EFFECTS OF CONCEPTUAL CHANGE INSTRUCTIONAL STRATEGIES ON SECONDARY SCHOOL STUDENTS' MISCONCEPTIONS, PERFORMANCE AND RETENTION IN GENETICS IN KADUNA, NIGERIA

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DECLARATION

I hereby declare that this thesis entitled:**"Effects of Conceptual Change Instructional Strategies on Secondary School Students' Misconceptions, Performance and Retention in Genetics in Kaduna, Nigeria"** has been performed by me in the Department of Science Education, Faculty of Education, Ahmadu Bello University, Zaria. It is the record of my research work which has not been presented in any previous form for a higher degree at this or another institution. In the course of writing this thesis, various sources of information have been consulted and these are duly acknowledged by means of references.

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CERTIFICATION

This thesis entitled **"Effects of Conceptual Change Instructional Strategies on Secondary School Students' Misconceptions, Performance and Retention in Genetics in Kaduna, Nigeria"** by Abigail Omolola Idowu DADA with Registration Number P16EDSC9171 meets the regulation governing the award of the degree of Doctor of Philosophy (Ph.D) in Science Education of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to my late parents: Chief (Mrs.) Ruth Wuraola and Chief James Owolabi Fabunmi. May their Gentle Souls Rest in Perfect Peace. Amen.

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ABBREVIATIONS

The following abbreviations used in the context of this study are presented as follows

CA	Conceptual Assignments
CD	Conceptual Discussions
ECDCA	Enriched Conceptual Discussions with Conceptual Discussions
SSIII	Senior Secondary III
SSS	Senior Secondary School
STAN	Science Teachers Association of Nigeria
MAN	Mathematical Association of Nigeria
NARSE	National Association of Researchers in Science Education
NERDC	National Education Research Development Council
NTI	National Teachers Institute
FME	Federal Ministry Education
WAEC	West African Examinations Council
WASC	West African School Certificate
WASSCE	West African Senior Schools Certificate Examinations
NECOSSCE	National Examinations Council Senior School Certificate Examinations
DNA	Deoxyribose Nucleic Acid
RNA	Ribose Nucleic Acid
CCM	Conceptual Change Model
GLMT	Generative Learning Model of Teaching
I Q	Intelligence Quotient
GMT	Genetic Misconceptions Test
GPT	Genetic Performance Test

OPERATIONAL DEFINITION OF TERMS

The following are definitions of terms as used in this study.

Accommodation (Conceptual Exchange):A mental process that occurs when a learner adjusts to new information.It is the process of refraining one's mental representation of the mental world to fit new experiences. If the new conception achieves higher status than the prior conception, accommodation which is also called conceptual exchange may occur.

Assimilation (Conceptual Capture):A mental process that occurs when a learner incorporates new knowledge into existing knowledge. The incorporation of the new experience in an existing framework without changing that framework which may occur when individuals' experience are aligned with their internal representation of the world, but may also occur as a failure to change a faulty understanding.

Conceptual Status: In conceptual change, learning requires that the existing conceptions be restructured or even exchanged for the new. Learning a new conception means that the status rises, that is., the learner understands it, accepts it sees that it is useful. If the new conception conflicts with an existing conception i.e. one that already has high status for the learner, it cannot be accepted until the existing conception is lowered.

Conceptual Change: This is the shift or restructuring of existing knowledge and beliefs. It is the learning that fundamentally changes or even replaces, an existing conception and becomes the conceptual framework that student uses to solve problems, explain phenomena, and function in their world.

Conceptual Change Instructional Strategy: An instructional strategy in which the teacher acts as a facilitator providing thought- provoking questions, experiments and guided discussion which help to lead students thinking towards constructing scientifically valid ideas.

Conceptual Assignment: This is a system of learning in which the teacher uses his skillful organization to give responsibility to the learner for his learning in order to replace a misconception with a scientifically acceptable concept.

Conceptual Change Discussion: This is a purposeful constructive and objective dialogue between the teacher and the learners on a particular concept which can fundamentally change or even replace an existing conception and become the conceptual framework that the learners can use to solve problems, explain phenomena and function in their world.

Conceptual Change Model: This is a model developed based on Piaget's epistemology which describes learning as a gradual process in which a person changes his/her conceptions by acquiring new conceptions or exchanging existing conception for superior or more functional new ones.

