateral learning are not separated categories, not along a spectrum depicting degrees of interaction and resolution.

### **2.3.2 The Process of Collateral Learning**

The process of collateral learning includes the followings as identified by Sutherland (2008)

- Parallel collateral learning (compartmentalization technique):- At end of the spectrum, the conflicting schemata do not interact at all. Spindler (2001) reported that this is parallel collateral learning or the compartmentalization technique. Students will access one schema or the other, depending upon the context. For example, students will use a scientific concept of genetics only in school, never in their everyday world where commonsense concepts of genetics prevail. In Biology class or during examination for instance a student may understand the principles of genetics perfectly. His/her religious beliefs may cause the student to believe in creationism. These two conflicting concepts may be held in different schemata and cued based on the context. The student will perfectly expound the laws of genetics and obtain an excellent grade. Outside the science classroom it will never be used, rather the student refers to the holy books (Bible and Qur'an) and creation in making his/her explanation of the heredity. According to Fakudze and Ogunniyi (2002) this is a very good case of collateral learning.
- Secured collateral learning:- At the opposite end of the collateral learning spectrum, conflicting schemata consciously interact and the conflict is resolved in some manner here. The person will have developed a satisfactory reason for holding on to both schemata even though the schemata may appear to conflict, or else the person will have achieved a convergence toward community by one schema reinforcing the other, resulting in a new conception in long- term memory. Two conflicting concepts are held in the long-term memory. The students develop a reason that causes them to hold both concepts. In fact, the conflicting concepts reinforce one another. An example may be found in a student believing

in the impending destructions of the earth proclaimed by Christians and Muslims. At the same time, student may believe in recent scientific speculations of the earth getting closer to the sun (or Ozone layer depletion), which may eventually destroy it, or the increasing scientific evidence that a giant meteorite may hit the earth in the near future. These seem to be contrasting but somehow mutually reinforcing. In view of this, Snively (2000) cited in Ogonnaya (2011) in his Solomon Island study, argued for a suplicated view of learning beyond the simple dichotomy of "Science versus traditional knowledge," his proposed view would empower students for life in the 21<sup>st</sup> century. Tobin and McRobbie (2006) in Ogonnaya, 2009 called this technique "empowerment" as it is associated with students setting conflicts between scientific claims and students, everyday notions of common sense.

- Dependent collateral learning:- This lies between the two extremes of parallel and secured collateral learning. This learning process occurs when a student's preconception or communal belief is (a) contrasted with a different conception encountered in the science classroom (b) given a tentative status, and then either (c) altered by reconstructing the original schema under the influence of the newly encountered schema or (d) rejected and replaced by a newly constructed schema. In other words, students modify or reject their original schema because it makes sense to do so. Contreras and Lee (2000) described that this type of learning is similar to piaget's accommodation assimilation model of information processing. An example is the replacement of communal reasons for recurrent infant mortality in a home by a scientific reason such as sickle cell anemia. If a student who holds the "Abiku" or "Ogbanje" conception comes in contact with the sickle cell phenomenon in a Biology class, the latter is very likely to challenge the former preconception. The result will likely be a discarding of the preconception for the more plausible and intelligible scientific concept. The student does not necessarily have to discard his communal world view for the scientific. This promotes meaningful learning in that if it occurs often in students cognition, it will eventually, lead to a change in the world view.

- Simultaneous collateral learning:- this fits between parallel and dependent collateral learning on the spectrum described above. Sutherland and Wolcott (2002) opined that this is a unique situation in which learning a concept in one domain of knowledge or culture can facilitate the learning of a similar or related concepts in another milieu. This does not happen often but when it does, it is usually coincidental. For instance, suppose a Nigeria student is studying photosynthesis in Biology class and come across terms such as "chlorophyll", denaturing and chloroplast. Initially, he/she may likely have problems comprehending these conceptions. But supposed that after encountering the concept in school, he/she finds something that makes the school science vivid while helping the mother in the kitchen, the initial conflicting concepts are either reinforced or extinguished. In Nigeria, people often bleach green vegetables before adding them to soup or any food. During this preparation the vegetables are left for some minutes to soak in boiling water, and the vegetables lose some of the green coloration (chlorophyll). When people drain the water, all they sees is green colour. In that situation, a student might simultaneously learn more about the school concepts of chlorophyll, denaturing and chloroplast while learning to prepare soup with green vegetables at home. In these two settings (school and home), learning about a arise spontaneously and simultaneously. By reflecting on the two settings and their concomitant concepts (for example green blanched water and chlorophyll), a student may easy cross the cultural border between home and school science. The two sets of schemata established in long-term memory by simultaneous collateral learning, may over time further compartmentalized, learning or interact and be resolved in some ways, resulting in either dependant or secured collateral learning depending on the manner in which the conflict is resolved. Therefore, meaningful learning often results in parallel, dependant or secured collateral learning. Sutherland and Dennick (2012) stated that:
  - Different students develop pre-conception and alternative frame works through interactions with their different environment,

- Students actively construct their own parameters of the world guided by previous perceptions which are often difficult to discard even after formal instruction,
- Learning may occur by either evolutionary process (the modification of existing student's personal models) or revolutionary processes (the complete replacement of existing models with new ones).

However, since the cultural activities of each learner as experienced from his/her cultural environment guide or influence his future observation and also determine what is learned, for effective learning of science concepts (biological concepts in particular) to occur, the use of multicultural based model is vital. Aikenhead (2006) gave a summary of fifteen (15) specific instructional strategies which can be employed in a multicultural science classroom these are:

- The use of a variety of material resources and ensure that the racially stereotyped material is either eliminated or addressed in an anti-racist fashion.
- The oral natives and heritage community should become part of the school science experienced. These should not be demeaned as being merely myth and legend.
- The similarities and differences, and the strengths and limitation of two traditions should be articulated and expected during instruction.
- Teachers should give attention to the language of science and help students who are accustomed to an oral tradition or who have language difficulties.
- Cultural imperialism should be acknowledged
- Integrated discussions about science with history, morality, justice, equality, freedom and spirituality.
- Where possible, direct comparisons between classification schemes in both traditions should be made.
- Show students how concepts such as life cycles, heredity, evolution are cultural laden in other traditions.

- Instruction should provide sensory experiences and experiential student centered learning,
- Instruction should identify local approaches for achievement sustainability.
- The student's world should be related to science.
- Teachers should provide a multicultural view of science by drawing upon a variety of cultures when teaching science (e.g. Collateral Learning Strategy).
- Activate the likelihood of continual change, conflict, ambiguity and increasing interdependence,
- Interactivity among student should encourage them to identify their own ideas and benefits.
- Teaching strategies should emphasize solving science problems, resources management, and sustainable society problems. Student's empowerment is the goal. In this model, the teacher is seen as more of a facilitator in the classroom. When conflict occurs between the two cultures (communal culture and modern science) the teacher aids the students in resolving them achieving a form of collateral learning strategy.

#### **2.3.4 Models of Collateral Learning**

There are many different models about how concepts are learned, what information people have when they have mastered a concept, and how information about new items is related to previously learned concepts. Jegede (2004) identified four models of collateral learning strategy as follows:

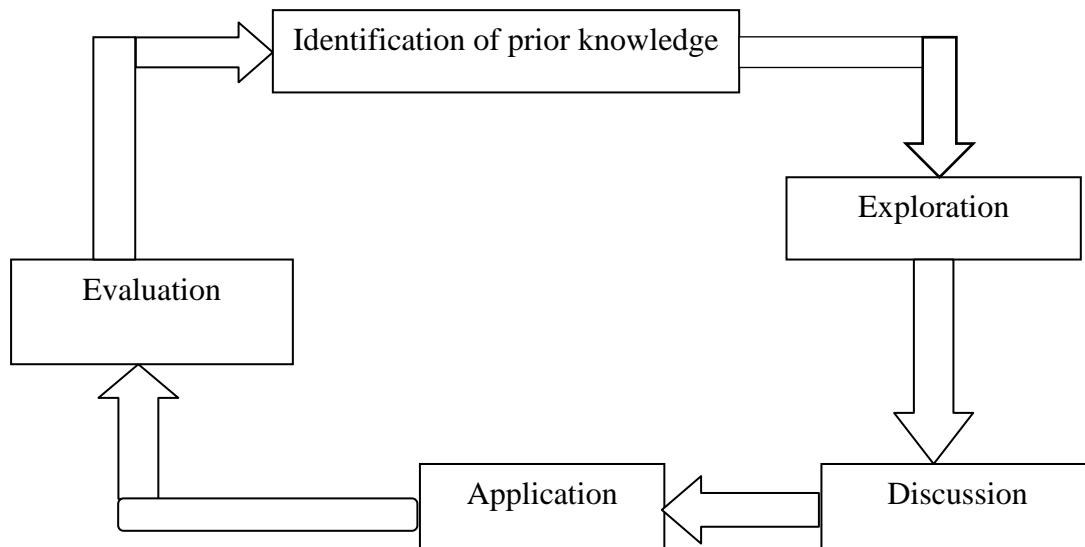
- Subsumption Model of Learning
- Collateral Learning Model
- Group Investigation Learning Model
- Learning Together Model
- Subsumption Model of Learning

Ausubel (1963) formulated subsumption model of learning which is based on prior knowledge and is used for the interpretation of new information to be learned. Thus he proposed the idea that meaningful learning takes place only when a general subsuming concept is available in learners' cognitive structure and that such idiosyncratic concepts are usually derived from currently held concepts in the society. Ausubel (1963) states that concept formation involves deliberate introduction of certain concepts and sub-concepts with learning materials in order to enhance meaningful learning. The introduction of materials is meant to provide prerequisite knowledge that would assist the students to understand a specific concept. He referred to sub concepts as advance organizer which he operationally defined as introductory materials at a high level of abstraction, generality and inductiveness.

According to Ausubel, the expository advance organizer can be used when no anchoring idea are available to the students. That is, when the new learning material is unfamiliar to the students. Ausubel, asserted that for any meaningful learning to take place, new materials to be learnt must be carefully linked to the learners' prior knowledge. Ausubel has suggested that meaningful leaning can be achieved only when there pre-exist in their mind the necessary relevant concepts and cognitive structures (subsumers) that will subsume the new knowledge. Otherwise, rote learning has to be invoked. If science teachers' are aware of Ausubel's (1963) recommendation that the most important single factor influencing learning is what the students already know, and use the basic demands of the model in teaching the students, then learning of science can likely be improved.

- Collateral Learning Model

Collateral learning model was based on constructivist learning theory. The model was used by Jegede (2004) and Aliyu (2014). The flow chart and steps of the model are as follows:



**Figure 2.1:**Flowchart of Collateral Learning Model

Source: Jegede (2004) and Aliyu (2014)

Identification of Prior Knowledge: Adamu (2010) expressed that in this step task introduced to students directly or indirectly involving them with concrete materials individually or grouped, storytelling about communal beliefs and personal beliefs on genetics also asked students pointed genetics question that can focused students attention on the tasks that will follow. The objective was to open students mind toward the concept to be learned. Thus, learners took part inactivities that allowed them to work with materials that gave them a 'hands on' experience of the phenomena being observed. Students' encountered the materials, define their questions, lay the groundwork for their tasks,and make connections from new to known. According to Adamu (2010), the teacher facilitates the process.

Exploration:Jegede (2004) opined that in this step students directly involved with material, Collateral Learning drives the process, teamwork was used to share and build knowledge base. The focus at this step was on analysis. The learner was encouraged to put observations, questions, hypotheses andexperiences from the previous step into language using

Collateral Learning Strategy. Communication between learners and learner groups can spur the process. The instructor chooses to introduce explanations, definitions, mediate discussions or simply facilitate by guiding students to find the words needed.

Discussion: Aliyu (2014) stated that, in this step students expanded on their knowledge, connect it to similar concepts, apply it to other situations that lead to new knowledge. Students explained the discoveries, processes, and concepts that have been learned through written, verbal or creative projects. Instructor supplied resources, feedback, vocabulary, and clarifies misconceptions. Using the understanding gained in the previous steps, now students should be encouraged to build and expand upon it. Inferences, deductions, and hypotheses were applied to similar or real-world situations. Varied examples and applications of concepts learnt strengthen mental models and provide further insight and understanding was used.

Application: The application step of the learning cycle provides an opportunity for students to apply their knowledge to new domains, which may include raising new questions and hypotheses to explore. Ramarogo, (2008) stated that the application step is in lined directly to the psychological construct called "transfer of learning". Transfer of learning can range from transfer of one concept to another and one school subject to another i.e. (evolution and genetics or genetics concept to apply genetics engineering) in order to facilitate effective understanding of the concept to be learned.

Evaluation: Yunusa (2008) mentioned that the evaluation was ongoing process by both instructor and learner to check for understanding. Results were used to evaluate and modify further instructional needs and should occur at all steps, in order to determine that learning objectives have been met and misconceptions avoided. Any number of rubrics, checklists, interviews, observation or other evaluation tools was used. If interest in a particular aspect or concept is shown, further inquiry was encouraged and a new cycle can begin that builds upon the previous one. Inquiries may branch off and inspire new cycles, repeating the process in a

spiraling fractal of interrelated concepts, where instruction is both structured and yet open to investigation.

- Group Investigation Learning Model

Group Investigation Learning Model as opined by Yusuf and Afolabi (2010) is a general classroom organization plan in which students work in small groups using cooperative inquiry, group discussion, Collateral Learning and projects. In this method, students form their own two- to six-member groups. After choosing subtopics from a unit that the entire class is studying, the groups break their subtopics into individual (asks and carry out the activities that are necessary to prepare group reports. Each group then makes a presentation or display to communicate its findings to the entire class. The absolute freedom given to students to form their own group, subjects this model to the danger of constituting a homogeneous group where students of equal ability may come together as a group. Exclusion of low ability students can easily manifest itself under this arrangement.

- Learning Together Model

Learning together model of cooperative learning as expressed by Sutherland (2008), it involves students working in four- or five-member heterogeneous groups on assignments. The groups hand in a single completed assignment and receive praise and rewards based on the group product. This method emphasizes team-building activities before students begin working together and regular discussions within groups about how well they are working together.

All the models reviewed in this section emphasized students communal beliefs and personal beliefs as an important tool for promoting learning. This present research adapt the collateral learning model to investigate the effects of Collateral Learning Strategy on attitude and performance in genetics among convergent and divergent senior secondary school II Biology students of Suleja Niger State. The model was adapted for the present study because according to Jegede (2004) it has the following advantages.

- It is a students learning centered in it characteristics
- It provides opportunity for activity based teaching and learning.
- It provides room for teamwork learning.
- Its identification of prior ideas step provide flexibility for collateral learning i.e. to acquired students communal beliefs and personal beliefs at the beginning of the lesson on genetics concept.

#### **2.4 Concepts of Genetics at Senior Secondary Schools Biology Syllabus**

The word genetics according to Falusi (2003) came from the Latin word "genesis" which means birth. Thus, genetics is the study of birth, or, more broadly the study of heredity. It is a branch of Biology concerned with heredity and variation. As a fundamental life science, genetics has been in a state of exceptionally vigorous growth. It has found applications not only in basic and biological disciplines such as taxonomy and evolution, but even in applied areas such as human and livestock medicine, agricultures and horticulture as well as even in unrelated disciplines of psychology, sociology, criminology and law. Michael (2015) mentioned that the science of genetics consists of three main branches viz: transmission genetics, molecular genetics and population genetics, the transmission genetics deals with the inheritance of characteristic that we can frequently see and understand easily i.e. The study of the transmission of traits from one generation to the next. It is frequently called Mendelian or classical genetics. The molecular genetics on the other hand deals with the study of the structure and expression of genes. The third branch of genetics which is population examines the extent of genetic variation within and among populations. These branches of genetics are not exclusive of one another, rather they reinforce one another. Katcha (2005) revealed that presently, a great deal of genetic research is going on at the molecular level. This however does not mean that other branches of genetics are in danger of disappearing. In keeping with the basic plan of teaching and learning genetic

concepts understanding. It is hoped that the simple style of presentation coupled with the illustrated summaries would facilitate the understanding of the genetics.

Umeh (2010) explained that it is a common knowledge that after sexual reproduction, the resulting offspring tends to look like their parent in one or more ways. This resemblance may be related to the immediate parent or even to the grandparents. This tendency of the offspring to look like their parent or grandparents is a phenomenon which goes on from generation to generation. This is due to certain characters or traits which the offspring have inherited from their parents thus confirming one of the fundamental observations about heredity made by men several thousand years ago, that is "like tends to beget like"

Very often in our homes such questions are asked about inheritance of traits such as hair colour or colour of eyes that a particular individual has. At other times a particular child may be described as showing some traits resembling one of his grandparents. Genetics may then be described as showing some traits resembling one of his grandparents. When questions of this nature are asked one is asking genetic questions. Genetics, may then be described as the science that deals with questions and answers on inheritance. This is the inheritance of traits or characters, such as height and skin colour which are transmitted from parents to offspring during sexual reproduction. Sorajini (2015) supported that the ways and manners by which these characters are inherited from parents is known as heredity. The study of genetics dates back to several years in man's curiosity to unravel the mechanism for the transmission of traits from parents to offspring. A breeder called Kilreuter worked with tobacco plants of about 1770 species. He recognized that parental characters were transmitted by both the pollen and the ovule however, studies of heredity before 1866 were not conclusive. The results obtained by earlier investigations offered little explanation of the way inheritable features were transmitted from one generation to the other.

Work in genetics continued to draw the attention of natural scientists, and in 1866 Austrian monk, who lived in the monastery in Brumme, published two treatises on the laws of

heredity in the journal of the local natural science society. This man, Gregory Mendel, later became the head of the monastery. His many added responsibilities prevented him from continuing his study of heredity. He died in 1866 without realizing that his two small contributions could form the foundation for all the work that has since been done in genetics. It was not until 1900 that three investigators working independently discovered what they thought were new findings about heredity. These men, Hugo Devries in Holland, Karl Correns in Germany (1871-1933) and Erich Von Tschermak in Austria (1871-1962) rediscovered the phenomenon of regular, predictable ratios of the types of offspring produce by mating pure breeding parents. But, then, searching through literature in the field, they came across Mendel's earlier report on the same subject. They then realized that Mendel was the pioneer in these investigations and gave him full credit for his work by naming two of the fundamental principles of heredity Mendel's laws. Sorajini (2015) reported that all the work that has been done in genetics, has made use of Mendel's basic discoveries, and so, today, he is known as "the father of modern genetics "great advances have been made in genetics, cytogenetic and related fields but Mendel's two laws still remain the fundamental laws of heredity in genetics.

- Cell:A cell is the smallest unit of life. Cells are the fundamental structure and functional unit that the plant body or the animal body is composed of. They are tiny mass of protoplasm bounded by a membrane and containing nuclear and cytoplasmic materials. The cell is the basic unit of the body and the study of heredity is centered on the nucleus of a living cell. Within the nucleus of the cell are materials that control the heredity of the individuals. Weshould remember that only the chromosome is involved in the heredity which is determined during the process of meiosis during gamatogenesis.
- Chromosomes the Basic of Heredity:-Within the nucleus of non - dividing cells are strands or string - like structure known as chromosomes. As the cell is about to divide, the chromatics become more visible as strands with bead-like structures on them. These are chromosome and contain genes, which carry the genetic information which are transmitted

from the parents to the offspring. We may then say that the chromosome is a nuclear component having a special organization, individuality and function. It is capable of self-reproduction (duplication) during cell division and of maintaining its morphological and physiological properties through successive cell divisions. Although Mendel published his data in 1866, its significance was only realized after 1900. By this time improved microscopes and staining techniques enabled scientists to observe the behavior of chromosomes in gametes and zygotes. An American scientist, Walter Sutton, saw striking similarities in the way:

- Mendel's factors were transmitted, and Chromosomes behaved during meiosis and fertilization.
  - In 1902, he proposed that chromosomes are the carriers of Mendel's factors (genes). This is called the chromosome theory of heredity. Later another American, Thomas Morgan (1866-1945), established clearly that Mendel's factors are indeed located on chromosomes. He used the fruit fly, *Drosophila melanogaster*, for his studies.
- Location of Chromosomes:- we learn that the nucleus of a eukaryotic cell contains threadlike structures that stain easily. These are chromatin granules, the precursors of chromosomes. Just before cell division, the chromatin granules shorten and thicken to form structures with definite shapes which we called chromosomes. These are visible in the nucleus of a cell when viewed under a light microscope. Like chromatin granules, they stain easily. In fact, this property of theirs gives rise to their name chromosome which means coloured body.
- Structure of Chromosomes:- in somatic cells of diploid organisms, chromosomes occur in pairs known as homologous. The members of each homologous pair during the first stage of meiosis. A given species always has a constant number of homologous chromosomes in all its somatic cells.