Constructivism: This is a theory of knowledge (epistemology) that argues that human generate knowledge and meaning from an interaction between their experience and their ideas. It is through the processes of accommodation and assimilation, individual construct new knowledge from their experiences. It emphasized that individuals construct their own knowledge through interaction with their environment.

Conceptual Ecology: It is a set of concepts which affect what the student will find plausible, comprehensible or reasonable which can be referred to as the conceptual niche in which a new idea must survive.

Genetics: It is the area of biological study concerned with heredity and with variations between organisms that result from it. It is a branch of science that deals with scientific examination of genes, heredity and variations in organisms which includes the interrelated fields of cytology, biochemistry, evolutionary theory and molecular biology.

Instructional Method: The professional skill and techniques employed by the teacher to disseminate knowledge in other to bring about learn.

Mental models: These are simplified, conceptual representations that are personalized interpretations of modeled target systems or phenomena in the world around us. Thus, the transformed modeled target systems or phenomena become the mental models which are more visible or comprehensible to an individual.

Misconceptions: These are those beliefs students have that contradict accepted scientific theories. They are ideas that differ from the corresponding scientific explanations.

Modeled Target System: It is a preliminary solid representation of the world or phenomena.

Performance: Assessment that requires creating answers or products that demonstrate knowledge and skill which may include writing and conducting an experiment, carrying out a project, solving a real world problem and creating a portfolio.

Preconceptions: These are personal ideas or opinions, which are formed based on what an individual sees or feels which may be wrong or right.

Preconceived Notion: These are the ideas the learner already has about the concept being taught i.e. the personal explanatory knowledge of the learner about the concept in question, before exposure to instruction about the concept in question. Popular notions that are rooted in everyday experiences of the learner about the concept taught which may be scientifically right or wrong.

Retention: Ability of the memory to store information which can be recalled sometime after exposure to series of instruction or training.

Traditional Instructional Strategy: The method of teaching where the teacher does most of the talking and the learner only listens most of the time and may copy down notes.

LIST OF TABLES

Table Page

LIST OF FIGURES

LIST OF APPENDICES

TABLE OF CONTENTS

CHAPTER FOUR: DATA ANALYSIS, RESULTS AND DISCUSSION

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

ABSTRACT

The study examined the Effects of Conceptual Change Instructional Strategies on Secondary Students' Misconceptions, Performance and Retention in Genetics in Rigachukun Education Zone of Kaduna, Nigeria**.** Eight research questions and six null hypotheses tested at 0.05 level of significance guided the study. Quasi experimental research design was used for the study. The population of the study consisted 2854 (SSIII) Biology students in nineteen government secondary schools in RigaChikun Education Zone of Kaduna State comprising 1620males and 1234females. The sample of the study consisted of 182 Senior Secondary School three Biology students (105 males and 77 girls) drawn from four government secondary schools in RigaChikun Education Zone of Kaduna State. The sample was drawn using random sampling technique. Two instruments were employed for data collection namely: Genetic Misconception Test (GMT) and Genetic Performance Test (GPT). The reliability of both instruments Genetic Performance Test and Genetic Misconception Test was determined using test retest method and was found to be r = 0.81 for GMT and 0.82 for GPT respectively. GPT content validity was ensured by three senior lecturers in Science Education Department, Ahmadu Bello University Zaria. Mean and standard deviation was used to answer the research questions while Analysis of Variance (ANOVA) was used to test the null hypotheses and Scheffe's Multiple Comparison Test to detect the source, magnitude and direction of significant variations. The findings showed that: 1. There was a significant difference between the pretest and posttest mean scores of the Genetic Misconception Test in the experimental groups and the control group in favour of the experimental groups. 2. There was a significant difference between the posttest mean scores of the Genetic Performance Test in the experimental groups and the control group in favour of the experimental groups.3. The genetic concepts post- posttest mean scores was significantly higher for those students taught using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Assignments with Conceptual Discussions instructional strategies than those taught using the traditional instructional strategy among other. Based on the results of the study the following recommendations were made: 1. Biology teachers should be encouraged to use conceptual change instructional model to improve the academic performance of Biology students among others.

CHAPTER ONE

THE PROBLEM

Introduction

Biology is one of the science subjects offered in secondary and tertiary institutions. Basic knowledge of biology is a pre-requisite for the study of several disciplines in tertiary institutions, such as Medicine, Agriculture, Pharmacy, Biochemistry and Biotechnology amongst others. Genetics is the branch of biology that deals with heredity, especially the mechanisms of hereditary transmission and the variation of inherited characteristics among similar or related organisms. Genetics has unified the biological sciences and led to the modern synthesis of evolutionnary theory and biology by demonstrating that organisms share the same basic genetic materials and processes (Whitesides, 2011).

Genetics is very useful to agriculture, industry, psychology, medico-legal, molecular genetic engineering, medicine and ethics. Genetics is one of the aspects of biology syllabus of West African Examinations Council (WAEC) which most students scarcely study before completing their secondary education (Okpala, 2005). Genetic concepts have been identified as a difficult aspect of biology, the reason being the time and position given to it in the school curriculum (Ndubuizu, 2004). Genetics is an interesting aspect of the biology curriculum but according to Ruiyong, (2004) it is a very difficult and analytical discipline. Nwaorgu, (2005) reported that the laboratory practical approach to the teaching of genetics is difficult as it involves a long term experimental work. She further explained that there is also the belief ofpeople in reincarnation which conflicts with the principles of molecular genetics. Other interpretations made on the laws governing inheritance were based on metaphysics and philosophy, preformationists, epigenesis and pangenesis. This division between the practical reality and what is learnt in the classroom is one of the major problems militating against the practical approach to teaching and learning of genetics in secondary schools. This conflict between reality and practice has been blamed to poor teaching method (Nwaorgu, 2005). Genetics is an area of biology students are finding difficult to understand. Fakunle and Smith (2005) also maintained that students had difficulty in understanding genetic concepts. The following concepts have been identified as difficultby both teachers and students, (i) Meiosis (ii) Variation (iii)

Mendelian laws and latter developments (iv) Genetic crosses and symbolic representation(v) Structure and replication of DNA (vi) Genetic ratios, analysis and probability (vii) Abstract nature of genetics and non–relation of functions to structures (viii) Use of synonyms (Mang& Piwuna, 2005; Nzewi U.M., Etokebe I.J., Pati E.I. and Akpan B.A. 2003; STAN, 2005).

According to Ndubuizu, (2004) the cognitive status of a child determines to a greater extent the level of understanding of any given concept. Most students operate at Piaget's concrete operational stage (Ndubuizu, 2005) and find it difficult to cope with the abstract nature of genetic concepts. Other problems of teaching and learning of genetics as identified by Deadman and Kelly and Mang and Piwuna (2005) are usually traced to both teachers and students as follows: Abstract nature and inability to relate structure to function, use of synonyms or many terms for some concepts, lack of adequate time for practical work in genetics, lack of confidence and competence in teachers, lack of coherence and association with other concepts in biology, lack of prerequisite knowledge for genetics, wrong perception of relevance in the curriculum, student attitude towards biology and lack of laboratory equipment and apparatus. According to Ndubuizu, (2004) students generally perceive biology as an easy subject. This deceptive notion makes them to develop a nonchalant attitude to its study that few spend time to study other science subjects (Ajewole, 2005). This attitude according to Soyibo, (2005) is one of the reasons for students' poor performance in biology.

According to Cirfat (2005) Biology is generally conceived by most students as the "easiest" science subject, thus it easily ranks as the most popular. The massive failure received in WASSCE and NECO SSCE does not testify to its being easy. As rightly noted by Ladon (2005) efforts need to be geared toward removing the difficulties that contribute to the failures. One of such effort is in the area of the better learning and understanding of difficult concepts. From available researches, genetics has been identified as one of the difficult concepts to learn in biology Johnstone and Mahmoud, Longden, Oyetunde and Okpala (2005). Ladon (2005) identified eight areas of genetics that posed difficult to students and teachers. These include: DNA and RNA, Meiosis, Symbolic representation, Mathematics- bias of genetics, the concept of chance, Mendelian laws, Genes, alleles, chromatids and chromosomes, and Terminologies. He further explained that some terminologies are redundant e.g. chromatids/chromosomes (Longden 2005; Deadman & Kelly 2005; Pearson & Hughes 2005; Radford & Bid-Steward, 2005).

Okpala (2005) opined that a fundamental problem many students face in the study of genetics is mostly that of inability to conceptualise the principles, processes and the terms involved. He further explained that one of these terms are "gene and locus". Lakpini (2009) observed that without students grasp of genetic concepts, performance of students will persistently remain low in biology. Research findings have shown that a number of topics in biology amongst which is genetics contain some concepts which pose difficulty for biology students (Esiobu & Soyibo; Okebukola; Nzewi, Etokebe, Pati & Akpan (2005). It is clear that when concepts in genetics are not meaningfully understood by the students, they tend to shy away from questions set on them during Senior Secondary Certificate Examination (SSCE). Repeated reports (Okafor 2005; Chikodi 2005) of constantly poor performance in biology at Senior Secondary Certificate Examination (SSCE) have attracted a lot of concern from science educators. Thus, research in science education in Nigeria has continued to seek better ways of teaching biology in order to improve academic performance (Esiobu, 2000, Kahindej, 2000, Ajaju & Kpangban 2001).