**Table: 2.1 Definitions of Common Terms used in Genetics.**

Genetics Terms	Definition
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Diploid	Having two sets of chromosomes known as homologous. Animals and dominant from most plants are diploids.
Haploid	Having only one set of chromosomes. Gametes and certain stages in the life cycle of plants are haploids.
Chromosomes	Dark staining structures in a cells nucleus on which the organisms genes (DNA molecules) are arranged. Each species has a characteristics number of chromosomes.
Gene	The basic unit of heredity. A segment of DNA molecule that usually codes for the synthesis of a polypeptide chain that eventually determine the nature of an inherited character.
Locus	The location of a gene on a chromosome.
Allele	One of two or more alternative forms of a gene.
Dominant Allele	An allele that completely dictates the appearance or phenotype of heterozygous. One allele is said to be dominant over another if a heterozygous individual bearing the allele has the same appearance as an individual who is homozygous for it.
Recessive Allele	An allele whose phenotypic expression is completely masked in heterozygote by the presence of a dominant allele
Homozygous	An individual carrying out identical alleles on both homologous chromosomes is said to be homozygous for the gene. If the gene determines a single character, then the individual is homozygous for the character
Heterozygous	A diploid individual whose two copies of a gene are the same. A diploid individual carrying out different alleles of a gene on its two homologous chromosomes is said to be heterozygous for the gene.
Genotype	Sum total of genes present in the cells of an organism. Also refers to the pair of alleles at a single gene locus.
Phenotype	The observable (visible) expression of the characters of an organism resulting from the interaction between its genes and its environment.

(Adopted from Aliyu, 2014).

Genetics Conceptis among the Biology topics taught at Senior Secondary School in Nigeria. According to Nsofor and Ala (2013) genetics is aspects of Biology syllabus at Senior Secondary School in Nigeria which most students scarcely study before completing their secondary education. Lawal (2009) asserted that many teachers exhibit apparent phobia towards teaching of genetics, while many students are somewhat completely disinterested in studying it, went further to state that the teacher's apathy towards teaching the topics is a major factor responsible for the student's poor background in it. Also, noted that because teachers are not interested in genetic, they cannot arouse student's interests who are rather given the impression

that the topic is difficult. According to West African Examinations Council (WAEC) Chief Examiners Report (2010-2015), genetics is area of Biology syllabus from which the candidates can score high marks with less effort. The depth of treatment required by West African Examinations Council (WAEC) and National Examinations Council (NECO) Syllabuses are relatively small and as such is not supposed to scare teachers and students/candidates away. Table 2.2 shows the syllabus on genetics as presented by the National Curriculum for Science Subjects for Senior Secondary School Biology.

**Table: 2.2 Content on Genetics Topic for Senior Secondary School Biology**

<b>Topic</b>	<b>Content</b>
Biology of Heredity (genetics)	<ol style="list-style-type: none"> <li>1. Transmission and expression of Characters in organisms <ul style="list-style-type: none"> <li>- Hereditary Variations</li> <li>- Characters that can be transmitted</li> <li>- How characters behave from generation to generation.</li> <li>- Mendel's work in genetics <ul style="list-style-type: none"> <li>• Mendel's Laws</li> <li>• Mendel's Traits</li> <li>• Mendel's experimental methods.</li> </ul> </li> </ul> </li> <li>2. Chromosomes the basis of heredity <ul style="list-style-type: none"> <li>- Location</li> <li>- Structure</li> <li>- Role in and Process of transmission of hereditary characters from parents to off spring</li> </ul> </li> <li>3. Probability in genetics</li> <li>4. Applications of the principles of heredity <ul style="list-style-type: none"> <li>- In agriculture:</li> <li>- In medicine advice for couples in relation to the sickle cell gene.</li> </ul> </li> <li>5. Explain the terms: <ul style="list-style-type: none"> <li>- Cross Fertilization</li> <li>- Self Fertilization</li> <li>- Out and in-breeding using Mendel's crosses.</li> </ul> </li> </ol>

Source: Nigerian Educational Research and Development Council (NERDC, 2009).

Table 2.2 showed clearly the content on genetics topic for senior secondary school Biology students in Nigeria. Usman (2010) stated that the level of attitude and readiness to learn content on genetics topic will depend on the teachers instructional strategy in presentations.

Aliyu (2014) opined that the prior knowledge of the students like communal and personal beliefs is very important for meaningful learning construction. Therefore, this present study intends to find out the effects of Collateral Learning on attitude and performance in genetics among convergent and divergent senior secondary school II Biology students in Suleja, Niger State.

## **2.5 Concepts of Cognitive Styles**

Cognitive styles could be defined from different perspectives. Most authorities agree that cognitive style is an approach to learning in order to solve problems. Cognitive styles or learning styles are often interchangeably used. Gray (2009). Define cognitive styles as a psychological construct that describes how individuals acquire knowledge, attitude and skill. It refers to mental behaviour which individuals apply habitually when they are solving problems. Cognitive styles is the mode by which individuals perceive information, synthesize and present the results in learning such as convergent and divergent. Adamu (2010), defined the concept of cognitive styles to include the individual's variation in modes of perceiving, a way of apprehending, storing, transferring and utilizing information. Witkins (2011) argued that cognitive style should be seen as a characteristic mode of functioning that the individual exhibits throughout his perceptual activities in highly consistent manner.

From the above operational definitions it would be seen that a factor basic to differentiation in learning efficiency is the learning style of an individual. Wallach (2005) shown that one of the major difficulties in educating the students is the inability of the teacher to be able to diagnose and adapt to the different cognitive styles of students. Therefore, the teacher's efficiency is not limited to merely passing instruction to student with different learning rates or just personalizing instruction to meet the students personal interest, but the teacher's efficiency should include awareness of students cognitive styles and techniques which are appropriately suited to learning. West and Pines (2013) stated that cognitive styles are numerous in psychological literature and are identified by various names, of interest and of greater exposure and relevance to schools are the convergence and divergence cognitive styles of Hudson (1967), the

field independence and field dependence cognitive styles of Witkin (2011) and the reflectivity and impulsivity cognitive styles of Kagan (1976). Wallach (2005) identified and proffered another nomenclature of cognitive styles as rigid, undisciplined, anxious and creative styles. As described below:

- **Rigid Learning Style:** this style has a tight system for processing information. The individual does not allow either internal or external sources of information to influence his behavior. The individual cannot symbolically manage information in a problem solving situation but must have lots of concrete examples in order to understand or learn.
- **Undisciplined Style:** this individual is strongly influenced by internal source of information but has not learned to effectively utilize external sources of information. He has developed a moderately symbolic level of conceptual ability which he mainly uses to seek immediate gratification of his internal needs and desires rather than responding to external influences.
- **Anxious Style:** the user of this style is strongly influenced by external source of information but tend to 'close out' internal sources of information. He has developed a moderately symbolic level of conceptual ability which he mainly uses to impress other people so as to get their admiration and approval rather than act on his own conviction.
- **Creative Style:** this individual is maximally open to influence of both internal and external sources of information. Because he has a high level of conceptual development, he can symbolically process both internal and external sources of information in deciding which source to allow influence his behavior.

### **2.5.1 Convergent and Divergent Thinking and Academic Performance in Science**

Tresa (2004) explained that human learning and the mechanisms it involves has attracted the attention of scholars for many centuries and different accounts have been put forward to capture different aspects of such learning. However, the recent history of learning started by behaviorists who believed that learning is defined by the outward expression of new behaviors. They focused solely on observable behaviors. They believed in a biological basis for learning. Nevertheless, this was criticized for failing to account for processes taking place in the mind that cannot be observed. This led to cognitivism. "Mental processes such as thinking, memory, knowing, and problem-solving need to be explored". The best teachers are those who equip their students to think for themselves. Greekz (2014) believe that teachers' critical thinking is highly intertwined with teachers' pedagogical success. As teachers' success is, in some ways, related to students' engagement, teachers' critical thinking which is interconnected with educational performance may affect students' engagement subsequently. Critical thinking is not a matter of accumulating information. Paul (2008) opined that a good critical thinker must not necessarily have a good memory or knows a lot of facts. A critical thinker is able to deduce consequences from what he knows, and he knows how to make use of information to solve problems, and how to seek relevant sources of information to inform him. Alsagoff (2012) supported that critical thinking consists of a mental process of analyzing or evaluating information to offer evidence and reasoning, and to form judgments about the facts.

Nezhad (2013) reported that convergent thinking is a term proposed by Hudson in 1967 as the opposite of divergent thinking. Williams (2003) defined convergent thinking as the process of finding a single best solution to a problem that we are trying to solve. While divergent thinking is the process to create several unique solutions intending to solve a problem. The process of divergent thinking is spontaneous and free-flowing, unlike convergent thinking, which is systematic and logical. Akbari (2011) opined that when using convergent thinking, we use logical steps in order to choose the single best solution. By using divergent thinking, instead

of only choosing among appointed options, we search for new options/ Convergent thinking stands firmly on logic and less on creativity, while divergent thinking is mostly based on creativity. Sandless (2003) stressed that we use divergent thinking mostly in open-ended problems that creativity is a fundamental part.

Lipoff (2012) studied on attractiveness of students with convergent and divergent learning styles to teachers with convergent and divergent learning styles. He mentioned that convergers have been described as favored over divergers by teachers. Although Guilford (2001) found both convergent and divergent students to be equal in scholastic performance. Ann (2003) studied the relation between creativity and convergent and divergent methods of teaching spelling. He found that there is no significant difference in performance between students taught by a convergent method and students taught by a divergent method.

Nezhad (2013) verified that convergent thinking emphasizes recognizing the familiar outcome, reapplying techniques, and accumulating information. Divergent thinking, however, causes the learner to generate and evaluate many creative ideas and draw unexpected connections. Koe (2005) studied the effects of convergent and divergent teaching methods on students' performance on two biology problem-solving tasks. The purpose was to investigate the interaction between the convergent and divergent teaching methods and the thinking style (either convergent or divergent) of the learner. Convergent thinkers scored significantly higher than divergent thinkers on both dependent measures. According to Akbari (2011) convergent and divergent students can be identify easily by their areas of interest. That convergent students rely heavily on reading and experiment to process information while divergent students rely heavily on listening and watching to process information. Kolb (2008) stated that convergent and divergent students are very different in their learning styles but they can both benefit greatly from working with one another. Kolb (2008) continued to explain the classroom mode of thinking of the convergent and divergent dimension and stated that:-

- Both convergers and divergers required school curriculum and appropriate teaching padagogy to be diversified enough to accommodate their thinking style.
- Informal school system should be advocated to encourage divergent thinking. This demands the flexibility of the instruction to enable students collect data through projects, educational tour, group work, interactions guided laboratory investigation collateral learning strategies and so on,
- Teachers should develop a knowledge based upon which students can build and come out with a variety of reasonable solutions to problems,
- Students should be encouraged to interact with accomplished models to enable them become original and imaginative.
- Elements or creativity such as fluency, originality flexibility should be introduced into the teaching learning process,
- Knowledge on students' cognitive style will be valuable in counseling them on their academic and career choices. This is particularly important in Nigeria today where few objective criteria like scholastic aptitudes or vocational interest tests exist for counselors to base their advisory services upon.
- Teachers should know which of their students are good at convergent or divergent thinking and regard them as desirable students or learners,
- Teachers in most times do not recognize students competent in divergent thinking and are likely to rate them as the sort of learners they like to have. In a similar study Wallack (2005) noted that both convergent and divergent thinking are clearly intellectual performances. It is therefore, reasonable to ask how we may encourage convergent and divergent thinking strategies since society needs the services of more creative scientists than it does of creative artists. Therefore, this present study will be carried out to investigate the effects of collateral learning strategy on attitude and

performance in genetics among convergent and divergent senior secondary school II Biology students of Suleja, Niger State.

### **2.5.2 Personality Characteristics of Convergent and Divergent Thinkers.**

This section of the literature review seeks to highlight the personality characteristic of convergent and divergent thinkers to serve as a guide in pursuing the major objective of the study. Studies by Lipoff (2012) indicated that convergers, are usually authoritarian masculine, unemotional and sober, while divergers are liberal, feminine, emotional and humorous. He further explained that convergers are more likely to change their opinion than the divergers when alternative judgment is given to them from authority. It was also observed that divergers preferred humour and emotion in contrast with the convergers preferences for sobriety and lack of emotion. Akbari (2011) also reports some personality traits of the dimension when he administered masculine - feminine test and discovered that the convergers saw the female pictures as far less wholesome exciting strong and safe. In other words the convergers were seen to be more sympathetic with the male picture than the female picture. This to Hudson is an indication that the convergers are masculine whereas the divergers are feminine furthermore his projective test found that, the convergers stories and descriptions were discovered to be more adventurous which is also a traditionally masculine area. The implication of these findings is that, the convergers are seen to be more authoritarian because they are obedient to authority. He further explained that they are rigid and social conformists.

They are good mannered and easily get along with other people. The divergers on the other hand are known to be emphatic about their beliefs that are self-confident fastidious and do not consider it desirable to obey authorities especially in skills and professional advice. Unlike the convergers, the diverges are feminine and often ask questions which often destabilize the teachers and this keeps them in the negative record of the teachers. Convergers are confident and derive their satisfaction from their own work more than from external reinforcement from anywhere. They are known to be disinterested in formal classroom work. They either see it as

too familiar, uninteresting, unstimulating or simply disinterested. They prefer to engage in the area of their own interest. This would be the possible reason why they are thought to be unserious and probably marked down by teachers. But they are liberal, emotional humorous and are pleasant people. Therefore an understanding of the personality characteristic of convergent and divergent thinkers is desirable for this study because this will help the teacher in designing the appropriate teaching strategies that will enhance better academic performance and enhance positive attitude toward learning of genetics to the senior secondary school students.

### **2.5.3 Identification of Convergence and Divergence Thinkers**

There are several instruments used in the categorization of convergence and divergence thinkers. In the early days, tests of creativity were used to determine convergence and divergence thinking but in recent years researchers have been using varieties of instruments to identify these dimensions. Greeks (2014) observed that unusual means have been employed for this purpose including a situation where a subject is asked to think of as many uses of an object as possible. Another approach is the consequences tests here the subject are asked to answer such questions like what would be the result if everyone suddenly loses the sense of balance and can no longer stay in an upright position? Here the subjects are expected to list as many reactions as possible. Another test used for this purpose was Anagram test. In this test the subjects are given a word such as "creativity" and asked to make as many new words as possible by rearranging the letters. Each of these tests can be scored for fluency, flexibility, novelty and originality.

The basic criterion to identify divergence thinking is generally known to include fluency, novelty, originality and spontaneity of thought and appropriateness or usefulness of production. These criteria are also true of creative production. Wallach (2005) and Guilford (2001) have utilized varieties of tests for the purpose of identifying and studying divergent and convergent cognitive styles.

Gray (2009) has presented some of these tests employed by the above author.

- Uses of Objects or Unusual Uses of Things: In these tests subjects were required to think of as many uses of common objects or words presented to them in a situation as possible. The numerosity and the originally or the unusual nature of responses are used as basis for classifying convergent and divergent production. Kolb (2008) and Adamu (2010), used Objects and Things Tests (OTT) for the determination of convergent and divergent students. This test contains six (6) common objects in form of specimens and the students were asked to write five (5) uses of each. Each correct answer attract 1 mark and the total marks for each object is 5 marks while the grand total for all the SIX (6) objects is 30 marks (i.e 5 marks x 6 objects = 30 marks) as showed below:

- a. Basket (BS) = 5 marks
- b. Knife (KF) = 5 marks
- c. Bucket (BT) = 5 marks
- d. Cup(CP) = 5 marks
- e. Spoon (SP) = 5 marks
- f. Broom (BM) = 5 marks

Total = 30 marks

The test was scored over thirty (30) and was used for the classification of convergent and divergent thinkers on a scale of 0 - 14 marks Convergent and 15 -30 marks Divergent (Kolb 2008 and Adamu,2010).

- The Line Meaning Tasks (LMT): This test involves visual stimulation materials in which the subjects are confronted with about eight or more to generate meanings relevant to each of the line in questions. The complexity of production and meaningfulness are used for classifying convergence and divergence thinkers.
- Drawing Completion: Here the subject will be requested to meaningfully complete a stimulus line or an uncompleted meaningless diagram. "The details included

in the completed exercise and the meaningfulness of the completed exercise as well as the originality of production will add up to distinguish the convergent from divergent.

- **Projection Test:** In the projection test, the subject is made to respond to a hand drawing or stimulus picture on every under scenery. This test is very similar to the Thematic Apperception Test (TAT). Since the stimulus picture is meaningless and conveys nothing concrete. The subject is induced to bring out his interest, disposition and personality. The focus of interest in this test is the details of originality and the level of interest in the production, it should be noted that the major difficulty in the use of these tests is the technicality of scoring and the interaction of intelligence in the open-ended test production. It is very difficult to come up with very objective scores on the open-ended test itself. Adequate care should therefore, be taken in scoring the test in order to be sure of reliability. Usually two or three scores will ensure the scorer's reliability. For the experimental purposes in the above tests divergent thinkers in most cases score high than their convergent counterparts. The isolation of the highest 25% of the subjects turned out to be the divergent individuals while the lowest 25% scores indicate the convergent individuals. Also researchers consider the highest scores in intelligence test as convergent. Nezhad (2013) reported that the convergers score more in intelligence test and low in open-ended test. The converger is more comfortable with mathematics and physical sciences. The diverger on the other hand scores low in intelligence test but scores higher in open-ended test. Diverger is more at home with arts subjects and humanities. Ability identification of convergers and divergers addressed in this section of the literature review puts the study in perspective about the varying dimensions of their abilities which is a sure guide to this research work.

## **2.6 Gender and Academic Performance in Biology**

In Nigeria, reports from a study by Akanbi (2004) requesting female and male adolescents to indicate their choices of subjects revealed that the adolescents selected different

courses that followed gender stereotype. Males prefer mathematics and sciences while the females opted for reading and if science, life sciences (Biology). Many research works carried on gender effects on academic performance have shown proportionately low performance of females in biology education programmes and careers. Bichi (2002) defines gender as the amount of masculinity and femininity found in a person and obviously while there are mixtures of both in most human beings, the normal male has a preponderance of masculinity and the normal female has a preponderance of femininity. Striving after academic achievement in science conflicts with the traditional female role in many societies. Right from childhood, a males traditionally receives more training and encouragement for performance than females. According to Oloyede (2011) a drop in academic performance of many females during adolescent is the side effect of their new concentration on personal appearance.

Olorunde (2011) supported that there is sex difference in subject choice and in academic performance within the subjects and that School subjects are sex - stereotyped such that mathematics, physical sciences, computing and engineering for example are regarded as masculine subjects while humanities, languages, domestic subjects are regarded as feminine. Research findings of Fakorede (2009) pointed out that male students are academically superior to their female counterparts in science. Aigbomian (2002) reported that males perform better than females in science, Technical and Mathematical subjects. Ogunkola and Olatoye (2010) still raised the concern and worry that female performance in Science, Technology and Mathematics is not encouraging. Nwaiwu and Audu (2005) in the same vein agreed, that, the number of female enrollment in tertiary education has increased at a slower rate than male enrollment. Adesoji (2009) viewed gender gap in education to be very wide with male enrollment at least three times higher than females. This development perhaps has resulted from the fact that females still have the difficulty of understanding the physical sciences notably Biology as observed by (Aigbomian, 2002). Nwagbo (2005) reported female science student's

appreciation of the role of science as much as their male counterparts but lagging behind in knowledge, application and communication in science. However, Jacinta (2011) revealed that exposure to science process skills based learning involving activities for both males and females yield more effective learning irrespective of gender and ability level. Ogunboyede (2013) in line with Jacinta (2011) reported that males are not better than females in terms of educational performance in his study of sex difference and students' performance at the primary school level.