In spite of efforts through research into the strategies to improve performance in biology, the WAEC chief examiners' yearly reports have continued to highlight students' weakness in answering questions relating to difficult concepts such as in the area of genetics. Such weakness induces student inability to comprehend or represent concepts (Chief Examiners Report West African Examination Council 2010, 2012, 2014). If the learning of genetic concepts can be shifted from using the expository or traditional method to constructivist strategy, it is likely that learning will be significantly more effective as students would actively construct knowledge by themselves. Despite all efforts to improve students' performance in biology, it has been observed, unfortunately, that the educational system is to a great extent not achieving its predetermined goals and objectives due to high failure in public examinations such as the senior secondary certificate examination (Agbowuro, 2008). The high failure rate could be attributed to improper instructional strategy that does not make reference to students' prior knowledge to provide links that enhance meaningful learning. The use of instructional strategy by teacher that allows students construct ideas, discuss and exchange them provide avenues for teachers to help students evaluate their ideas, discover basis for such ideas and adopt strategy to raise cognitive conflicts necessary to enhance capacity to reorganize their thoughts in line with new ideas. The continuous use of this strategy is expected to correct misconceptions as cognitive conflicts raised during interactions will trigger their thought processes and enable learners to see the inadequacy of their ideas or prior knowledge. Thus, their misconceived prior ideas or knowledge are reorganized to provide meaningful links for the new knowledge which could promote retention and improve students'performance. The use of instructional strategy is necessary as students always have prior knowledge that are wrong which can only be realized when cognitive conflicts are raised to show the incongruity of their prior knowledge and the new knowledge. As conceptual discussions instructional strategy often challenge students to compare and reorganize ideas, its potential to correct misconceptions among learners seems feasible.

Concepts in science mean different things to different scientists. Abimbola (2002) defined concept as the meaning attached to a given symbol or label. He categorized concept into three: empirical, theoretical and relational. Goje, (2007) defined concepts as ordered information about the properties of one or more things, objects, events or process that enables any particular thing or class of things to be differentiated from and also related to other things or classes of things. In science, there are many concepts such as ecology, equilibrium, osmosis, diffusion, genetics, heat, reproduction, physiology, growth, ageing, embryology, electrolysis among others. James (2001) ascertained that the primary goal of science education is to engage students in an active process of identifying, constructing meaningful learning of science concepts. Jegede and Okebukola (2002) lamented that majority of science students lack the understanding of even the basic science concepts. This is evident in poor performance of students in WASSCE irrespective of the large enrolment of students in the subject (Nworgu, 2005).Studies have shown that the understanding of biology requires a functional understanding of the requisite sub-ordinate concepts like genetics (Mete, 2007), evolution (Bichi, 2008) and ecology (Moemeke & Omoifo, 2003;

Mete, 2007; Mohammed & Jongur, 2008). A lack of understanding of these concepts is believed by the scholars to have effect on students' performance in biology. Studies on genetics such as those of Lakpini (2009) and Lawal (2009) have shown that a major factor responsible for students' poor academic achievement is misconception of genetic concepts. Also, WAEC chief examiners' report (2010, 2012& 2013) pointed out that one of the major areas of biology where students failed is the genetic concepts.

Discussion of conceptual change needs to consider the nature of conceptions. Glynn and Duit (2005) viewed conceptions as learners' mental models of an object or an event. Conceptions can be regarded as the learner's internal representations constructed from the external representations of entities constructed by other people such as teachers, textbook authors or software designers. From a conceptual change learning perspective, learners need to be able to make different representations of entities to make difficult concepts intelligible. Learning always involves some ways of representing information and science teachers use different representational techniques such as voice, writing, and gestures in the classroom to communicate ideas to students. Representations are ways to communicate ideas or concepts by representing them either externally, taking the form of spoken language (verbal), written symbols (textual), pictures, or physical objects or a combination of these forms or internally when thinking about these ideas. Students come to science classes with pre-instructional conceptions and ideas about the phenomena and concepts to be learned that are not in harmony with science views. Furthermore, these conceptions and ideas are firmly held and are often resistant to change (Duit 2007).

A lot of interest has been focused on students' misconceptions of variety of scientific concepts. There are a number of research studies in students' misconceptions about a variety of scientific concepts that all cannot be cited in this work such as selected science misconceptionsin photosynthesis, respiration, osmosis and pressure by Soyibo (1981); misconceptions about force and motion by Eryilmaz, (2002); misconception of mole concepts by Goje, (2007) and misconceptions in genetic concepts by Lawal, (2009). Different terms have been used to describe these misconceptions by different researchers. Novak (1977) called them preconceptions. While Driver and Easley, (1978) referred to them as alternative conceptions. Helm (1980) called them misconceptions. Suton (1980) preferred the term children's scientific intuitions, Gilbert, Watts and Osborne (1982) called them children's science, Halloun and Hestenes (1985b) called them common sense concepts, and Pines and West (1986) called them spontaneous knowledge. Preconceptions can indicate all beliefs students have before enrolling in their formal subject course. Misconceptions refer to those beliefs students have that contradict accepted scientific theories (Eryilmaz, 2002). Driver and Erickson (1983) called misconceptions alternative frameworks. Fisher and Lipson (1986) called them students' errors. There are different types of misconceptions. These are preconceived notions, non-scientific beliefs, conceptual misunderstandings, vernacular misconception and factual misconceptions (Blosser, 1987).In this research work, misconceptions are described as conceptual misunderstandings, which have occurred during or as a result of instruction, which are more likely to have been held or developed over a long period of time.

Gender refers to the amount of masculinity and femininity found in an individual. While there are mixtures of the two traits in human beings, the normal man has a preponderance of masculinity and the normal female has a preponderance of femininity (Bichi, 2002). A number of explanations attribute gender differences in educational achievement to biological differences between males and females. These explanations propose that gender differences in behaviour, skills and cognitive abilities are determined by biological factors such as brain organization, hormones and genetics, and thatthese biologically determineddifferences in behaviour and abilities are responsible for gender differences in educational achievement.This study examined the gender performance variable. The study also investigated the issue of gender difference on the basis of effect of instructional strategies under study. An attempt was made to investigate if the conceptual assignments and conceptual change discussions has influence on retention ability and academic performance of genetic concepts among male and female students at the senior secondary school level or not.

Retention is the ability to retain and consequently remember things experienced or learned by an individual at a later time. When teaching is characterized by rote learning, meaningless memorizing and emphasis on verbalism, students make ineffective learning, and the facts thus learned are not long retained, nor do they seem to have much effect in changing behaviour (Bichi, 2002). In contrast, when teaching is organized and meaningful in which students apply principles, to solve problems and interpret experimental data, learning becomes effective and the facts thus learned are long retained with the passage of time (Tyler in Bichi, 2002). Discussions encourage learners' active participation in learning activities and build confidence in the learners as they express their views (Atadoga&Onaolapo, 2008).

A student who participates in a discussion lesson learns to support his views rationally, based on facts, appreciates the need to argue logically, define clearly concepts and terms and examine critically rules, principles and construct his or her thoughts in line with the new ideas. Discussion teaching strategy crosses all barriers and gulfs peculiar with the lecture method. It centres on shared conversations, discussions, and exchange of ideas in the class. It also gives opportunity for all to sit and listen, as well as talk and think, thus emphasizing the process of "coming to know" as valuable as "knowing the right answer" (Omatseye, 2011).The teacher in the discussion class is not the sole performer and the students are not passive listeners. Students are allowed to develop critical thinking ability, learn to evaluate ideas, concepts and principles, procedures and even programmes and policies on the basis of clearly set criteria. In discussion, the teacher brings students face to face as they engage in verbal interchange of ideas. Discussion instructional strategy can provide a format in which students can apply newly acquired knowledge, thereby consolidating and deepening their understanding of it (Omatseye, 2011). In essence anything that aids learning should improve retention while things that lead to confusion or interference among learned materials decrease the speed and efficiency of learning and accelerates forgetting. When a material is forgotten, it means it has not been retained and hence cannot be remembered at a later period (Bichi, 2002).

The term conceptual change refers to the development of fundamentally new concepts, through restructuring elements of existing concepts, in the course of knowledge acquisition. Conceptual change is a particular profound of learning – it goes beyond revising one's specific beliefs and involves restructuring the very concepts used to formulate those beliefs. In conceptual change, an existing conception is fundamentally changed or even replaced and becomes the conceptual framework that students use to solve problems, explain phenomena, and function in their world (Carey, 2001).