Ndirika (2015) suggest that gender - stereotyping has to be discouraged in homes, schools and societies to enable females participate freely in the learning of Biology and genetics in particular. Therefore, this research was carried out to investigate the effects of Collateral Learning on gender among convergent and divergent secondary school II student in genetic concepts of Biology.

## **2.7 Attitude and Academic Performance in Biology**

Attitude is acquired through learning and can be changed through persuasion using variety of techniques. Attitudes, once established, help to shape the experiences the individual has with object, subject or person. Although attitude changes gradually, students constantly form new attitudes and modify old ones when they are exposed to new experiences. Gagne (1979) defined attitudes as an internal state that influences the personal actions of an individual. He recognized attitudes as a major factor in subject choice. He considers attitude as a mental and neutral state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual's responses to all objects and situations with which it is related. Akinbobola (2012) explain that teachers have the opportunity of structuring lessons cooperatively, competitively or individualistically and the decisions teachers make in structuring lessons can influence students' interactions with others, knowledge and attitudes.

Teaching strategies can also influence the attitude of students positively or negatively, Ajewole (2001) reported that students taught using cooperative learning strategy in science has

positive attitude to the educational benefits derived from group work. Erdemir and Bakirci (2009) stressed that conceptual change instructional strategy significantly improved students' attitude towards science (Biology). Aliyu (2014) founded out that Collateral Learning help students develop a significantly more favorable attitude to Biology subject than the lecture method and hence enhanced students' cognitive performance in biology at senior school level. Also, Lakpini (2013) suggest that the attitude of students is likely to play a significant part in any satisfactory explanation of variable level of performance shown by students in their school science subject. While Eta (2000) stated that many students develop negative attitudes to science learning, probably due to the fact that teachers are unable to satisfy their aspiration or goals. Usman (2010) showed that there is positive correlation between attitudes and performance in the Biology subject.

Other studies such as Muraya and Kinamo (2011) attributed students' poor performance in Biology to poor teaching methods, unqualified and inexperienced teachers, poor student attitude toward Biology, poor learning environment and gender effect. To combat the negative attitude towards Biology and the enduring problem of high dropout rates with Biology course new initiatives must be implemented into the classroom. Adesina and Akinbobola (2005) highlighted five conditions to help promote persistence within a course; which include expectations, support, feedback, involvement and learning. This study highlights how inclusion of Collateral Learning Strategy can offer the opportunity to integrate these five conditions into a Biology classroom thus enhancing the performances of students and improve their attitudes towards Biology subject.

## **2.8 Overview of Similar Studies**

Various studies have been conducted in Nigeria examples Adamu (2010), Yusuf and Afolabi (2010), Umar (2011), Ajaja (2013) and Aliyu (2014) and elsewhere in the world like Koe (2005), Medenegerze (2008), Sutherland (2008) and Lipoff (2012), that are either directly

or indirectly related to this study. In this section the researcher looked at some of these studies one after the other. Related research studies have demonstrated the educational soundness of Collateral Learning.

Koe (2005) investigated the effects of Convergent and Divergent Learning Strategy on performance in Biology among secondary school students of California, America. The design of the study was quasi experimental, specifically the pre-test, post-test, non-equivalent control group design was used. The sample consisted of sixty three (63) secondary Biology students 43 female and 20 males were randomly drawn from two secondary schools in California America. The instrument used was Convergent and Divergent Biology Performance Test (CDBPT) there are three research questions and three null hypotheses in the study. The data collected was analyzed using mean, standard deviation to answer the research questions while t-test and analysis of covariance (ANCOVA) were used to test hypotheses at 0.05 level of significance. The findings of the study showed that Convergent and Divergent Learning Strategy was more effective in fostering convergent students performance than the divergent students. The interaction effect between the learning strategy and gender of the subjects was not significant. That there is no significant interaction effects between instructional strategy and gender on performance. Therefore, the present study unlike Koe (2005) was carried out to investigate the effect of Collateral Learning Strategy on Attitude and Performance in Genetics among Convergent and Divergent Senior Secondary School II Biology Students in Suleja, Niger State of Nigeria.

Medinajerez's (2008) investigated the effect of Collateral Learning Strategy on urban students' performance in Biology in Eastern Columbia. The design of the study was quasi-experimental which involved pre-test and post-test control group design. The instrument used was Biology Performance Test (BPT). A total of 140 students consisting of 66 males and 77 females were selected by simple random sampling technique from a population of 721 senior

secondary school two Biology students drawn from all the public secondary school in eastern Morobin of Columbia. The study stated four null hypotheses. The data collected were analyzed using t-test and analysis of variance (ANOVA). Findings of the study revealed that Collateral Learning Strategy enhanced the performance of urban students and also showed that science teaching that ignores cultural alienation and does not acknowledge cultural difference including epistemological, ontological and axiological differences will fail most students. The present study unlike Medinajerez's (2008) was carried out to examine the effect of Collateral Learning Strategy on Attitude and Performance among Convergent and Divergent Senior Secondary School II Biology Students in Suleja, Niger State.

Sutherland (2008) carried out research on the effect of Collateral Learning on Performance in Biology among secondary students of Cree ancestry in central Canada. The design of the study adopted quasi-experimental pre-test and post-test control group design. The instrument used was Biology Students Performance Test (BSPT). A sample of 101 SSI Biology students were drawn from a population of 670 public senior secondary school students using simple random sampling technique. Three research questions and three null hypotheses were stated for the study. The data was analyzed using mean, standard deviation, t-test and ANOVA statistics at 0.05 level of significance. Finding of the study revealed that cross cultural pedagogy (Collateral Learning) lead to successful programs in teaching and learning of Biology. Also the findings shows that when teaching cross cultural school science, teachers learn to build bridges between the modern science culture and the students communal culture, which make teaching and learning of Biology subject meaningful and more effectiveness. Thus, it is in line with these facts, the present study unlike Sutherland (2008) investigate the effect of Collateral Learning Strategy on attitude and performance in genetics among convergent and divergent senior secondary school II Biology students in the classrooms interactions.

Yusuf and Afolabi (2010) investigated the effect of Collateral Learning Strategy (CLS) on secondary school students' performance in Biology in Oyo State Nigeria. The instrument

used was Biology Performance Test (BPT). The sample of the study comprised of 120 first year senior secondary school students (SS1) sampled from three private secondary schools in Oyo state, Nigeria. The study adopted a quasi-experimental design. There are four research questions and four null hypotheses in the study. The students pre-test and post-test scores were subjected to mean, standard deviation and t-test. The finding of the study showed that the performance of students exposed to CLS either individually or cooperatively were better than their counterpart exposed to lecture method. However, no significant differences existed in the performance of male and female students exposed to CLS either individual or cooperative settings. The present study unlike Yusuf and Afolabi (2010) was carried out to determine the effects of Collateral Learning Strategy on gender differences in performance among convergent and divergent senior secondary school II Biology students in Suleja, Niger State.

Adamu (2010) conducted a similar research on the effects of Collateral Learning on Performance and attitude in Biology concepts among selected senior secondary school students in Katsina State, Nigeria. Biology Performance Test (BPT) and Biology Attitude Questionnaire (BAQ) were used to obtain information for the study. The design of the study was Quasi-experimental which involved pre-test and post-test control group design. The sample of the study consisted of 110 Biology students in two interactive classes. Four research questions were raised with four null hypotheses. The hypotheses were tested using t-test, u-test statistics at 0.05 level of significance. The fourth hypothesis was tested using analysis of variance (ANOVA) statistics while the research questions were tested using mean and standard deviation statistical tools. The major findings of this study included: a significant difference in the mean scores between pre-test and post-test of Biology students; a significant difference in the mean scores between students exposed to Collateral Learning Strategy and those who were not exposed, it showed that students exposed to Collateral Learning performed better than those who were not exposed. It was concluded that Collateral Learning Strategy enhanced students understanding of Biology, improved students' attitude towards Biology and significantly influenced

their performance in the subject. The present study unlike Adamu (2010) find out the effect of Collateral Learning Strategy on Attitude and Performance in Genetics among Convergent and Divergent Senior Secondary School II Biology Students in Suleja, Niger State.

Umar, (2011) investigated the effects of Collateral Learning Strategy on Performance in Biology among Senior Secondary School Students of Toto, Nasarawa State, Nigeria. The design of the study was quasi experimental, specifically the pre-test, post-test, non-equivalent control group design was used. The sample consisted of one hundred and eleven (111) senior secondary one Biology students 60 males and 51 females were randomly drawn from two senior secondary schools in Toto, Nasarawa State. The instrument used was Biology Performance Test (BPT) there are three research questions and three null hypotheses in the study. The data collected was analyzed using mean, standard deviation to answer the research questions while t-test and analysis of covariance (ANCOVA) were used to test hypotheses at 0.05 level of significance. The findings of the study showed that Collateral Learning Strategy was more effective in fostering students' performance than the lecture method. The interaction effect between teaching method and gender of the subjects was not significant. That there is no significant interaction effects between instructional method and gender on performance. Therefore, the present study unlike Umar, (2011) was carried out to investigate the effect of Collateral Learning Strategy on gender among Convergent and Divergent Senior Secondary School II Biology Students in Suleja, Niger State.

Lipoff (2012) conducted a similar research on the effects of Convergent and Divergent Learning Strategy (CDLS) on secondary school students' performance in Biology in Nairobi, Kenya. The instrument used was Convergent and Divergent Biology Performance Test (CDBPT). The sample of the study comprised of 96 second year senior secondary school students from the three sampled public secondary schools in Nairobi, Kenya. The study adopted a quasi-experimental design. There are four research questions and four null hypotheses in the

study. The students pre-test and post-test scores were subjected to mean, standard deviation, t-test and F-test. The finding of the study showed that convergent student performed better than their counterpart divergent either exposed individually or cooperatively. However, no significant differences existed in the performance of male and female students exposed to Convergent and Divergent Learning Strategy either individual or cooperative settings. The present study unlike Lipoff (2012) was carried out to determine the effects of Collateral Learning Strategy on Gender Differences in Attitude and Performance among Convergent and Divergent Senior Secondary School II Biology Students in Suleja, Niger State.

Ajaja, (2013), investigated the effect of Collateral Learning Strategy on attitude and performance in Biology. The major purpose of the study was to determine the effects of Collateral Teaching Strategy on students' attitude and academic performance in Biology in Emure Metropolis, Ekiti State, Nigeria. The design of the study was Quasi-experimental involved pretest and posttest control group design. The sample of the study contained 100 Biology students in two intact classes. Four research questions and four null hypotheses were used for the study. Biology Performance Test (BPT) and Biology Attitude Questionnaire (BAQ) were used to obtain data. The first two hypotheses were tested using t-test statistic at 0.05 level of significance, the third hypothesis was tested using Mann Whitney and the fourth hypothesis was tested using the analysis of variance (ANOVA) Statistic while the research questions were tested using mean and standard deviation statistical tools. The major findings of the study included a significance difference in the mean scores between pretest and posttest of the students, a significant difference in the mean scores between students exposed to Collateral Learning Strategy and those who were not exposed, it showed that student exposed to Collateral Learning performed better than those who were not exposed. The findings of the study also shown that there is no significant different in the attitude of the students exposed to Collateral Learning Strategy. It was concluded that Collateral Learning Strategy enhanced students

understanding of Biology, improved students' attitude toward Biology and significantly influenced their performance in Biology. Therefore, the present study unlike Ajaja, (2013), was investigated the effects of Collateral Learning Strategy on attitude and performance in genetics, among convergent and divergent secondary school Biology students.

Aliyu (2014) examined the effects of Collateral Learning Strategy on achievement and retention in some Biology concepts among senior secondary school students in Minna, Nigeria. gender and age differences in the achievement of students taught with Collateral Learning Strategy were also examined. The pre-test, posttest, experimental control group research design was employed. Simple random sampling technique was used to select 40 students (20 Males and 20 Females) for the study. The instrument used was Biology Performance Test (BPT). Four research questions and four null hypotheses were raised for the study. The data was analyzed using mean, standard deviation, t-test and analysis of variance (ANOVA) statistics at  $\alpha$  0.05 level of significance. The findings revealed that there is significant difference in the mean achievement scores of students in experimental and control groups. That the experimental group performed better than the control group. Also the finding showed that there was no significant difference between the mean scores of male and female students taught using Collateral Learning Strategy, implying that Collateral Learning Strategy is gender friendly. Thus, it can be deduced that the use of Collateral Learning Strategy enhanced the performance of both male and female students equally. Therefore, the present study unlike Aliyu (2014) was carried out to determine the effect of Collateral Learning Strategy on Attitude and Performance in Genetics among Convergent and Divergent Secondary school II Biology Students of Suleja, Niger State, Nigeria.

Duniya (2016) the study was carried out to determine the impact of Laboratory Instruction on attitude, science -processes-skills and Performance in Biology of Convergent and Divergent Secondary School Students, Kaduna State, Nigeria. The research design used for the

study was quasi-experimental design employing pretest and posttest non-randomized control group design. The study population consisted of one thousand one hundred and thirty seven (1137) SS II Biology students drawn from the twenty eight state government owned schools in Zonkwa education division of Kaduna state. The sample of the study was made up of sixty two (62) SS II students randomly chosen from the two schools in the population. The instruments used were Biology Performance Test (BPT), Test of Science-Processes-Skills Acquisition (TOPSA) and Biology Students' Attitude Test (BSAT). Data were collected and analyzed using mean and standard deviation statistic to answer the research questions and ANCOVA to test the null hypotheses at  $\alpha \leq 0.05$  level of significance. Findings from the hypotheses testing revealed a significant difference between the convergent and divergent students exposed to laboratory instruction (experimental group) and those exposed to lecture method (control group) with respect to performance science-process-skills acquisition and attitude change in favour of the convergent and divergent experimental groups. There was however no significant difference in the performance, science-process-skills acquisition and attitude change between the convergent and divergent students exposed to the lecture method at  $\alpha \leq 0.05$ . Based on these results it was concluded that the laboratory instruction enhances better performance and science-processes-skills acquisition and develops more positive attitude change in convergent and divergent Biology students than the lecture method at secondary schools. Unlike Duniya (2016) the present study investigates the effects of Collateral Learning Strategy on attitude and performance among convergent and divergent senior secondary school of Suleja Nigeria.

## **2.9 Implication of Literature Reviewed for the Present Study**

The literature reviewed clearly explained the concept of Collateral Learning Strategy of instruction. The scope of the description of academic performance as it relates to teaching/learning of sciences is shown. In the same vein, related studies covering gender mainly in Biology subject were reviewed. Koe (2005), Medinajeres (2008), Sutherland (2008),

Adamu(2010), Yusuf and Afolabi (2010), Umar (2011), Lipoff (2012), Ajaja (2013)Aliyu (2014) and Duniya (2016). Also attitude as a factor in the teaching/learning of Biology was highlighted. The related literature reviewed for the purpose of this study showed that the use of Collateral Learning Strategy in Biology instruction enhanced students performance as well as improved students attitude to Biology subject. However, the use of the lecture method of teaching has been shown to be of little help to students in enhancing performance. Reports in the literatures showed that the studies were carried out without considering cognitive styles of the students (convergent and divergent learning style). In the light of this reports the researcher deem it necessary to employed the use of Collateral Learning Strategy to teach the genetic concepts among convergent and divergent senior secondary school II Biology students. Therefore, this study was focuses on Collateral Learning Strategy on attitude and academic performance of students in genetics among convergent and divergent senior secondary school two Biology students of Suleja, Nigeria. From the literature reviewed so far, Collateral Learning Strategy was found to have had strong theoretical support. Collateral Learning Strategy was embedded in meaningful learning theory of Ausubel (1963) which emphasized the importance of prior knowledge and active role of students in the learning process. This active role allowed students to interact with one another and construct their own knowledge. According to Alwater (2006) meaningful learning theory was said to have an important place in Biology teaching and learning at senior secondary school. From the reviewed related studies it was discovered that not much attempt had been made to find out the effect of Collateral Learning Strategy on attitude and performance in genetics among convergent and divergent senior secondary school two Biology students. This research is unique from other studies reviewed, because it involves the use of attitude, performance and cognitive style (Convergent and Divergent Learning Style) unlike other studies that used only performance and attitude.

## **CHAPTER THREE**

### **METHODOLOGY**

#### **3.1. Introduction**

The aim of this study is to investigate effects of Collateral Learning Strategy on attitude and performance in genetics concept among Convergent and Divergent Senior Secondary School II Biology Students. This chapter outlines the methodology of the study under the following sub-headings:

3.2 Research Design

3.3 Population of the Study

3.4 Sample and Sampling Procedure

3.5 Instrumentation

3.5.1 Validity of Instruments

3.6 Pilot Testing

3.6.1 Reliability of Instruments

3.6.2 Items Analysis

3.7 Administration of Treatment

3.8 Procedure for Data Collection

3.9 Procedure for Data Analysis

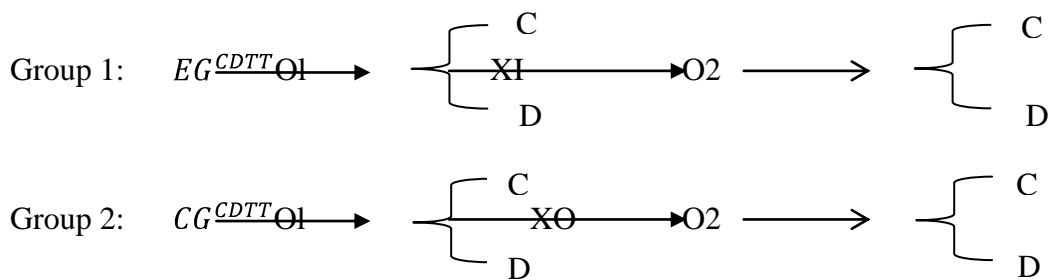
#### **3.2 Research Design**

This study employ pretest posttest quasi-experimental control group design. The study used two groups: experimental and control. Experimental group (EG) was exposed to be experimental treatment ( $X_1$ ). That is, teaching using Collateral Learning Strategy. While control group (CG), was group taught using lecture method ( $X_0$ ). This design have been prescribed by Kerlinger (1973) and used by Bichi (2002), Lawal (2007), and Aliyu, (2014). Two intact classes (one experimental and one control groups) were used for the study. The two study schools both experimental and control groups was selected from the four pre-tested schools out of the study

population. The essence of pre-testing is to ensure selection of samples that are not significantly different in abilities in terms of academic performance before the treatment. Test was given to both experimental and control groups to identify convergent and divergent students. Also Genetic Concepts Attitude Questionnaire was given to only experimental group to determine the attitude of the students before the treatment. The two groups were taught Genetic Concepts for a period of Six weeks. Posttest (O<sub>2</sub>) was administered after treatment to determine the effect of the two instructional strategies on students' Attitude and Performance in Genetics Concept. Kerlinger (1973) and Sambo (2008), affirmed that this design offer numerous advantages such as:

- It revealed whether or not a particular instructional strategy is superior over the other.
- It can be used to identify differences in the groups at the beginning of the study.
- It is an indicator for gaining mastery of the concepts selected.

The research design of the study is represented in Figure 3.1.



**Fig.3.1:** Research Design

Source: (Adapted from Sambo, 2008)

**Keys:**

- EG = Experimental group
- CG = Control group
- XI = Treatment (Teaching using Collateral Learning Strategy)
- XO = No treatment (Teaching using Lecture Method only)
- O<sub>1</sub> = Pre-test administration
- O<sub>2</sub> = Post-test administration
- C = Convergent Thinker
- D = Divergent Thinker
- CDTT = Convergent and Divergent Thinker Categorization Test

### 3.3. Population of the Study

The population for this study covered all public senior secondary schools (SS II) offering Biology in Suleja Education Zone of Niger State. According to Suleja Educational Zone (2016) there are eight public senior secondary schools with population of 2263 Senior Secondary School II Biology students in the study area. From this figure, 1380 were male while 883 were female with average age of 16 years. The schools are public, operating as day and boarding schools and offer Biology, as a core science subject out of the eight school two (2) were single sex (that is, one male one female) while six (6) others schools were co-educational (mixed schools). Detail of the population of this study is summarized in Table 3.1.

**Table 3.1: Population of the Study**

S/N	School	School Location	School Types	Male	Female	Total
1	CDSS Suleja	Old Army Barrack Suleja	Co-educational	213	89	302
2	CDSS Madalla	Madalla Suleja	Co-educational	129	103	232
3	GMSS Suleja	Anguwar Iya Suleja	Co-educational	331	167	498
4	GDSS Maje	Maje Suleja	Co-educational	131	64	195
5	SBTC Suleja	Kwamba Suleja	Co-educational	139	34	173
6	GDSS Kwamba	Kwamba Suleja	Co-educational	113	75	188
7	GGSS Suleja	Anguwar Gayan Suleja	Female	-	351	351
8	GSS Suleja	Kantoma Bridge Suleja	Male	324	-	324
	Total			1380	883	2263

Source: Suleja Education Zone, (2016).

### 3.4. Sample and Sampling Technique

To select the sample, initially four schools were selected from the population of the study listed in Table 3.1 through simple random sampling using hat draw method. The four schools chosen are co-educational and includes Government Day Secondary School Kwamba, Government Day Secondary School Madalla, Community Day Secondary School and Government Model Secondary School, all schools were located within Suleja metropolis of

Niger State. According to William (2003) random sampling is a sampling procedure which assures that each element in a population has equal chance of being selected. A pretest was administered to the subjects of the four schools chosen for the purpose of comparability of academic ability. Two schools with close academic performance equivalence were selected as the sample of this study. The result obtained from the pretest was subjected to analysis of variance (ANOVA), the four schools showed no significant difference out of which two schools were randomly picked (Appendix N).

Simple random sampling technique involved balloting with replacement was used to select the study sample schools. The first two schools picked from the pretested schools was used for the study. The first school picked served as experimental group while the second school picked served as control group. Two intact classes one from experimental school and one from control school were drawn using balloting without replacement. This was to ensure that every students in the population had equal chance to participate in the study. Since all the schools in the population are at different locations, it was assumed that interaction will not occur between the groups during the period of treatment, which could affect the result of the study. There are 93 SSII Biology students in experimental group and 82 in control group, 105 males and 70 females. The choice of the sample size for the study is in line with central limit theorem which recommended minimum of thirty sample size as noted by Sambo (2008). This suggests that the minimum of 30 sample size is viable for experimental research. The detail of the sample is presented in Table 3.2

**Table 3.2: Sample for the Study**

<b>Group</b>	<b>School</b>	<b>Male</b>	<b>Females</b>	<b>Total</b>
Experimental	CDSS Suleja	57	36	93
Control	GMSS Suleja	48	34	82
Total		105	70	175

Source: Researcher (2016).

### **3.5. Instrumentation**

Three research instruments were used by the researcher for data collection. These are:

- Convergent and Divergent Thinker Test (CDTT) of Kolb (2008) and Adamu (2010)
- Genetics Concept Performance Test (GCPT)
- Genetics Concept Attitude Questionnaire (GCAQ).

#### **3.5.1 Convergent and Divergent Thinkers Test (CDTT)**

Several tests have been used for the categorization and determination of these two cognitive styles dimension (i.e divergent and convergent thinker)such as:-

- Uses of Objects and Things Tests (UOTT).
- Line Meaning Tasks (LMT),
- Drawing Completion Test (DCT)
- Project Tests (PT)

The one adapted for this study is that of Kolb (2008) and Adamu (2010).The test is called the "Modified Use of Objects and Things Tests" (MUOTT) for the determination of convergent and divergent students. This test contains six (6) common objects in form of specimens and thestudents were asked to write five (5) uses of each in eight minutes.Each correct answer attract 1 mark and the total marks for each object is 5 marks while the grand total for all the six(6) objects is 30 marks (i.e 5 marks x 6 objects = 30 marks)as showed below:

- a. Basket (BS) = 5 marks
- b. Knife (KF) = 5 marks

- c. Bucket (BT) = 5 marks
- d. Cup(CP) = 5 marks
- e. Spoon (SP) = 5 marks
- f. Broom (BM) = 5 marks

Total = 30 marks

The test was scored over thirty (30) and was used for the classification of convergent and divergent thinkers on a scale of 0 - 14 marks Convergent and 15 -30 marks Divergent (Kolb, 2008 and Adamu,2010), (Appendix J and K).

### **3.5.2. Genetic Concepts Performance Test (GCPT)**

The instrument was 40 items performance test adapted from WAEC and NECO pass questions of (2005-2015) by the researcher to determine the performance of students in genetic concepts. The instrument developed from the genetic concepts, of Senior Secondary School Biology syllabus (Table 3.3). The (GCPT) items consists of 40 objectives (multiple type) test items each with four alternatives A-D (Appendix A). The items took into consideration all the five topics of senior secondary school Biology syllabus on genetics to ensure equal distribution of the items over the topics. The number of questions and weight allocated to each topic are showed in Table 3.3.

**Table 3.3- Table of Specification for (GCPT) Based on Topics Selected**

S/N	Topics Selected	Items						Total (100)	Weight (%)
1	Genetics terminologies	1,7	3	4	34	17	40,20	8	(20)
2	Transmission and expression of characteristics in organisms	6,30	2,32	26	14	15	39	8	(20)
3	Chromosome the basis of heredity	5,9,10	11	29	24	23	38	8	(20)
4	Probability in genetics (Hybrid formation)	21,28	37	19,21	35	25	33	8	(20)
5	Sex determination and sex linked characters	12,16	8,31	27	13	18	22	8	(20)
<b>Total</b>							<b>40</b>	<b>100</b>	

Source:Adapted from Nsofor, (2013) & Aliyu, (2014)

### 3.5.3. Genetic Concepts Attitude Questionnaire (GCAQ).

The Genetic Concepts Attitude Questionnaire (GCAQ) is a 30 items attitude inventory questionnaire adapted by the researcher from Nwagbo (2005) to determine the attitude of students before and after treatment on genetic concepts of Biology. The items developed using the Linkert 4 point rating scale involving; Strongly Agreed (S.A); Agreed (A); Disagreed (D); and; Strongly Disagreed (S.D). Each option carries weight in the order of priority from 4-1 in positive attitude responses and from 1-4 in negative attitude responses. The students was asked to freely indicate their attitude on Genetic Concepts of Biology by simply ticking one of the four options that suit their attitude (Appendix D). From the item, maximum score is 120, minimum score is 30 and the average score is 75.

### 3.5.4 Validity of the Instruments

The validity of Genetic Concepts Performance Test (GCPT) achieved by presenting the instruments to a panel of qualified experts that include the following:

- Panel of two qualified expert with a PhD. qualification and rank of Senior lecturers in the department of Science Education, Ahmadu Bello University, Zaria.
- One experts in Biology (Cell Biology/Cytogenesis)
- Two language education specialist and two Biology teachers at secondary school level with B.A. Ed and B.Sc. Ed qualification.

The validity of Genetic Concepts Attitude Questionnaire (GCAQ) achieved by presenting the instrument to a panel of qualified experts that include the following:

- Panel of two qualified expert with a PhD. qualification and rank of Senior lecturers in the department of Education Psychology and Guidance and counseling, Ahmadu Bello University, Zaria.
- Two language education specialist and two Biology teachers at secondary school level with B.A. Ed and B.Sc. Ed qualification.

A copy of the developed items submitted to each expert listed above for content validity and requested to:

1. Study the instrument and certify if the questions were considered to be testing the academic performance and attitude of the students.
2. Examine whether the items are clear to avoid ambiguity.
3. Certify if they are appropriate for the level of the students under study
4. Check for possible errors in the instruments and suggest corrections

The validators went through the instruments and pointed out some mistake in term of spelling errors, inappropriate use of genetic concepts terms base on the students level and made recommendations on use of four linker scales instead of five which the researcher put their suggestions into consideration and effected the corrections

### 3.6 Pilot Testing

Pilot testing was conducted with a group of 30 students in one senior secondary school (GDSS Maje) that is not part of the study sample but part of the population to determine the reliability of the instruments. The school selected for this purpose is similar to those of the main study in term of location, ownership and status levels.

- Genetic Concepts Performance Test (GCPT):The instrument was administered to 30 students at the beginning of the first week and collected back for scoring. After an interval of two weeks the same instrument was re-administered to the same group of 30 students (re-test). The test scores were correlated using Pearson Product Moment Correlation (PPMC). Sambo (2008) proposed the minimum interval of two or more weeks between first and second administration (Appendix G).
- Genetic Concepts Attitude Questionnaire (GCAQ):Was also pilot tested at the Government Day Secondary School, Maje. However, unlike GCPT the GCAQ test items was administered once to the group of 30 students and split half method (odd-even) was used to test the reliability of scores on 30 students. Here, the test scores was split into two equivalent halves arranged as odd and even numbered. The test scores of the instrument were correlated using Spearman Rank Order Correlation (SROC) Appendix H.

The essence of this pilot study is to:

- Find out the characteristics of the instruments item analysis.
- determined the appropriateness of the length of time required to answer items in the two tests separately
- ascertain the appropriateness of the wording of the two instruments
- find the reliability of the instruments.
- to find out the administrative and logistics problems that may hinder the main study.

### **3.6.1 Reliability of the Instruments**

Pilot study was conducted with a group of 30 students in one Senior Secondary School that did not form the study sample, to determine the reliability of Genetic Concepts Performance Test (GCPT). The instrument was administered to these students at the beginning of the first week (test) and collected back for scoring. After an interval of two weeks, the same instrument was re-administered to the same group of students (re-test), "The use of two weeks interval can be justified by scholar view Tuckman, (1975) and Sambo, (2008) who proposed the interval of two or three weeks between first and second administration. The result of the GCPT tests was correlated, reliability coefficient of the instrument (GCPT) was determined as 0.89 using Pearson Product Moment Correlation (PPMC) method, (Appendix G).

While Genetic Concepts Attitude Questionnaire (GCAQ) test items was administered once to the group of 30 students in Government Day Secondary School Maje and split half method (odd-even) was used to test the reliability of scores on 30 students. Here, the test score was split into two equivalent halves each testees two scores, one from each half of the test and arranged as odd and even numbered items. The result of the GCAQ tests was correlated, reliability coefficient of the instrument (GCAQ) was obtained as 0.71 using Spearman Rank Order Correlation (SROC) method, (Appendix H).

### **3.7 Items Analysis**

Item analysis was carried out from the pilot study score to determine the Item Facility Index, and Discrimination Index.

Item Facility Index: Sambo (2008), defines Item Facility Index as a measure of percentage of people, candidate who got the items right over the total number of candidates that attempted the items it is determine by using the formula:

$$F = R/T$$

F = Facility Index

Where: R= is the number of candidate who got the items right

T= is the total number of candidate

Sambo (2008), further recommended that, in the research literature, items with Facility Index between 0.40 to 0.60 are accepted. For the present study, items with Facility Index of 0.40 to 0.60 was retained. Items below 0.40 are considered being too easy, and above 0.60 being too difficult. These items was modified to suit the research.

Item Discrimination Index: The Discrimination Index of the test is the ability of the test items to separate between high and low-ranking students in the entire test. To compute Discrimination Index of test items, the researcher proposed the use of the following relation:

$$D = \frac{RU - R_1}{\frac{1}{2}N}$$

Where: D = Discrimination Index of test items.

RU = number of candidate that got the items correct in the upper 27% of the group.

R<sub>1</sub> = number of candidate that got the items correct in the lower 27% of the group.

N = number of candidates in the 27% upper or lower part of the group.

Sambo (2008) posited that items of Discrimination Index of 0.40 and above are very good for the study, 0.30 - 0.39 are reasonably good, 0.20 — 0.29 are marginal items that need improvement, while items with Discrimination Index of 0.19 and below are poor items to be discarded. Thus, in this study, item above 0.40 was retained for final selecting of GCPT instrument (Appendix I).

### **3.8 Administration of Treatment**

The treatment that was administered to the subjects involved teaching the concept of genetics by the researcher using: Collateral Learning Strategy model adapted from Jegede, (2004) and Aliyu (2014). One intact Biology SS II class containing 93 students was used. The model was adapted because it has the following advantages for the present research.

- It is a students learning centered in it characteristics

- It provides opportunity for activity based teaching and learning.
- It provides room for teamwork learning.
- It identification of prior ideas step provide flexibility for collateral learning i.e. to acquired students communal beliefs and personal beliefs at the beginning of the lesson on genetics concept.

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

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

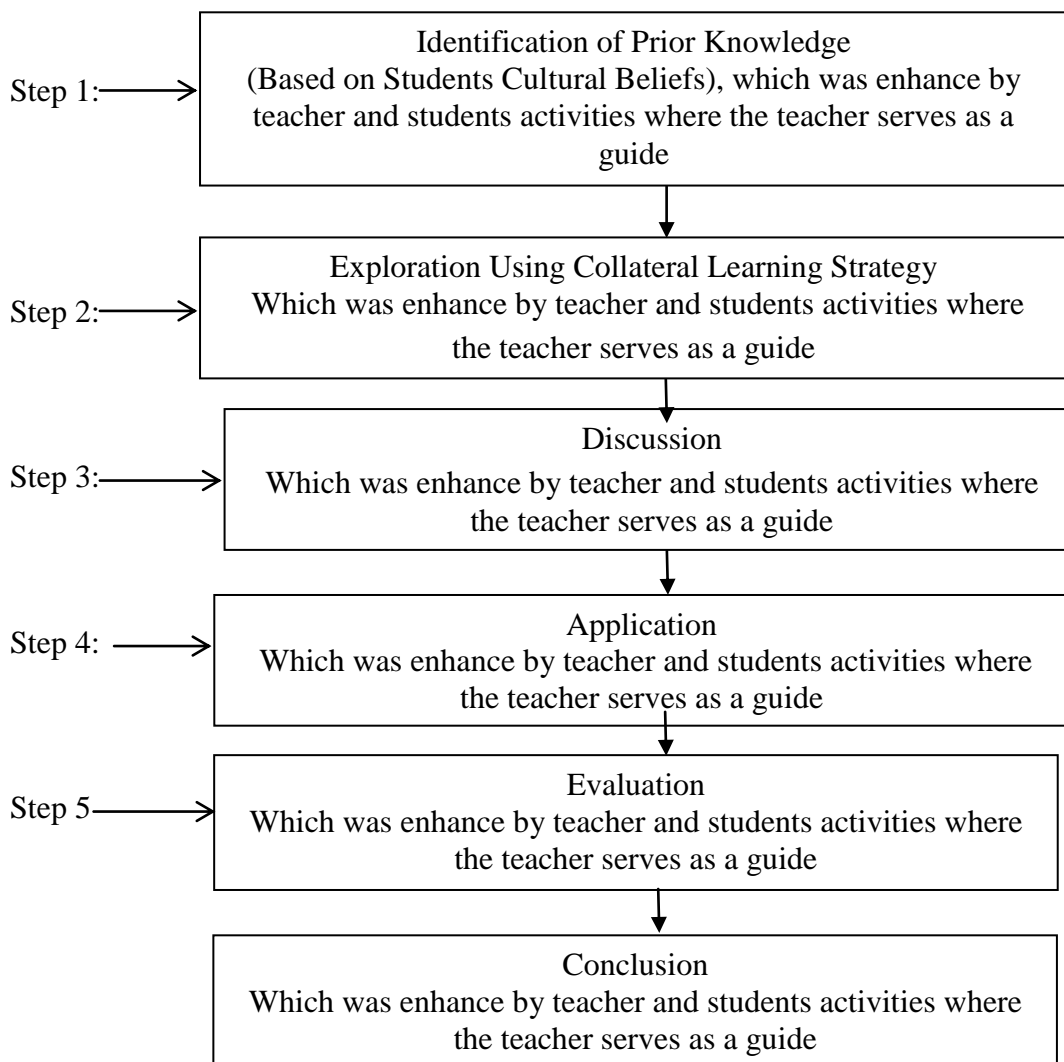
**Step 1:** Identification of prior knowledge:- The teacher introduces the lesson by guiding the students to identify various cultural beliefs on genetics and make connection from new to known.

**Step 2:** Exploration: The teacher guides the students using Collateral Learning Strategy to explain the specific objectives of the lesson through mind on and hand on activities in a group.

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

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

**Step 5:** Evaluation: The teacher guides the students to assess their knowledge, skill and abilities through answering questions and provides opportunities for teacher to evaluate students progress toward achieving the educational objectives.(See the flow-chart below)



**Fig.3.2:**Flowchart of Collateral Learning Strategy Model.

..Source: Adapted from Jegede, (2004) and Aliyu (2014).

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

The subject was taught genetic terminologies, transmission and expression of characteristics in organisms, chromosome the basis of heredity, probability in genetic (Hybrid formation), sex determination and sex linked characters. The control group was also taught the same concept by the researcher for six weeks using lecture method (Appendix F).

### **3.9 Procedure for Data Collection**

At the end of the treatment, study subjects were post-tested and data was collected through the following:

- Genetic Concepts Performance Test (GCPT): A posttest (GCPT) was given and marked using the marking scheme. Data was collected after marking the students' scripts with maximum score of 40. The scores was collated into convergent and divergent, experimental and control groups. Also the scores was further collated based on gender, i.e. male and female. After sorting out the scores, the data was subjected to analysis. This is to determine significant difference if any in their academic performance and any gender difference.

- Genetic Concepts Attitude Questionnaire (GCAQ): GCAQ was also administered as posttest on the experimental group. Data collected was subjected to statistical analysis to determine attitude change if any in the group and gender difference.

### 3.10 Procedure for Data Analysis

The students' scores from the pretest and posttests of both Genetic Concepts Performance Test (GCPT) and Genetic Concepts Attitude Questionnaire (GCAQ) were collated for analysis. The research questions was analyzed using mean and standard deviation while null hypotheses was re-stated with corresponding statistical tools for data analysis at  $P \leq 0.05$  level of significant as follows:

**H<sub>01</sub>:** There is no significant difference between the mean academic performancescores of convergent anddivergent students taught Genetic Concepts using Collateral Learning Strategy and those taught using lecture method.

ANCOVA (F-test) statistical tool was used for data analysis.

**H<sub>02</sub>:** There is no significant difference between the mean attitudescores of convergent and divergentstudents taught Genetic Concepts using Collateral Learning Strategy.

Mann Witney (U-test) statistical tool was used for data analysis.

**H<sub>03</sub>:** There is no significant difference in the mean academicperformancescores ofconvergent maleand femaleand divergent male and female students taught Genetic Concepts using Collateral Learning Strategy.

ANCOVA statistical tool was used for data analysis.

**H<sub>04</sub>:** There is no significant difference between the mean attitude scores of convergent male and female and divergent male and female students taught genetic concepts using Collateral Learning Strategy.

Kruscal wallis (H-test) statistical tool was used for data analysis.

## CHAPTER FOUR

### DATA ANALYSIS, RESULTS AND DISCUSSION

#### 4.1 Introduction

This study is titled “Effect of Collateral Learning Strategy on Attitude and Performance in Genetics among Convergent and Divergent Senior Secondary School II Biology Students of Suleja, Nigeria”. In this chapter, the result obtained from the analysis of the data collected and the discussions of the results are presented. The Statistical Package of Social Science (SPSS) IBM 23th Edition was used for the analysis.

The work is presented under the following sub-headings;

- Data Analysis and Result Presentation.
- Summary of Findings
- Discussion of the Findings.

#### 4.2 Data Analysis and Result Presentation

The data collected from the study using the instruments (GCPT) and GCAQ were analysed, the result obtained were used to answer the following research questions and null hypotheses testing's.

##### 4.2.1 Answers to Research Questions

**Research Question 1:** What is the difference in the mean academic performance scores of convergent and divergent students taught genetic concepts using Collateral Learning Strategy and those taught using lecture method?

To answer this research question one, the scores obtained from pretest and posttest were analyzed using descriptive statistics and the result is presented in Table 4.1.

**Table 4.1: Mean Scores and Standard Deviations of Students Performance for Experimental and Control Groups**

Group	N	Cognitive Level	Test Level	Mean	SD	Mean Difference
Experimental	52	Convergent	Pretest	5.87	2.08	11.06
			Posttest	16.93	2.36	
	41	Divergent	Pretest	7.59	2.14	10.21
			Posttest	17.80	2.51	
Control	48	Convergent	Pretest	5.94	2.11	7.34
			Posttest	13.28	2.71	
	34	Divergent	Pretest	7.74	2.34	6.54
			Posttest	14.28	3.53	

Table 4.1 results shows that the difference in the mean scores of experimental group convergent and divergent students are 11.06 and 10.21 respectively, while that of control group convergent and divergent students are 7.34 and 6.54 respectively. This shows that between the convergent and divergent students of the experimental and control groups there is mean difference in term of academic performance with experimental group having high scores.

**Research Question 2:** What is the difference in the mean attitude scores of convergent and divergent students taught genetic concepts using Collateral Learning Strategy?

To answer this research question two, the scores obtained from pretest and posttest were analyzed using descriptive statistics and the result is presented in Table 4.2.

**Table 4.2: Differences in the Mean Attitude Scores of Convergent and Divergent Students for Experimental Group**

Group	N	Cognitive Level	Test Level	Mean Rank	Sum of Rank	Mean Difference
Experimental	52	Convergent	Pretest	30.39	2512.00	17.92
			Posttest	48.31		
	41	Divergent	Pretest	28.38	1859.00	16.96
			Posttest	45.34		

From Table 4.2 the results of the mean rank test showed that the computed mean attitude rank scores for pretest are 30.39 and 28.38 by convergent and divergent students respectively while the computed mean attitude rank scores for posttest are 48.31 and 45.34 by convergent and divergent students respectively. From Table 4.2 result the difference between the attitude of convergent and divergent students mean different scores is 0.96 (17.92 – 16.96).

**Research Question 3:** What is the effect of Collateral Learning Strategy on the mean academic performancescoresofconvergent male and female and divergent male and female students taught genetic concepts?

To answer this research question three, the scores obtained from pretest and posttest were analyzed using descriptive statistics and the result is presented in Table 4.3.

**Table 4.3: Post-test Mean Scores and Standard Deviation of Performance for Gender Between Convergent and Divergent Students**

Group	Sex	Cognitive Level	N	Mean	SD	Mean Difference
Experimental	Male	Convergent	29	16.81	2.12	0.47
	Female	Convergent	23	17.28	2.77	
	Male	Divergent	28	17.96	2.66	0.27
	Female	Divergent	13	18.23	3.13	

From Table 4.3, the results of the descriptive statistic shows that the mean performance scores of convergent male and female students are 16.81 and 17.28 respectively, while that for divergent male and female are 17.96 and 18.23 respectively. A mean difference of 0.47 and 0.27 is therefore calculated. From the results, the difference between the male and female convergent and divergent students is 0.20 (0.47-0.27).

**Research Question 4:** What is the effect of Collateral Learning Strategy on the mean attitude scores of convergent male and female and divergent male and female students taught genetic concepts?

To answer this research question four, the scores obtained from pretest and posttest were analyzed using descriptive statistics and the result is presented in Table 4.4.

**Table 4.4 Post-test Mean Rank Scores of Attitude on Gender Between Convergent and Divergent Students for Experimental Group**

Group	Sex	Cognitive Level	N	Mean Rank	Rank Mean Difference.
Experimental	Male	Convergent	29	49.21	3.45
	Female	Convergent	23	45.76	
	Male	Divergent	28	45.21	4.67
	Female	Divergent	13	49.88	

Table 4.4 is the results of the mean rank test which showed that the computed mean ranks are 49.21, 45.76, 45.21 and 49.88 by male convergent, female convergent, male divergent and female divergent respectively with a mean rank difference of 3.45 and 4.67 respectively. From the result the difference between attitude of male and female convergent and divergent students mean rank difference score is 1.22 (4.67-3.45).

#### 4.2.2 Null Hypotheses Testing

**H<sub>01</sub>:** There is no significant difference between the mean academic performance scores of convergent and divergent students taught genetic concepts using Collateral Learning Strategy and those taught using lecture method.

To test this null hypothesis one, the scores obtained from pretest and posttest were analyzed using ANCOVA statistic and the result is presented in Table 4.5.

**Table 4.5: ANCOVA Result of Performance Between Convergent and Divergent Students for Experimental and Control Groups**

Source	Type III Sum of Squares	Df	Mean Square	F	P-Value	Remark
Corrected Model	608.98 <sup>a</sup>	3	202.99	26.82	.00	S
Intercept	41346.87	1	41346.87	5461.80	.00	S
Cognitive	37.27	1	37.27	4.92	.03	S
Group	548.74	1	548.74	72.49	.00	S
Cognitive* Group	.169.00	1	.169.00	.022.00	.88	NS
Error	1294.50	171	7.57			
Total	44600.75	175				
Corrected Total	1903.48	174				

\*Level of significant at  $P \leq 0.05$

From the result of Table 4.5 the ANCOVA (Analysis of Covariance) statistics shows that the computed P-value of intercept of 0.00 is less than the significant level of  $\alpha \leq 0.05$ . Also the computed P-value of the ANCOVA in students' groups is 0.00 which was found to be less than the significant level of  $P \leq 0.05$ . This shows that there is significant difference between the performance mean scores of experimental and control groups for convergent and divergent students. This implies that the Collateral Learning Strategy is effective for both convergent and divergent students in their genetic concepts mean performance scores. The findings of this study indicate that the performance mean scores of experimental group was higher than the control group. Therefore the null hypothesis which state that there is no significant difference between the performance mean scores of convergent and divergent students taught genetic concepts using Collateral Learning Strategy and those taught using lecture method, is hereby rejected.

**H<sub>02</sub>:** There is no significant difference between the mean attitude scores of convergent and divergent students taught genetic concepts using Collateral Learning Strategy.

To test this null hypothesis two, the scores obtained from posttest was analyzed using Mann Whitney statistics and the result is presented in Table 4.6.

**Table 4.6: Summary of Mann Whitney Result of Attitude Between Convergent and Divergent Students of Experimental Group**

Group	Cognitive Level	N	Mean Rank	Sum of Ranks	Man Whitney U	Z	P	Remark
	Convergent	52	48.31	2512.00				
Experimental	Divergent	41	45.34	1859.00	998.00	0.53	0.60	NS
	Total	93						

\*Level of significant at  $P \leq 0.05$

From Table 4.6 Results of the Mann Whitney non parametric mean rank test shows that the calculated p value of 0.60 is above the  $P \leq 0.05$  level of significant and the computed Mann Whitney U value of 998.00 is higher than the 0.53 Z scores. The computed mean attitude rank scores are 48.31 and 45.34 by convergent and divergent students respectively. The computed Sum of rank scores are 2512.00 and 1859.00 by convergent and divergent students respectively. These mean ranks are quite close. This implies that the mean attitude change of convergent and divergent students is not significantly different when both students are taught genetic concepts using Collateral Learning Strategy. Consequently, the null hypothesis which states that there is no significant difference in attitude change of convergent and divergent students taught genetic concepts using Collateral Learning Strategy, is hereby retained.

**H<sub>03</sub>:** There is no significant difference in the mean academic performance scores of convergent male and female and divergent male and female students taught genetic concepts using Collateral Learning Strategy.

To test this null hypothesis three, the scores obtained from pretest and posttest were analyzed using ANCOVA statistic and the result is presented in Table 4.7.

**Table 4.7: ANCOVA Result of Performance on Gender Between Convergent and Divergent Students of Experimental Group**

Source	Type III Sum of Squares	Df	Mean Square	F	P-Value	Remark
Corrected Model	27.79 <sup>a</sup>	3	9.26	1.56	.20	NS
Intercept	25920.49	1	25920.49	4374.21	.00	S
Sex	23.18	1	23.18	3.91	.08	NS
Group	2.86	1	2.86	.48	.49	NS
Sex *Group	.22	1	.22	.04	.85	NS
Error	527.39	89	5.93			
Total	28949.00	93				
Corrected Total	555.18	92				

\*Level of significant at  $P \leq 0.05$

From the result in Table 4.7 the effect of the treatment on sex shows a significant level of 0.08 which is greater than  $P \leq 0.05$  level of significant, this implies that there is no significant difference of the treatment on sex meaning treatment is gender friendly. Also for sex and group exposed to the treatment (Collateral Learning Strategy) relation to cognitive style (Convergent and Divergent), it shows a significant level of 0.85 which is greater than  $P \leq 0.05$ . This implies that the Collateral Learning Strategy produces the same effect in the genetic concept mean performance of convergent male and female and also the same effect on divergent male and female students alike. Therefore the null hypothesis which state that

there is no significant difference between the performance mean scores of male and female convergent and divergent students taught genetic concepts using Collateral Learning Strategy, is hereby retained.

**H<sub>04</sub>:** There is no significant difference between the mean attitude scores of convergent male and female and divergent male and female students taught genetic concepts using Collateral Learning Strategy.

To test this null hypothesis four, the scores obtained from posttest was analyzed using Kruskal-Wallis statistics and the result is presented in Table 4.8.

**Table 4.8: Summary of Kruskal-Wallis Result of Attitude by Gender Between Convergent and Divergent Students in Experimental Group**

Group	Sex	Cognitive Level	N	Mean Rank	H-Value	Sum of Rank	P-Value	Remark
Experimental	Male	Convergent	29	49.21	3.47	1427.09	0.89	NS
	Female	Convergent	23	45.76		1052.48		
	Male	Divergent	28	45.21		1265.88		
	Female	Divergent	13	49.88		648.44		
	Total			93				

\*Level of significant at  $P \leq 0.05$

From Table 4.8 results of the Kruskal-Wallis test on gender shows that the computed p value of 0.89 is above the  $P \leq 0.05$  level of significant and the computed mean ranks are 49.21, 45.76, 45.21 and 49.88 by male convergent, female convergent, male divergent and female divergent respectively. This implies that the difference in attitude between male and female convergent and divergent students taught genetic concepts using Collateral Learning Strategy is not significant. Hence, the null hypothesis which states that there is no significant difference in attitude between male and female convergent and divergent students taught genetic concepts using Collateral Learning Strategy is hereby retained.

### **4.3 Summary of Major Findings**

The followings are the summary of the major findings of the study.

1. There was significant difference between the mean performance scores of convergent and divergent students taught genetic concepts using Collateral Learning Strategy and those taught using lecture method. The ANCOVA statistic performance mean scores shows that between the control group their mean scores were 13.28 and 14.28 by convergent and divergent students respectively. In the experimental group their performances mean scores are 16.93 and 17.80 by convergent and divergent students respectively. This indicated that there is significance different between the performance mean scores of experimental and control groups in favour of experimental group. The finding of the study also implies that the Collateral Learning Strategy is effective for both convergent and divergent students in their genetic concepts performance mean scores.
2. There was no significant difference in Attitude of convergent and divergent students taught genetic concepts using Collateral Learning Strategy. Their computed mean Attitude rank scores are 48.31 and 45.34 by convergent and divergent students respectively. This implies that the mean Attitude of convergent and divergent students is not significantly different when both groups are taught genetic concepts using Collateral Learning Strategy.
3. There was no significant difference between the mean performance scores of convergent male and female and divergent male and female students taught genetic concepts using Collateral Learning Strategy. The statistics shows that their performance mean scores of male and female convergent are 16.81 and 17.28 respectively. On the other hand their performance mean scores of male and female divergent are 17.96 and 18.23 respectively. This implies that the Collateral Learning

Strategy produces the same effect in the genetic concepts performance mean scores of convergent male and female and also the same effect on divergent male and female students alike.

4. There was no significant difference in mean attitude scores between convergent male and female and divergent male and female students taught genetic concepts using Collateral Learning Strategy. The computed mean ranks are 49.21, 44.76, 45.21 and 49.88 by male convergent, female convergent, male divergent and female divergent respectively. This implies that the attitude between male and female convergent and divergent students taught genetic concepts using Collateral Learning Strategy is the same.

#### **4.4 Discussion of the Results**

This study investigated the effect of Collateral Learning Strategy on attitude and performance in genetics among convergent and divergent senior secondary school II Biology students in Suleja education zone, Niger State, Nigeria. The data collected from the posttest administered were analyzed using ANCOVA, Mann-Whitney and Kruskal Wallis statistical test at  $\alpha \leq 0.05$  levels of significant. The findings of the study are discussed as follows:

In Table 4.5 the result of testing hypothesis one shows that there is a significant difference in the academic performance mean scores of convergent and divergent students exposed to Collateral Learning Strategy and those taught using lecture method with experimental group having higher performance. The significant difference found between the two groups is likely to be a result of the use of Collateral Learning Strategy on the experimental group. If the treatment administered has no effect, the two groups are expected to perform equally. Since the experimental group performed significantly better, it implies that using Collateral Learning Strategy for teaching convergent and divergent students improved their performance. The result confirms earlier findings of Adamu

(2010)Akinbobola (2012) and Ajaja (2013), who showed that Collateral Learning Strategy enhanced students understanding of Biology concepts, and significantly influenced their performance in the subject.

On the issue of students' attitude to science (Genetics), the results in Table 4.6 show that Collateral Learning Strategy improved the attitudes of both convergent and divergent students to genetic concepts of Biology. This finding agrees with the findings of Koe (2005), Erdermir and Bakirci (2009), Usman (2010) and Lawal (2011) that the nature of science teaching affects students' attitude strongly. The greater success and positive attitude toward genetics using Collateral Learning Strategy of students in experimental group could be because the strategy is students centred, it provided opportunities for teamwork learning, its identification of prior idea step provides flexibility for students to acquire communal and personal beliefs at the beginning of the lesson and it is activity based teaching and learning.

On the issue of gender in relation to academic performance and attitude when exposed to Collateral Learning Strategy, the results in Table 4.7 and 4.8 shows that Collateral Learning Strategy enhanced the academic performance and attitude of both convergent male and female and divergent male and female students in genetics at senior secondary school level. This finding is in agreement with those of Bichi (2002), Yusuf and Afolabi (2010), Umar (2011), Jacinta (2011), and Aliyu (2014) who individually found out that there is no gender difference in the academic performance and attitude of students when exposed to activity-based methods of instruction such as Collateral Learning Strategy, problem solving and process approach e.t.c. In addition, the finding is in lined with those of Olorukooba (2001) and Akinbobola (2012) who observed that the type of instructional strategy used does not discriminate between male and female. The finding however, disagreeswith the findings of Aigbomian (2002) and Fakorede (2009) who reported a significant difference in the performance and attitude of male and female of the experimental group in favour of male.

The findings of this study shows that there is no significant difference in the performance mean scores of convergent male and female and divergent male and female students in genetics at senior secondary school level when exposed to Collateral Learning Strategy. Also the findings indicates that there is no significant difference in attitude change of convergent male and female and divergent male and female students exposed to Collateral Learning Strategy. Since the method allows students to participate actively without violating their communal and personal beliefs, and makes learning meaningful and promotes understanding of the concept despite gender and cognitive thinking (convergent and divergent) difference among the students. Therefore, there is need for improvement in Biology learning and teaching condition and practices existing in Nigeria Senior Secondary School through the use of effective teaching and learning strategies such as Collateral Learning Strategy which is an activity based approach to teaching and learning instead of the use of lecture method in classroom interaction.

## **CHAPTER FIVE**

### **SUMMARY, CONCLUSION AND RECOMMENDATIONS**

#### **5.1 Introduction**

This study investigate the Effect of Collateral Learning Strategy on Attitude and Performance in Genetics among Convergent and Divergent Senior Secondary School II Biology Students of Suleja Metropolis, Nigeria. In this chapter, the work is presented under the following sub-headings.

- Summary
- Major Findings of the Study
- Conclusion
- Contributions to Knowledge
- Recommendations
- Limitation of the Study
- Suggestions for Further Studies

#### **5.2 Summary**

This study investigated the Effect of Collateral Learning Strategy on Attitude and Performance in Genetics among Convergent and Divergent Senior Secondary School II Biology Students of Suleja Metropolis, Nigeria. A total of 175 subjects (93 in the experimental and 82 in the control groups) were used for the study. The experimental group

was exposed to Collateral Learning Strategy for six weeks while control group was taught the same concepts for six weeks using lecture method. The two sample schools were;

- Community Day Secondary School Suleja.
- Government Model Secondary School Suleja.

A simple random sampling technique by balloting was used to select the experimental and control groups respectively. The instruments used were Genetic Concepts Performance Test and Genetic Concepts Attitude Questionnaire. They were used to collect data as pre-test and post-test which was also used in answering the research questions and to test the stated null hypotheses. The GCPT was a 40 items multiple choice and GCAQ was 30 items Genetic Concepts Attitude Questionnaire. The GCPT with a reliability coefficient of 0.89 was used to collect relevant data which were analysed using mean, standard deviation and ANCOVA. While GCAQ with a reliability coefficient of 0.71 was used to collect relevant data related to students attitude towards genetics which were analysed using Mean Rank, Mann Whitney and Kruskal Wallis Test. Significant confidence of 0.05 (was adopted) for retaining or rejecting the hypotheses. The SPSS statistical package of version IBM 23 was used to analyse the data obtained. The distribution of the scores at the pre-test reveals that a high proportion of student's score was low which can be said might be the cause of low academic performance at SSCE level. Students at SS2 and at average age of 16 years, they were theoretically expected to have an appropriate teaching method that will open their mind for meaningful learning like Collateral Learning Strategy.

Five types of data were collected using the GCPT and GCAQ as follows;

1. Pre-test performance scores was collected from the students in the four selected schools, the data collected was analyzed using Analysis of Variance (ANOVA) to

establish two groups that are equivalent academically before commencement of the treatments.

2. Post-test performance scores of both groups obtained were analyzed using mean, standard deviation and ANCOVA respectively to establish significant difference in the mean scores of the convergent and divergent students for the two groups which could be attributed to the treatment.
3. Post-test attitude scores of experimental group for convergent and divergent students were obtained and analysed using Mean Rank and Mann Witney to establish a significant difference in attitude of convergent and divergent students exposed to the treatment. If the treatment is suitable for convergent only, divergent only or if is a convergent and divergent sensitive approach.
4. Post-test performance scores of convergent male and female and divergent male and female students were analysed using Mean, Standard Deviation and ANCOVA to establish a significant difference in gender when exposed to the treatment. If the treatment is suitable for male only, female only or if it is a gender friendly.
5. Post-test attitude scores of convergent male and female and divergent male and female students were analysed using Mean Rank and Kruskal Wallis to establish a significant difference in gender when exposed to the treatment. If the treatment is suitable for male only, female only or if it is a gender sensitive approach in term of students attitude.

### **5.3 Major Findings of the Study**

The following were findings obtained from the study.

1. The analysis of the post-test scores indicates that there is significant difference in the mean performance scores between convergent and divergent students exposed to

Collateral Learning Strategy compared to those taught using lecture method in favour of the experimental group. That is to say, the experimental group performed better than the control group in their academic performance after undergoing the experimental treatment of Collateral Learning Strategy irrespective of cognitive style (convergent and divergent).

2. The analysis of post-test scores indicates that there is no significant difference between the mean attitude of convergent and divergent students exposed to the treatment using Collateral Learning Strategy. Collateral Learning Strategy was found to be more effective in enhancing the attitude of students toward learning of Biology (Genetics)
3. The analysis of the post-test score indicates that there is no significant difference between the mean performance scores of convergent male and female and divergent male and female students exposed to the treatment using Collateral Learning Strategy. This indicates that Collateral Learning Strategy is gender sensitive as it is suitable for both male and female subjects.
4. The analysis of the post-test score indicates that there is no significant difference between attitude of convergent male and female and divergent male and female students exposed to the treatment using Collateral Learning Strategy. This indicates that Collateral Learning Strategy is gender friendly as it is suitable for both male and female subjects. The result of data analysis were presented and discussed, contributions to knowledge were identified, conclusion was drawn from the results obtained and recommendations were made for further studies.

#### **5.4 Conclusion**

Based on the results obtained from this study, the following conclusions were made:

1. The analysis of the result shows that the experimental subjects performed significantly better as a result of the treatment using Collateral Learning Strategy. This is an indication that Collateral Learning Strategy is effective in improving students meaningful learning and cognitive thinking which in turn enhances their academic performance. This also revealed that lecture method commonly used by teachers in secondary schools is not quite suitable for meaningful teaching and learning of Biology concepts and genetics in particular. As it is not a students centred approach.
2. Cognitive ability of the experimental group convergent and divergent was enhanced significantly after treatment which was reflected in their academic performance. This implies that Collateral Learning Strategy is effective in promoting high order thinking skills of science students, especially in Biology. Based on this, Collateral Learning Strategy can be used as an effective instructional tool for eliminating poor performance and a fundamental step towards enhancing students' performance and positive attitude in science learning as it encourages learners to construct their own knowledge out of the prior knowledge.
3. The experimental group shows significant improvement in their cognitive style for convergent and divergent students than the control group after treatment. This showed that cognitive style (convergent and divergent) of science students could be enhanced through appropriate used of teaching strategies and models. This is also an indication that teacher centered teaching methods may be responsible for low performance and inability of students' to answer WAEC and NECO questions effectively in Biology at SSCE level.

4. Exposure of male and female students to the treatment showed that the two groups gained tremendously from the treatment. This implies that the treatment is suitable for both male and female convergent and divergent students meaning it is gender sensitive and not bias. Also the finding of the study showed that the attitude of male and female convergent and divergent students was improved. Therefore, Collateral Learning Strategy has the potentiality for enhancing students attitude and academic performance and it is gender friendly.

## **5.5 Contributions to Knowledge**

This research work was initiated to determine the most effective ways to improve students' positive attitude towards the learning of Biology and academic performance through the use of Collateral Learning Strategy. It was observed that;

1. Most studies in this area were carried out to determine effects of Collateral Learning Strategy on academic performance or attitude on students. In this study however, Collateral Learning Strategy was employed to determine convergent and divergent students attitude and performance and was also used to enhance a paradigm shift in students' cognitive thinking towards meaningful learning. The implication of this shift on academic performance of students in Senior Secondary School was very significant as obtained from the study findings. The method is an activity based approach which is students centered meant to improve attitude and academic performance among convergent and divergent Senior Secondary School II Biology Students.
2. The Collateral Learning Strategy used for this study encourages students' constructing their own knowledge from pre-existing knowledge and high order thinking skills. This implies that, the treatment with Collateral Learning Strategy enhanced convergent

and divergent students' ability to participate actively in classroom teaching and learning without violating their communal and personal beliefs.

3. In this area of study, that is Suleja metropolis, this study is relatively the first of its kind, especially on cognitive style (convergent and divergent) with respect to exposure to Collateral Learning Strategy.
4. The instruments used for this study can be adopted or adapted for use in similar studies or other science education based researches to move forward the frontier of knowledge.
5. Also the findings of this study has added new information to the frontier of knowledge in the existing literature.
6. The adapted flow-chart used as a guide to Collateral Learning Strategy based on the study findings, was so effective and added values in terms of disseminating meaningful knowledge to students.

## **5.6 Recommendations**

Based on the findings of this study, the following recommendations were made;

1. There is a need for the improvement of Biology teaching and learning conditions and practices existing in Nigerian Senior Secondary School through the use of different effective teaching and learning methods and models such as Collateral Learning Strategy which is an activity based approach to teaching and learning instead of the conventional lecture method.
2. Since the level of students' cognitive processes and skills affects the learning of science concepts, there is therefore the need for science teacher to systematically and periodically assess or determine the cognitive thinking of their students. One way of doing this is by the use of Convergent and Divergent Thinker

Test (CDTT). This is with a view to adapting circular contents, achievement goals, instructional methods and educational strategies to improve their teaching and learning performance.

3. Nigerian universities and colleges of education as well as secondary school educational planners should be encouraged to design educational programs that will equip teachers in training with skills for the use of individual differences such as Collateral Learning Strategy for effective teaching and learning of Biology.
4. The Collateral Learning Strategy is effective and should be used for both convergent and divergent students in the teaching of science in general and genetic concepts in particular.
5. The Collateral Learning Strategy does not discriminate between male and female and should therefore be used for both sexes in the teaching of genetics.
6. Teachers should be motivated and encouraged by State Ministry of Education and Science Teachers Association of Nigeria (STAN) to attend seminars and workshops on the effective use of the Collateral Learning Strategy in the teaching of science in general and genetic concepts in particular.

## **5.7 Limitations of the Study**

The following limitations were noted in the course of this study;

1. The study was restricted to only two government schools and to Biology students. A wider scope of the study might influence the study. The geographical coverage is Suleja metropolis of Niger State, thus limiting generalization made from the study.
2. Large sample size due to the use of intact classes in the sample schools.
3. The restriction of the study to only senior secondary schools is narrowing the study. If for instance, the study covered primary school, junior secondary school and tertiary level of educations, the outcomes might be different from the present findings.

## **5.8 Suggestions for Further Studies**

1. Similar studies could be carried out at tertiary institutions such as colleges of education, Polytechnics, Mono-technics and Universities.
2. It is needful to extend the study over a period of two or three years to ascertain the substances or other-wise the effect of Collateral Learning Strategy in promoting positive attitude, performance and cognitive gains in students. This could also help to establish if a long period of exposure to Collateral Learning Strategy could help to remedy poor academic performance and negative attitude in science and Biology in particular.
3. The use of other teaching method such as Demonstration Method, Science Process Teaching Approach, Discovery Methods, Problem Solving Methods and Practical Methods should be employed to determine its effect on cognitive style (convergent and divergent) of science students.
4. This study can be replicated in rural schools to determine if there are difference in the cognitive ability between students in the rural schools and those in urban areas.
5. The study could also be conducted in other science disciplines such as Physics, Agricultural Science, Chemistry and Basic Science among Others.

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## APPENDIX A

### GENETIC CONCEPTS PERFORMANCE TEST (GCPT)

#### SECTION A: Bio-data

**Admission Number:** .....

**Gender:** Male [ ] Female [ ]

#### SECTION B: Instruction

- Write your name, identification number and tick the gender in the space provided.
  - Read each question carefully.
  - Go to your answer sheet and shade correct option/letter/alphabet.
  - Shade only one alphabet on each question.
1. The transmission of the inherited characters from parents to their young is called?
    - a. Mutation
    - b. Heredity
    - c. gene
    - d. Variation
  2. All of the following are examples of characters that can be transmitted from parents to their young EXCEPT
    - a. Eye colour
    - b. skin colour
    - c. muscles

- d. height
3. Genetic make-up is another name for?
- a. genotype
  - b. dominant character
  - c. phenotype
  - d. recessive allele
4. The physical expression of character is an organism's.....
- a. allele
  - b. chromosomes
  - c. genotype
  - d. phenotype
5. A change in the structure of gene known as
- a. mutation
  - b. genetics
  - c. heredity
  - d. gametes
6. In all living organisms, inherited characters are determined by
- a. Traits
  - b. alleles
  - c. genes
  - d. sperms
7. Each alternative form of a gene is called?
- a. first filial generation
  - b. parental generation
  - c. second filial generation

- d. allele
8. Which of these best described Albinism
- a. A condition where individuals received curse from their an ancestor
  - b. A condition where couples refused to follow their traditional rites during marriage accordingly
  - c. A condition where the external pigment fails to develop resulting in the person onhaving a light skin, white hair and pink eyes.
  - d. A situation that occurred when a pregnant woman always goes to the river to'
9. A diploid individual whose two copies of gene are the same is called?
- a. Homozygous for the gene
  - b. Homologous chromosome
  - c. heterozygous for the gene
  - d. dominant allele
10. Chromosomes emanate from the....?
- a. Gene of prokaryotes
  - b. Gene of eukaryotes
  - c. DNA double helix
  - d. Nucleus of eukaryotic cell.
11. In the study of chromosomes, each organism has a....?
- a. 23 number of chromosomes
  - b. 31 number of chromosomes
  - c. 32 number of chromosomes
  - d. characteristic number of chromosomes
12. Which of the following represents sex chromosomes' of male and female human beings?
- a. XY male, XX female

b. XY female, XX male

c. XO male, XX female

d. XX female, YY male

13. The difference in sex chromosomes determines?

a. The variation of genes

b. the sex of the organism

c. the homologous pair

d. the size and appearance of chromosomes

14. The process by which DNA molecule makes an EXACT copy of itself is called?

a. Replication

b. condensation

c. centromere

d. cell division.

15. DNA carries information that directs the synthesis of specific proteins, and is in form of?

a. Genetic variation

b. code system

c. genetic code

d. protein synthesis

16. Sickle cell anaemia can be described....?

a. As a condition that arises due to witchcraft leading to frequent sickness

b. As an inherited disease cost by abnormal shape of thered blood cell. The normal red blood indented from both parents by the off-spring

c. A situation where by a death person returns to the society as ghost and live a normal life with people

- d. As the ill-health condition resulting from charming by various individual.
17. A test cross is carried out to determine an Organism's
- Phenotype
  - Dominant gene
  - Blood group
  - Genotype
18. When two carriers of sickle cell gene marry what percentage of their F<sub>i</sub> generation will be carriers?
- 50%
  - 35%
  - 60%
  - 70%
19. What is the theoretical probability that a normal male child will be born
- $\frac{1}{2}$
  - $\frac{1}{4}$
  - 1
  - $\frac{2}{3}$
20. Which of the following statement is correct about variation?
- Offspring are different from their parents only
  - Offspring differ from their ancestors but look like their immediate parent
  - Offspring's differ from their ancestors and from each other
  - Offspring's from the same parent look like
21. The genotypic ratio of 1:2:1 in the offspring of a hybrid cross illustrates the law of:
- Use and disuse
  - Segregation

- c. Linkage
  - d. Dominance
22. Which of the following traits may not be important in marriage counseling?
- a. Colour of skin
  - b. Sickle-cell factor
  - c. Rhesus factor
  - d. Sex-determination
23. Which of the following is the precise location of the gene?
- a. Chromosome
  - b. Centresouce
  - c. Centriole
  - d. Ribosome
24. How many chromosomes are found in the human ovum?
- a. 46
  - b. 23
  - c. 33
  - d. 13
25. If a black guinea pig of genotype BB, is crossed with a white guinea pig of genotype bb, what will be the phenotype of F1 generation?
- a. Half would be white, while half would be black
  - b. All would be grey
  - c. All would be black
  - d. 1/3 would be black, while 2/3 would be white
26. An individual with blood group O can receive blood from those in blood group
- a. B only

- b. AB only
  - c. A and B
  - d. O only
27. The role of Y chromosome is to determine\_\_\_\_\_?
- a. Sex of female animal
  - b. Homozygous animal
  - c. Heterozygous animal
  - d. Sex of male animal
28. When both alleles in a heterozygous individual are fully expressed in the phenotype of the F1 generation this phenomenon is described as
- a. Co-dominance
  - b. Dominant
  - c. Mutation
  - d. Recession
29. The significance of the second meiotic division is to:
- a. Produce DNA
  - b. Re-arrange genes
  - c. Reduce the chromosomes to haploid
  - d. Double the number of chromosomes
30. Which of this is controlled by multiple alleles?
- a. Blood group
  - b. Hemophilia
  - c. River blindness
  - d. Sickle anemia
31. A sex-linked allele cannot be passed from a
- a. Man to his grandsons

- b. Man to his sons
  - c. Women to her daughter
  - d. Women to her grand daughter
32. During blood transfusion, agglutination may occur as a result of the reaction between
- a. Similar antigens and antibodies
  - b. Contrasting antigens and antibodies
  - c. Two different antigens
  - d. Two different antibodies
33. 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. 3:2
  - d. 3:1
34. A pair of genes which controls a trait is described as
- a. Dominant
  - b. Recessive
  - c. Allele
  - d. Variant
35. 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 breed
  - b. Heterozygous

- c. Homozygous
- d. Co-dominant

36. Which of the following statement is not correct about sex determination?

- a. Females contribute only X chromosome
- b. Males contribute an Y or X chromosome
- c. Females alone determines the sex of a child
- d. The sex of an child is determined by the contribution of the males and females

37. In human beings the albino trait is recessive and the normal skin colour is dominant.

Therefore, the probability of parents that are heterozygous for albinism having an albino child is

- a.  $\frac{1}{4}$
- b.  $\frac{1}{2}$
- c.  $\frac{1}{3}$
- d. 1

38. Which of the following is a carried of heredity materials.

- a. Centriole
- b. Cytoplasm
- c. Lysosome
- d. Chromosome

39. Which of these statements is correct in human ABO blood grouping system?

- a. A and B are both recessive
- b. O is recessive
- c. A is dominant over B
- d. B is dominant over A

40. Which of these is not a hereditary variation?

- a. Infant paralysis
- b. Blood group
- c. Sickle cell
- d. Colour of hair

## APPENDIX B

### MARKING SCHEME OF GENETIC CONCEPTS PERFORMANCE TEST (GCPT)

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

Total = 1 mark X 40 = 40 marks

**APPENDIX C**

**ANSWER SHEET FOR GENETIC CONCEPTS PERFORMANCE TEST (GCPT)**

**SECTION A: Bio-data**

**Admission Number:** .....

**Gender**                      **Male** [   ]      **Female** [   ]

**SECTION B: Instruction**

**Please shade the correct option appropriately.**

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

## **APPENDIX D**

### **ATTEMPT ALL THE FOLLOWING QUESTIONS**

#### **GENETIC CONCEPTS ATTITUDE QUESTIONNAIRE (GCAQ)**

Dear Respondent,

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

Please take note of the following keys:

SA	-	-	-	-	-	Strongly Agreed
A	-	-	-	-	-	Agreed
D	-	-	-	-	-	Disagreed
S.D	-	-	-	-	-	Strongly Disagreed

Thanks!

**SHUAIBU ADO MOHAMMED**

**SECTION A: Bio-data**

**Admission Number:** .....

**Gender:**      Male [ ]      Female [ ]

**SECTION B: Instruction**

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

S/NO	ITEMS	SA	A	D	SD
1	Genetics concepts need to be taught right from primary school for the students to be familiar with their trait.				
2	The genetics topic taught to us I really appreciate it very well				
3	I like to study genetics in future because of its significant to the society development				
4	I don't like Biology class when there is genetics concept in it				
5	Study of genetics concept is no longer useful to me and my society.				
6	I am very interested in the lesson attended on genetics concept.				
7	I always appreciate reading genetics concept in test books.				
8	I appreciate the way how my teacher explained the concept of genetics.				
9	Because of my interest in genetics concept I always attended Biology class.				
10	I like watching and listening to television always if there is report on genetics concept.				
11	It is waste of time to listen to genetics concept report on electronic media.				
12	I am not interested in discussing the effect of genetics concept development				

13	I hate spending my free-time doing genetics work				
14	Listening to a talk on genetics concept is boring				
15	I would like to work with people who make discoveries in genetics				
16	Geneticist have no social concerns or interests.				
17	Geneticist are less friendly than other people are.				
18	Geneticist are very useful in the society				
19	Participating in genetics practical is thrilling				
20	Working as a geneticist would be too hard for me				
21	Genetics is the simplest biology topic and that is the reason for offering it.				
22	I study genetics only as a fulfillment of WAEC and NECO requirement.				
23	Genetics is for gifted students.				
24	Collateral Learning Strategy can be used to enlighten people on the danger of genetics disease				
25	Collateral Learning strategy has the capacity to bring firsthand experience in genetics classroom interaction				
26	Collateral Learning Strategy improves meaningful learning in genetics classroom interaction.				
27	The best way of teaching genetics concept is through Collateral Learning Strategy.				
28	I believe that Collateral Learning Strategy will be interaction.				
29	I am interested in listening to my teacher teaching genetics concept using Collateral Learning Strategy				
30	I will like my school to introduced Collateral Learning Strategy in order to supplement classroom activities for teaching genetics				

## APPENDIX E

### LESSON NOTE FOR EXPERIMENTAL GROUP

**LESSON ONE**                      WEEK ONE

**Theme:**                              Continuity of life

**Model of Teaching:**              Collateral Learning Strategy

**Class:**                                SS2

**Duration:**                         80 Minutes

**Subject:**                             Biology

**Topic:**                                Basic Terms in Genetics

**Number of Students:**            103

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

- i. Define and explain the following terms: genetics, heredity, variation, chromosome and gene.
- ii. Discuss the meaning of genotype, phenotype, homozygous, heterozygous and alleles.
- iii. Differentiate between dominant gene and recessive gene, diploid and haploid

**Instructional Materials:**

- i. Plants of same species that have some slight variation among themselves.
- ii. Chart showing animals of same species with different variation

**Presentation:**

**Step 1: Identification of Prior Ideas**

TeacherActivities:

Teacher asks students the following questions based on their cultural beliefs about genetics

- i. What is genetics and heredity
- ii. What is chromosome and gene

Students Activities:

- i. Students answer teacher questions above.
- ii. Students ask questions.

**Step 2: Exploration**

Teacher Activities:

- i. Teacher guides the students to observe the lesson instructional materials.
- ii. Teacher guides students to identify and explain the lesson instructional materials.
- iii. Teacher leads students using Collateral Learning Strategy to define and explain the following terms genetics, heredity, variation, chromosome and gene.
- iv. Teacher guides students to discuss the meaning of genotype, phenotype, homozygous, heterozygous and alleles.
- v. Teacher guides students to differentiate between dominant gene and recessive gene, diploid and haploid.

Students Activities:

- i. Students carried out the activities given by the teacher above.
- ii. Students ask questions

**Step 3: Discussion**

TeacherActivities:

Teacher guides students to discuss ideas from the various activities they had carried out using the following questions.

- i. What are similarities between genetics and heredity
- ii. What is variation

- iii. What is differences between gene and chromosome
- iv. What is the example of homozygous and heterozygous
- v. What is the genotype and phenotype
- vi. What is the relationship between haploid and diploid, dominant gene and recessive gene.

#### Students Activities

- i. Students participate actively in the discussion by contributing ideas and answering questions.
- ii. Students ask questions

#### **Step 4: Application**

##### Teacher Activities:

Teacher guide students to mention the application of basic terms in genetics using the following questions.

- i. What are the importance of variation to society
- ii. What are the significance of genotype
- iii. What are role of haploid and diploid in genetics study

##### Students Activities:

- i. Students mention the application of basic terms in genetics by answering the above questions.
- ii. Students ask questions

#### **Step 5: Evaluation**

##### Teacher Activities:

Teacher ask students the following questions.

- i. Define and explain the terms genetics, heredity, variation, chromosome and gene.
- ii. Discuss the meaning of genotype, phenotype, homozygous and alleles.
- iii. Differentiate between dominant gene and recessive gene, haploid and diploid

##### Students Activities:

- i. Students answer the above questions orally
- ii. Students ask question

#### **Conclusion:**

## Teacher Activities

Teacher concludes the lesson by given students note and assignment.

## Student Activities

1. Student copied the note given by the teacher
2. Student carried out assignment given by the teacher

## LESSON NOTE FOR EXPERIMENTAL GROUP

### LESSON TWO

### WEEK TWO

**Theme:** Continuity of life

**Model of Teaching:** Collateral Learning Strategy

**Class:** SS2

**Duration:** 80 minutes

**Subject:** Biology

**Topic:** Monohybrid Inheritance

**Number of Students:** 103

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

- i. Explain how a single trait is inherited in organisms
- ii. State and explain Mendel's first law of inheritance
- iii. Discuss how Mendel's work on inheritance led to the discovery of chromosomes and genes.

### **Instructional Materials:**

Diagram showing crosses between parent plants (first filial generation and second filial generation)

### **Presentation:**

#### **Step 1: Identification of Prior Ideas**

Teacher Activities:

Teacher asks students the following questions based on their cultural beliefs about genetics

- i. What make people of same parent to have variation
- ii. What make plants of same species to have variation

Students Activities:

- i. Students answer teacher questions above.
- ii. Students ask questions

**Step 2: Exploration**

Teacher Activities:

- i. Teacher guides students to observe the lesson instructional materials
- ii. Teacher guides students to identify and explain the lesson instructional material.
- iii. Teacher leads students using Collateral Learning Strategy to explain how a single trait is inherited in organisms.
- iv. Teacher guides students to state and explain Mendel's first law of inheritance
- v. Teacher guides students to discuss how Mendel's works on inheritance led to the discovery of chromosomes and genes.

Students Activities:

- i. Students carried out the activities given by the teacher above.
- ii. Students ask questions

**Step 3: Discussion**

Teacher Activities:

Teacher guides students to discuss ideas from the various activities they had carried out using the following questions.

- i. What is Mendel's first law of inheritance
- ii. What is gamete formation

- iii. What is the relationship between Mendel's works and discovery of chromosomes and genes
- iv. What is the product of a cross between tall male and a dwarf female chicken?

#### Students Activities

- i. Students participate actively in the discussion by contributing ideas and answering questions.
- ii. Students ask questions

#### **Step 4: Application**

##### Teacher Activities:

Teacher guide students to mention the application of monohybrid using the following questions.

- i. What are the importance of monohybrid to the society
- ii. What are the significance of Mendel's first law of inheritance
- iii. What is the role of Mendel's first law of inheritance to agricultural production

##### Students Activities:

- i. Students mention the application of monohybrid in the society by answering the above questions.
- ii. Students ask questions

#### **Step 5: Evaluation**

##### Teacher Activities:

Teacher ask students the following questions.

- i. Explain how a single trait is inherited in organisms
- ii. State and explain Mendel's first law of inheritance
- iii. Discuss how Mendel's works on inheritance led to the discovery of chromosomes and genes.

##### Students Activities:

- i. Students answer the above questions orally
- ii. Students ask questions

#### **Conclusion:**

## Teacher Activities

Teacher concludes the lesson by given students note and assignment.

## Student Activities

1. Student copied the note given by the teacher
2. Student carried out assignment given by the teacher

## LESSON NOTE FOR EXPERIMENTAL GROUP

### LESSON THREE

### WEEK THREE

**Theme:**

Continuity of life

**Model of Teaching:**

Collateral Learning Strategy

**Class:**

SS2

**Duration:**

80 minutes

**Subject:**

Biology

**Topic:**

Dihybrid Inheritance

**Number of Students:** 103

**Specific Objectives:**

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

- i. Explain how two contrasting characters are inherited using crossing and punnet square methods
- ii. State Mendel's second law of inheritance
- iii. Discuss the ratio of the F2 generation

**Instructional Materials:**

Diagram showing crosses of gametes.

**Presentation:****Step 1: Identification of Prior Ideas****Teacher Activities:**

Teacher asks students the following questions based on their cultural beliefs about genetics

- i. What make organisms to acquire more than one character

- ii. What is inheritance of more than one trait

Students Activities:

- i. Students answer teacher questions
- ii. Students ask questions

### **Step 2: Exploration**

Teacher Activities:

- i. Teacher guides students to observe the lesson instructional materials
- ii. Teacher directs students to identify and explain the lesson instructional materials
- iii. Teacher leads students using Collateral Learning Strategy to explain how two contrasting characters are inherited using crossing and punnet square methods.
- iv. Teacher guides students to state Mendel's second law of inheritance
- v. Teacher directs students to discuss the ratio of the F<sub>2</sub> generation

Students Activities:

- iii. Students carried out the activities given by the teacher
- iv. Students ask questions

### **Step 3: Discussion**

Teacher Activities:

Teacher guides students to discuss ideas from the various activities they had carried out using the following questions.

- i. What is Mendel's second law of inheritance
- ii. What is the genotypic ratio of F<sub>2</sub> generation
- iii. A tall and smooth haired chicken was crossed with a dwarfed and curled haired chicken. What is the phenotypic ratio of the event.

Students Activities

- i. Students participate actively in the discussion by contributing ideas and answering questions.
- ii. Students ask questions

#### **Step 4: Application**

Teacher Activities:

Teacher guide students to mention the application of dihybrid using the following questions.

- i. What are the importance of dihybrid to the society
- ii. What are the significance of Mendel's second law of inheritance
- iii. What is the role of dihybrid to agricultural production

Students Activities:

- i. Students mention the application of dihybrid by answering the above questions.
- ii. Students ask questions

#### **Step 5: Evaluation**

Teacher Activities:

Teacher ask students the following questions.

- i. Explain how two contrasting characters are inherited using crossing and punnet square methods.
- ii. State Mendel's second law of inheritance
- iv. Discuss the ratio of the F2 generation

Students Activities:

- iii. Students answer the above questions orally
- iv. Students ask questions

#### **Conclusion:**

Teacher Activities

Teacher concludes the lesson by given students note and assignment.

Student Activities

1. Student copied the note given by the teacher
2. Student carried out assignment given by the teacher

### LESSON NOTE FOR EXPERIMENTAL GROUP

#### LESSON FOUR

#### WEEK FOUR

<b>Theme:</b>	Continuity of life
<b>Model of Teaching:</b>	Collateral Learning Strategy
<b>Class:</b>	SS2
<b>Duration:</b>	80 minutes
<b>Subject:</b>	Biology
<b>Topic:</b>	Sex Determination and Sex Linkage

**Number of Students:** 103

<b>Specific Objectives:</b>	By the end of the lesson, students should be able to:
	i. Define a sex chromosome
	ii. Explain how the sex of child is determined at conception.
	iii. Describe sex linkage with example

#### **Instructional Materials:**

Diagram showing crosses between parent plants (first filial generation and second filial generation)

#### **Presentation:**

#### **Step 1: Identification of Prior Ideas**

Teacher Activities:

Teacher asks students the following questions based on their cultural beliefs about genetics

- i. What determine the sex of a child
- ii. What is sex chromosome

Students Activities:

- i. Students answer teacher questions above.
- ii. Students ask questions

### **Step 2: Exploration**

Teacher Activities:

- i. Teacher directs students to observe the lesson instructional materials.
- ii. Teacher guides students to identify and explain the lesson instructional materials.
- iii. Teacher directs students to define a sex chromosome using Collateral Learning strategy
- iv. Teacher leads students to explain how the sex of a child is determined at conception
- v. Teacher guides students to describe sex linkage with example

Students Activities:

- i. Students carried out the activities given by the teacher
- ii. Students ask questions

### **Step 3: Discussion**

Teacher Activities:

Teacher guides students to discuss ideas from the various activities they had carried out using the following questions.

- i. What is sex chromosome
- ii. How is the sex of a child determined
- iii. What is sex linkage

- iv. What are the examples of sex linkage

#### Students Activities

- i. Students participate actively in the discussion by contributing ideas and answering questions.
- ii. Students ask questions

### **Step 4: Application**

#### Teacher Activities:

Teacher guide students to mention the application of sex determination and sex linkage using the following questions.

- i. What are the importance of sex determination to the society
- ii. What is the role of sex linkage

#### Students Activities:

- i. Students mention the application of sex determination and sex linkage by answering the above questions.
- ii. Students ask questions

### **Step 5: Evaluation**

#### Teacher Activities:

Teacher ask students the following questions.

- i. Define a sex chromosomes
- ii. Explain how the sex of a child is determined at conception
- iii. Described sex linkage with example

#### Students Activities:

- i. Students answer the above questions orally

- ii. Students ask questions

**Conclusion:**

Teacher Activities

Teacher concludes the lesson by given students note and assignment.

Student Activities

1. Student copied the note given by the teacher
2. Student carried out assignment given by the teacher

**LESSON NOTE FOR EXPERIMENTAL GROUP**

**LESSON FIVE**

**WEEK FIVE**

**Theme:**

Continuity of life

**Model of Teaching:**

Collateral Learning Strategy

**Class:**

SS2

**Duration:**

80 minutes

**Subject:**

Biology

**Topic:**

Types of Mutation

**Number of Students:** 103

**Specific Objectives:**

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

- i. Define and list the causes of mutation
- ii. Differentiate between gene and chromosomes mutations
- iii. Explain how gene and chromosomal mutations take place

**Instructional Materials:**

Small plants, seeds, leaves, stems, and diagrams of animals all with abnormalities

**Presentation:**

**Step 1: Identification of Prior Ideas**

Teacher Activities:

Teacher asks students the following questions based on their cultural beliefs about genetics

- i. What is mutation
- ii. What are the causes of mutation

Students Activities:

- i. Students answer teacher questions
- ii. Students ask questions

**Step 2: Exploration**

Teacher Activities:

- i. Teacher guides students to observe the lesson instructional materials
- ii. Teacher directs students to identify and explain the lesson instructional material
- iii. Teacher guides students to define and list the causes of mutation
- iv. Teacher directs students to differentiate between gene mutation and chromosome mutation
- v. Teacher guides students to explain how gene and chromosomal mutations take place.
- vi. Teacher guides students to list example of gene and chromosome mutations in plants, animals and human

Students Activities:

- i. Students carried out the activities given by the teacher above.
- ii. Students ask questions

**Step 3: Discussion**

Teacher Activities:

Teacher guides students to discuss ideas from the various activities they had carried out using the following questions.

- i. What is mutation

- ii. What are the causes of mutation
- iii. What are the differences between gene mutation and chromosome mutation
- iv. What are the examples of gene mutation
- v. What are the examples of chromosomal mutation

#### Students Activities

- i. Students participate actively in the discussion by contributing ideas and answering questions.
- ii. Students ask questions

### **Step 4: Application**

#### Teacher Activities:

Teacher guide students to mention the application of mutation using the following questions.

- i. What are the importance of gene mutation
- ii. What are the significance of chromosome mutation
- iii. What is the role of organisms environment in mutation

#### Students Activities:

- i. Students mention the application of mutation by answering the above questions.
- ii. Students ask questions

### **Step 5: Evaluation**

#### Teacher Activities:

Teacher ask students the following question

- i. Define mutation and list causes of mutation
- ii. Differentiate between gene mutation and chromosome mutation
- iii. Explain how gene and chromosomal mutation take place

#### Students Activities:

- i. Students answer the above questions orally

- ii. Students ask questions

**Conclusion:**

Teacher Activities

Teacher concludes the lesson by given students note and assignment.

Student Activities

1. Student copied the note given by the teacher
2. Student carried out assignment given by the teacher

**LESSON NOTE FOR EXPERIMENTAL GROUP**

**LESSONSIX**

**WEEK SIX**

**Theme:** Continuity of life

**Model of Teaching:** Collateral Learning Strategy

**Class:** SS2

**Duration:** 80 minutes

**Subject:** Biology

**Topic:** Applied genetics

**Number of Students:** 103

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

- i. Mention the various areas in which genetics is applied
- ii. Name some examples of plants that are produced by applied genetics
- iii. List some examples of animals that are produced by applied genetics

**Instructional Materials:**

Samples of modified fruits, cereals and legumes, ink and inkpad

**Presentation:**

### **Step 1: Identification of Prior Ideas**

Teacher Activities:

Teacher asks students the following questions based on their cultural beliefs about genetics

- i. What is modified fruits
- ii. What are the examples of modified animals

Students Activities:

- i. Students answer teacher questions above.
- ii. Students ask questions

### **Step 2: Exploration**

Teacher Activities:

- i. Teacher guides students to observe the lesson instructional materials
- ii. Teacher directs students to identify and explain the lesson instructional material
- iii. Teacher guides students using Collateral Learning Strategy to mention the various areas in which genetics is applied
- iv. Teacher guides students to mentioned example of plants that are produced by applied genetics
- v. Teacher guides students to list some examples of animals that are produced by applied genetics

Students Activities:

- i. Students carried out the activities given by the teacher above.
- ii. Students ask questions

### **Step 3: Discussion**

Teacher Activities:

Teacher guides students to discuss ideas from the various activities they had carried out using the following questions.

- i. What do you understand by the term applied genetics

- ii. Give specific examples of how genetics is applied in crops
- iii. What qualities new hybrids have over the old ones
- vi. What are the examples of modified genetics animals

#### Students Activities

- i. Students participate actively in the discussion by contributing ideas and answering questions.
- ii. Students ask questions

### **Step 4: Application**

#### Teacher Activities:

Teacher guides students to mention the application of mutation using the following questions.

- i. What are the importance of applied genetics in agricultural production
- ii. What is the role of applied genetics in economic growth and development

#### Students Activities:

- i. Students mention the application of mutation by answering the above questions.
- ii. Students ask questions

### **Step 5: Evaluation**

#### Teacher Activities:

Teacher asks students the following questions.

- i. Mention the various areas in which genetics is applied
- ii. Name some examples of plants that are produced by applied genetics
- iii. List some examples of animals that are produced by applied genetics

#### Students Activities:

- iv. Students answer the above questions orally
- v. Students ask questions

**Conclusion:**

Teacher Activities

Teacher concludes the lesson by given students note and assignment.

Student Activities

- 1. Student copied the note given by the teacher
- 2. Student carried out assignment given by the teacher

**APPENDIX F**

**LESSON NOTE FOR CONTROL GROUP**

**LESSON ONE**

**WEEK ONE**

**Model of Teaching**

Lecture

**Class**

SS2

**Duration:**

80 minutes

**Subject:**

Biology

**Topic:**

Basic Terms in Genetics

**Numberof Students:**

082

**Specific Objectives:**

By the end of the lesson, students should beable to:

- i. Define and explain the following terms: genetics, heredity, variation, chromosome and gene.
- ii. Discuss the meaning of genotype, phonotype, homozygous, heterozygous and alleles.
- iii. Differentiate between dominant gene and recessive gene, diploid and haploid

**Previous knowledge:**

Students are familiar with the variations thatexist among organisms of same species including humans.

**Instructional Materials:** (i) Plants of same species that have some slight variations among themselves.  
(ii) Charts of animals of same species showing some variations.

**Presentation:**

**Step 1: Introduction** The Teacher asks the students questions on the variations they observed exist among organisms of same species.

**Step II; Basic Genetic Terms** The Teacher gives and writes the definition of the following terms: genetics, heredity, variation, chromosome, gene, genotype, phenotype, homozygous, heterozygous, alleles, dominant and recessive. The teacher explains each term with example.

**Student Activities:** Students observed, listen and answer teacher's questions

**Step III: Evaluation:** The teacher asks the students the definitions of each term and the examples.

- i. Define and explain the following terms: genetics, heredity, variation, chromosome and gene.
- ii. Discuss the meaning of genotype, phenotype, homozygous, heterozygous and alleles.
- iii. Differentiate between dominant gene and recessive gene, diploid and haploid

**Conclusion** The teacher concludes the lesson by briefly giving the definitions of the basic terms once more.

## LESSON NOTE FOR CONTROL GROUP

### LESSON TWO

### WEEK TWO

**Model of Teaching**

Lecture

**Class**

SS2

**Duration:**

80 minutes

**Subject:**

Biology

**Topic:**

Monohybrid inheritance

**Number of Students:**

082

**Specific Objectives:**

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

- i. Explain how a single trait is inherited in organisms.
- ii. State and explain Mendel's First law of inheritance.
- iii. Explain how Mendel's work on inheritance led to the discovery of chromosomes and genes.

**Previous Knowledge;**

Students are familiar with the terms 'genes' and 'alleles'. They are also familiar with traits like "tall" and "short"<sup>1</sup>, the terms "genotype", and "phenotype".

**Instructional Materials:**

Diagrams showing crosses between parent plants, first filial generation, resultant plants - F<sub>1</sub> and F<sub>2</sub> generations.

**Presentation:**

**Step 1: Introduction**

The teacher asks the students questions based on previous knowledge: Basic terms in genetics

**Step II**

i. Monohybrid inheritance: Teacher explains how pollens of a tall plant were robbed on the stigma of a dwarf plant. Seeds were collected and sown. Seeds gave rise to tall plants only. i.e. F<sub>1</sub> generation. F<sub>1</sub> were self-pollinated. Seeds from F<sub>1</sub> gave rise to tall and dwarf plants in the ratio 3:1.

ii. conclusion from above : Chromosomes and genes occur in pairs, they separate (Segregate) independently during gametes' formation (sperms, eggs, pollen, ovules). Thus a gamete receives only one gene from a pair. This forms Mendel's first law of inheritance, known as "Law of segregation. i.e. genes are transmitted singly, T or T and t or t not in pairs.

iii. Teacher now states Mendel's first law of inheritance (Law of segregation): This law states that. An organism's characteristics are controlled by internal factors (genes ) which occur in pairs they separate (segregate ) independently during gamete formation, thus a gamete receives only one gene from a pair". The teacher now tells the students that Mendel's work led to the discovery of genes and chromosomes, and also forms the foundation upon which the study of heredity is built.

**Student Activities:**

Students observed, listen and answer teacher's questions

**Step III Evaluation:**

Teacher asks the students the following questions:

- i. Explain how a single trait is inherited in organisms.
- ii. State and explain Mendel's First law of inheritance.
- iii. Explain how Mendel's works on inheritance led to the discovery of chromosomes and genes.

**Step IV; Conclusion:** The teacher concludes the lesson with a summary of the main points.

### LESSON NOTE FOR CONTROL GROUP

#### LESSON THREE

#### WEEK THREE

**Model of Teaching**

Lecture

**Class**

SS2

**Duration:**

80 minutes

**Subject:**

Biology

**Topic:**

Dihybrid Inheritance

**Number of Students:**

082

**Specific Objectives:**

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

- i. explain how two contrasting characters are inherited using crossing and punnet square methods,
- ii. state Mendel's second law of inheritance.
- iii. write the ratio of the F2 generation'

**Previous Knowledge:**

Students are familiar with how inheritance takes place in monohybrid cross.

**Instructional Materials:**

Diagrams showing crossing of gametes

**Presentation:**

**Step 1: Introduction:**

Teacher asks the students questions based on previous knowledge: Monohybrid inheritance.

**Step II:**

Dihybrid inheritance: The teacher explains how Dihybrid Inheritance takes place by using crosses and punnet square. e.g. colour and texture of a seed's surface (green smoothed surface seed and white wrinkled surface seed). Green and smooth are dominant over white wrinkled. Crossing the two shows: F1 generation all green smoothed seeds. F2 generation;

Green smooth = 9

Green wrinkled = 3

White smooth = 3

White wrinkled = 1

Ratio = 9:3:3:1

Teacher then states Mendel's second law of Inheritance: The two pairs of alleles are transmitted independently from parents to offspring and assort freely. This is called law of independent assortment.

**Student Activities:**

Students observed, listen and answer teacher's questions

**Step III: Evaluation:** The teacher evaluates the lesson by asking students the following questions:

- i. Explain how two contrasting characters are inherited using Crossing and punnet square methods,
- ii. State Mendel's second law of inheritance.
- iii. Write the ratio of the F2 generation'

**Step IV: Conclusion:**

The teacher concludes the lesson by a brief summary of the major points.

## LESSON NOTE FOR CONTROL GROUP

### LESSON FOUR

### WEEK FOUR

**Model of Teaching**

Lecture

**Class**

SS2

**Duration:**

80 minutes

**Subject:**

Biology

**Topic:**

Sex determination and sex linkage

**Number of Students:**

082

**Specific Objectives:**

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

- i. define a sex chromosome;
- ii. explain how the sex of a child is determined at conception.
- iii. describe sex linkage.
- iv. give examples of sex linkage.

**Previous Knowledge:**

Students are familiar with the terms chromosome and 'sex' of a child; how chromosomes segregate singly into a gamete, and how gametes come together at conception.

**Instructional Materials:**

diagrams depicting sex chromosomes.

## Presentation

### Step I: Introduction

The teacher introduces the lesson by asking students the following questions:-

- i. What are chromosomes?
- ii. What are genes?
- iii. State Mendel's First Law.
- iv. State Mendel's Second Law of inheritance.

### Step II:

Sex Determination: the teacher explains how the sex of child is determined by the XX and XY chromosomes after they have separated and gone into gametes during meiosis or gamete formation. The researcher uses a diagram to illustrate how this happens: X from mother + X from father = XX (Female) X from mother + Y from father = XY (Male)

### Step III:

Sex Linkage the teacher explains what sex linkage means:

- All the genes that are carried on the sex chromosomes. Teacher gives an example of how sex linkage takes place in drosophila. i.e. the inheritance of red eyes.
- How it is only transmitted by an X Chromosome from the father and not the Y chromosome.
- Even in humans it's the same. Thus, a male child cannot inherit a sex linked trait from his father because he received only a Y chromosome from his father; this does not carry any sex linked character or gene.

A female will however inherit a sex linked character from her father because she received an X chromosome from him. She will transfer it to all her children e.g. the inheritance of the red green colour blindness in man.

A colour blind gene is recessive. A man with it who marries a normal woman will transmit it to his daughters who will not be colour blind because they are heterozygous for that trait (they are carriers). His sons will not have the recessive allele because they received a

Y chromosome and not an X chromosome; their X chromosome is from their mother. If the daughter marries a normal man and they introduce a son, the probability is  $\frac{1}{2}$  that he will be colour blind.

Their daughter will be phenotypically normal, but probability is  $\frac{1}{2}$  that she will be a carrier. As would be expected there are more men than women who are red green colour blind. Haemophilia is another sex linked disease and operates like colour blindness.

**Student Activities:** Students observed, listen and answer teacher's questions

**Step IV: Evaluation: -** The teacher ask the students the following question

- i. define a sex chromosome;
- ii. explain how the sex of a child is determined at conception.
- iii. describe sex linkage.
- iv. give examples of sex linkage.

**Step VI: Conclusion:** The teacher concludes the lesson with a summary of the main points.

## LESSON NOTE FOR CONTROL GROUP

### LESSON FIVE

WEEK FIVE

**Model of Teaching**

Lecture

**Class**

SS2

**Duration:**

80 minutes

**Subject:**

Biology

**Topic:**

Types of Mutation

**Number of Students:**

082

**Specific Objectives:**

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

- i. Define mutation and list causes of mutation
- ii. Differentiate between gene mutation and chromosome mutation
- iii. Explain how gene and chromosomal mutation take place

**Instructional Materials:**

Small plants, seeds, leaves, stems, and diagrams of animals all with abnormalities

**Previous knowledge:**

Students have been seeing abnormalities in plants, animals and humans.

They are also familiar with genes, chromosomes and some of their characteristics.

**Presentation:**

**Step I Introduction:**

Teacher introduces the lesson by asking the students questions based on their previous knowledge.

- i. Name some of the abnormalities you see in plants, animals and man.
- ii. Can you suggest the causes of these abnormalities?

**Step II: Mutations:**

The teacher now groups the abnormalities given by students into two, based on the two main causes of mutation: Chromosome and Gene.

The genetic abnormalities are as a result of mutations.

Two types of mutations: Gene

mutations and chromosomal mutations.

**Step III: Chromosomal Mutations:** The teacher explains how chromosomal mutations take place.

- Involve a whole chromosome
- Take various forms: e.g

Deletion

Inversion

Translocation

Duplication

Non - disjunctions or polyploidy

Teacher explains each diagrammatically.

Examples of effects of non-disjunctions in man

include: Mongolism (Down's

syndrome). Klinefelter's syndrome. Turners syndrome.

Also the teacher explain gene mutation to the students with examples.

**Student Activities:**

Students observed, listen and answer teacher's questions

**Step IV: Evaluation:**

The teacher evaluates the lesson by asking the following questions:

- i. Define mutation and list causes of mutation

- ii. Differentiate between gene mutation and chromosome mutation
- iii. Explain how gene and chromosomal mutation take place

**StepV:Conclusion:** The teacher concludes by going through the main points once more.

### **LESSON NOTE FOR CONTROL GROUP**

**LESSON SIX**

**WEEK SIX**

**Model of Teaching**

Lecture

**Class**

SS2

**Duration:**

80 minutes

**Subject:**

Biology

**Topic:**

Applied genetics

**Number of Students:**

082

**Specific Objectives:**

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

- i. Mention the various areas in which genetics is applied;
- ii. Name some examples of plants that are produced by applied genetics.
- iii. List some examples of animals that are produced by applied genetics

**Instructional Material:**

Samples of modified fruits, cereals, legumes.  
ink and inkpad

**Previous Knowledge:**

Students see and use new species of tomatoes, fruits and some cereals that are introduced into the market these

days; They have been thumb- printing on various documents.

**Presentation:**

**Step 1: Introduction:**

The teacher introduces the lesson by asking students to carry out the following activities:

- i. Break open two species of tomatoes and state the differences you can see;
- ii. Thumb-print on a plain sheet. Tell us where else are people mandated to carry out such an activity and for what purpose?.

**Step II: Applied Genetics:**

The teacher explains what applied genetics is all about and the various ways the science of genetics is used by man to his advantage.

**Step III: Areas of Applications:**

The teacher states and explains: where and how genetics is applied:  
forensic Science ( identify and convict criminals and to confirm ownership) ; treat diseases ; production of drugs and gene therapy in treating cancer and cystic fibrosis; alter a plant or animal structure to make it more useful, e.g. to withstand pests, increase yield, resist discoloration and bruise, produce more milk and meat. This leads to the production of new species of organisms.

**Student Activities:**

Students observed, listen and answer teacher's questions

**Step IV: Evaluation:**

The teacher evaluates the lessons by asking them the following questions:

- i. Mention the various areas in which genetics is applied;
- ii. Name some examples of plants that are produced by applied genetics.
- iii. List some examples of animals that are produced by applied genetics

**Step V: Conclusion:**

The teacher concludes the lesson by going through the major points of the content.

## APPENDIX G

### RELIABILITY OF GENETIC CONCEPTS PERFORMANCE TEST (GCPT)

Raw Data for Reliability of GCPT

X: 31, 21, 22, 22, 24, 25, 27, 29, 21, 20, 19, 18, 20, 20, 22, 11, 07, 21, 20, 31, 32, 21, 18, 17, 20, 22, 24, 20, 21, 23.

Y: 23, 30, 31, 29, 27, 29, 21, 23, 27, 20, 22, 21, 21, 22, 24, 19, 17, 24, 21, 30, 33, 24, 20, 20, 22, 23, 25, 20, 20, 24

X	Y	$X-\bar{X}$	$X-\bar{Y}$	$(X-\bar{X})^2$	$(Y-\bar{Y})^2$	$(X-\bar{X})(Y-\bar{Y})$
31	23	9.37	0.73	87.80	0.53	6.84
21	30	-0.63	6.27	0.40	39.31	-3.95
22	31	0.37	7.27	0.14	52.85	2.69
22	29	0.37	5.27	0.14	27.77	1.95
24	27	2.37	3.27	5.62	10.69	7.75
25	29	3.37	5.27	11.36	27.77	17.76
27	21	5.37	-2.73	28.84	7.45	-14.66
29	23	7.37	-0.73	54.32	0.53	-5.38
21	27	-0.63	3.27	0.40	10.69	-2.06
20	20	-1.63	-3.73	2.66	13.91	6.08
19	22	-2.63	-1.73	6.92	2.99	4.55
18	21	-3.63	-2.73	13.18	7.45	9.91
20	21	-1.63	-2.73	2.66	7.45	4.45
20	22	-1.63	-1.73	2.66	2.99	2.82
22	24	0.37	0.27	0.14	0.07	0.10
11	19	-10.63	-4.73	113.00	22.37	50.28
07	17	-14.63	-6.73	214.04	45.29	98.46

21	24	-0.63	0.27	0.40	0.07	-0.17
20	21	-1.63	-2.73	2.66	7.45	4.45
31	30	9.37	6.27	87.80	39.31	58.75
32	33	10.37	9.27	107.54	85.93	96.13
21	24	-0.63	0.27	0.40	0.07	-0.17
18	20	-3.63	-3.73	13.18	13.91	13.54
17	20	-4.63	-3.73	21.44	13.91	17.27
20	22	-1.63	-1.73	2.66	2.99	2.82
22	23	0.37	-0.73	0.14	0.53	-0.27
24	25	2.37	1.27	5.62	1.61	3.00
20	20	-1.63	-3.73	2.66	13.91	6.08
21	20	-0.63	-3.73	0/40	13.91	2.35
23	24	1.37	0.27	1.88	0.07	0.37
				$\Sigma (X-\bar{X})^2 = 791.06$	$\Sigma (Y-\bar{Y})^2 = 473.78$	$\Sigma (X-\bar{X})(Y-\bar{Y}) = 546.06$

$$PPMC = r = \frac{\Sigma(x-\bar{x})(y-\bar{y})}{\sqrt{\Sigma(x-\bar{x})^2 \Sigma(y-\bar{y})^2}}$$

Where

$$\Sigma (x-x) (y-y) = 546.04, \Sigma (\bar{x}-\bar{x})^2 = 791.06, \Sigma (\bar{y}-\bar{y})^2 = 473.73$$

$$\text{Hence } r = \frac{546.04}{\sqrt{(791.06)(473.78)}}$$

$$= \frac{546.04}{\sqrt{374788.41}}$$

$$= \frac{546.04}{612.20}$$

$$= 0.89$$

$$r = 0.89$$

The Genetics Concept Performance Test Reliability Co-efficient was obtained as 0.89 which was high correlation.

## APPENDIX H

### RELIABILITY OF GENETIC CONCEPTS ATTITUDE QUESTIONNAIRE (GCAQ)

Raw Data for reliability of (GCAQ)

X: 73, 63, 76, 92, 76, 80, 59, 72, 80, 81, 72, 77, 76, 73, 81

Y: 77, 90, 75, 63, 74, 71, 92, 81, 72, 80, 80, 81, 75, 81, 75

X	Y	RX	RY	D	d <sup>2</sup>
73	77	5.5	8	-2.5	6.25
63	90	2	14	-12	144
76	75	8	6	2	4
92	63	15	1	14	196
76	74	8	4	4	16
80	71	11.5	2	9.5	90.25
59	92	1	15	-14	196
72	81	3.5	12	-8.5	72.25
80	72	11.5	3	8.5	72.25
81	80	13.5	9.5	4	16
72	80	3.5	9.5	-6	36
77	81	10	12	-2	4
76	75	8	6	2	4
73	81	5.5	12	-6.5	42.25
81	75	13.5	6	7.5	56.25
					$\Sigma d^2 = 955.5$

$$SROC = rho = 1 - \frac{6 \Sigma d^2}{N(N^2 - 1)}$$

Where

$$\Sigma d^2 = 955.5$$

$$N = 15$$

Hence

$$\rho = 1 - \frac{6(955.5)}{15(15^2-1)}$$

$$= 1 - \frac{6 \times 955.5}{15(225-1)}$$

$$= 1 - \frac{6 \times 955.5}{15 \times 224}$$

$$= 1 - \frac{3 \times 191.1}{3 \times 112}$$

$$= 1 - \frac{573.3}{336}$$

$$= \frac{237.3}{336}$$

$$= 0.71$$

The Genetics Concept Attitude Questionnaire reliability co-efficient was obtained as 0.71 which was high correlation

## APPENDIX I

### ITEM ANALYSIS OF GENETIC CONCEPTS PERFORMANCE TEST (GCPT)ITEMS

Items	$F = \frac{R}{T}$	$D = \frac{RU-RL}{\frac{1}{2}N}$
1	0.43	0.48
2	0.51	0.53
3	0.46	0.49
4	0.49	0.50
5	0.54	0.62
6	0.64	0.67
7	0.57	0.47
8	0.45	0.51
9	0.50	0.46
10	0.46	0.61
11	0.46	0.64
12	0.51	0.62
13	0.52	0.54
14	0.46	0.52
15	0.52	0.46
16	0.49	0.69
17	0.47	0.52
18	0.52	0.49
19	0.44	0.66
20	0.50	0.45
21	0.53	0.61
22	0.44	0.52
23	0.50	0.44
24	0.48	0.49

25		0.51	0.63
26		0.45	0.53
27		0.52	0.50
28		0.56	0.66
29		0.43	0.50
30		0.46	0.57
31		0.52	0.53
32		0.54	0.49
33	RR	0.23	0.42
34		0.49	0.54
35	RR	0.31	0.41
36		0.40	0.56
37	RR	0.22	0.44
38		0.46	0.59
39		0.51	0.145
40		0.45	0.60

RR= Re-modified and Retained

## APPENDIX J

### CONVERGENT AND DIVERGENT THINKERS TEST (CDTT)

Several tests have been used for the categorization and determination of these two cognitive styles dimension (i.e divergent and convergent thinker) such as

- Uses of Objects and Things Tests (UOTT)
- Line Meaning Tasks (LMT)
- Drawing Completion Test (DCT)
- Project Tests (PT)

The one adapted for this study is that of Kolb (2008) and Adamu (2010).The test is called the "Modified Use of Objects and Things Tests" (MUOTT) for the determination of convergent and divergent students. This test contains six (6) common objects in form of specimens and the students were asked to write five (5) uses of each in eight minutes. Each correct answer attract 1 mark and the total marks for each object is 5 marks while the grand total for all the six(6) objects is 30 marks (i.e. 5 marks x 6 objects = 30 marks)as showed below:


- a. Basket (BS) = 5 marks
- b. Knife (KF) = 5 marks
- c. Bucket (BT) = 5 marks
- d. Cup(CP) = 5 marks
- e. Spoon (SP) = 5 marks
- f. Broom (BM) = 5 marks





Total = 30 marks


The test was scored over thirty (30) and will be used for the classification of convergent and divergent thinkers on a scale of 0 - 14 marks Convergent and 15 -30 marks Divergent (Kolb, 2008 and Adamu,2010) (Appendix K).

### APPENDIX K

#### CONVERGENT AND DIVERGENT THINKER TEST (CDTT) CHECK-LIST GUIDE

Objects	Teacher Expectation	Student Responses
  <b>BROOM</b>	<ul style="list-style-type: none"> <li>- It can be used for sweeping</li> <li>- It can be used for washing</li> <li>- It can be used for turning soup</li> <li>- It can be used for source of income</li> <li>- It can be used for identifications e.g. organisation or political parties</li> </ul>	
	<ul style="list-style-type: none"> <li>- It is used to sharp</li> </ul>	

 <p style="text-align: center;"><b><i>KNIFE</i></b></p>	<p>object</p> <ul style="list-style-type: none"> <li>- It is used to cut object</li> <li>- It can be used to kill or slaughter animal.</li> <li>- It can be used for peeling object</li> <li>- It can be used as weapon during a war</li> </ul>	
 <p style="text-align: center;"><b><i>BUCKET</i></b></p>	<ul style="list-style-type: none"> <li>- It is used for bathe</li> <li>- It is used for fetching water</li> <li>- It is used for keeping or holding water</li> <li>- It is used for washing</li> <li>- It is used to carried food substances etc.</li> </ul>	
 <p style="text-align: center;"><b><i>CUP</i></b></p>	<ul style="list-style-type: none"> <li>- It can be used for drinking water</li> <li>- It can be used for fetching water</li> <li>- It can be used for eating food</li> <li>- It can be used to mixed liquid substances</li> <li>- It can be used for measurement</li> </ul>	
 <p style="text-align: center;"><b><i>SPOON</i></b></p>	<ul style="list-style-type: none"> <li>- It can be used for eating food</li> <li>- It can be used for stirring mixture</li> <li>- It can be used for measurement and</li> </ul>	

	<p>taking medicine</p> <ul style="list-style-type: none"> <li>- It can be used for serving food</li> <li>- It can be used for preparing soup</li> </ul>	
 <p><b>BASKET</b></p>	<ul style="list-style-type: none"> <li>- It can be used to pack dirty etc.</li> <li>- It can be used to separate different items.</li> <li>- It can be used to keep or store items.</li> <li>- It can be used to dry object e.g. fish</li> <li>- It can be used to carry load.</li> </ul>	

**Source:** Kolb, (2008) and Adamu (2010).

## APPENDIX L

### COLLATERAL LEARNING STRATEGY SHEET FOR ROUGH RECORD OF STUDENTS RESPONSES DURING THE CLASS ACTIVITIES

Lesson Plan Steps	Students Responses	Teacher Remark
<p><b>IDENTIFICATION OF PRIOR IDEAS</b></p>		

<b>EXPLORATION</b>		
<b>DISCUSSION</b>		
<b>APPLICATION</b>		

<b>EVALUATION</b>		
<b>CONCLUSION</b>		

**Source:** Researcher, (2016).

**Note:** The lesson objectives and the lesson note served as teacher expectation.

### **APPENDIX M**

#### **LETTER FOR VALIDATION OF INSTRUMENTS**

Department of Science Education,  
Faculty of Education,  
Ahmadu Bello University, Zaria.  
10<sup>th</sup> August, 2016

Dr. F.K. Lawal,  
Department of Science Education,  
Ahmadu Bello University, Zaria

Ma,

#### **VALIDATION OF RESEARCH INSTRUMENT**

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

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

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

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

I very much thank you and appreciate your assistant please.

Yours sincerely,

Shuaibu Ado Mohammed

Department of Science Education,  
Faculty of Education,  
Ahmadu Bello University, Zaria.  
10<sup>th</sup> August, 2016

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

Sir,

### **VALIDATION OF RESEARCH INSTRUMENT**

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

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

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- i. Do the items relate to genetic concepts expected of secondary students?
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- iii. What general criticism and suggestions can you give for the improvement of the instrument?

I very much thank you and appreciate your assistant please.

Yours sincerely,

Shuaibu Ado Mohammed

Department of Science Education,  
Faculty of Education,  
Ahmadu Bello University, Zaria.  
10<sup>th</sup> August, 2016

Dr. Aisha Mohammed,  
Department of Educational Psychology and Counselling,  
Ahmadu Bello University, Zaria

Ma,

### **VALIDATION OF RESEARCH INSTRUMENT**

I have developed a research instrument design to generate data for my M.Ed Dissertation on students attitude to genetics in our Senior Secondary School.

The instrument titled, Genetic Concepts Attitude Questionnaire (GCAQ) consist of 30 items adapted from (Nwagbo, 2005). It is to be used as both pre-test and post-test. Research Objectives, Questions and Null Hypotheses of the study from chapter one is attached here with for your reference.

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

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

I very much thank you and appreciate your assistant please.

Yours sincerely,

Shuaibu Ado Mohammed

Department of Science Education,  
Faculty of Education,  
Ahmadu Bello University, Zaria.  
10<sup>th</sup> August, 2016

Dr. J.O. Bawa,  
Department of Educational Psychology and Counselling,  
Ahmadu Bello University, Zaria

Ma,

### **VALIDATION OF RESEARCH INSTRUMENT**

I have developed a research instrument design to generate data for my M.Ed Dissertation on students attitude to genetics in our Senior Secondary School.

The instrument titled, Genetic Concepts Attitude Questionnaire (GCAQ) consist of 30 items adapted from (Nwagbo, 2005). It is to be used as both pre-test and post-test. Research Objectives, Questions and Null Hypotheses of the study from chapter one is attached here with for your reference.

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

I very much thank you and appreciate your assistant please.

Yours sincerely,

Shuaibu Ado Mohammed

## APPENDIX N

### PRETEST GENETIC CONCEPTS PERFORMANCE TEST (GCPT) FOR EQUIVALENT

#### Pretest Result (Scheff)

Groups	N	Mean Differences	Standard Deviation	P-Value	Remark
GDSS Kwamba	86	0.50	0.40	0.66	NS
GDSS Madalla	84	0.45	0.41	1.00	NS
GDSS Suleja	93	0.55	0.41	0.61	NS
GMSS Suleja	82	0.69	0.18	0.98	NS

Significance at  $\alpha \leq 0.05$  level

**GENETIC CONCEPT PERFORMANCE TEST GROUP EQUIVALENT TEST ONE  
WAY ANOVA**

**PRETEST (GCPT) RESULT**

	<b>Sum of squares</b>	<b>DF</b>	<b>Mean square</b>	<b>F</b>	<b>P-Value</b>	<b>Remark</b>
Between Groups	343.95	3	114.65			
				98.84	0.10	NS
Within Groups	396.98	341	1.16			
Total	740.93	344	2.16			

Significant at  $\alpha \leq 0.05$  at  $df = 3$  and  $341$ .