Although traditional instructional methods have a significant effect on students' misconceptions, it is far from being sufficient in remediating students' misconceptions that are persistent and highly resistant to change (Eryilmaz, 2002). Eryilmaz, (2002) reported that some of the most common suggestions to remedy students' misconceptions include teaching physics conceptually, and by conceptual discussion methods (Posner, Strike & Hewson 1982; Brouwer,1984& Eryilmaz, 2002).Studies such as that ofEryilmaz, (2002) have revealed that some instructional strategies or methods can be effectively used to restructure students thinking and ideas so that correct conceptions or ideas are developed. Eryilmaz, (2002) reported that assignment is one area in which few studies have been conducted. Assignment is part of the lesson that tells students what to do after school hour and is related to what they have already done or what they still have to do in class. It is a set of tasks or a specific task which students are expected to complete in a given time. It may be a project, a series of problems to be solved, some questions to be answered, a chapter to be read and summarized, a story to be outlined or a view of past lessons (Atadoga &Onaolapo, 2008). Different types of assignments could be given to individual students or to groups depending on the time available to students to complete the tasks and their ability. Simple and smaller units of work may be given to individuals and larger unit to group. In this present research defines conceptual assignment is defined as a set of task or a specific task which students are expected to complete in a given time on a particular concept. Eryilmaz, (2002) noted the importance of homework problems in creating the cognitive conflicts necessary for preparation of the conceptual change. According to Eryilmaz, (2002) some researchers suggested using conceptual assignment to establish the first four steps of the conceptual change strategy. These are Step 1: Awareness or orientation phase, Step 2: Disequilibrium/ Elicitation of ideas, Step 3: Reformation phase and Step 4: Application phase.

Discussion simply means talking over subjects from various points of view and the teachers' role is not to dispense or communicate knowledge but act as moderator (Atadoga &Onaolapo, 2008). It is students' centred and it is based on the philosophy that “knowledge arises within the person and not from any external source” (Brown, Nacino-Brown & Oke, 1982). The students carefully, consider a topic, react to it, argue with one another, suggest solutions, evaluate alternatives and draw conclusions or generalizations. They become creators rather than passive recipients of ideas (Atadoga& Onaolapo, 2008). In discussion, all the students see themselves as members of a group as they participate in discussions, listen to each other, resolve differences, make suggestions and critically examine issues for the benefit of all. As students formulate their own views in the act of give and take, they also learn to resist the influences of their personal prejudices, commitments, stereotype; likes or dislikes, at the same time continue to focus attention on the theme of problem at hand. The discussion method is important in bringing about meaningful increase in students’ achievement (Johnson & Johnson, 2001).

In conceptual change discussions instructional strategy, the instructor shifts from telling (lecturing) to questioning, probing and facilitating students’ discussion which provides a format in which students can apply newly acquired knowledge, verbalize, defend and reformulate their understanding and retention. The important points are resolved, divergent students’ opinions are reconciled and the relevant is clearly distinguished from irrelevant thereby consolidating and deepening their understanding of it which will improve their retention and promote their academic achievement. Conceptual change discussion encourages students to identify, represent, contrast, and debate the adequacy of competing explanatory frameworks in terms of emerging classroom epistemological standards. Such discussion supports many aspects of the conceptual change process, including making students aware of their initial conceptions, helping students construct an understanding of alternative frameworks, motivating students to examine their conceptions more critically (in part through awareness of alternatives), and promoting their ability to evaluate, and at times integrate, competing frameworks (Challen & Brazdil, 2000).

In this present study, conceptual discussion is described as an instructional strategy in which students talk over subjects from various points of view and the teacher’s role is not to dispense or communicate knowledge but act as a moderator to cause a change or correct students’ idea or prior knowledge about a concept that is misconceived. A student who participates in a discussion lesson learns to support his views rationally, based on facts, appreciates the need to argue logically, define clearly concepts and terms and examine critically rules, principles and construct his or her thoughts in line with the new ideas (Challen & Brazdil, 2000). The study therefore investigated the effects of conceptual change discussions on students' misconceptions, retention and academic achievement in genetics bearing in mind that what one already knows usually helps one to learn, but it can also impair learning. This is especially so if the prior knowledge or assumptions are misleading; plainly incorrect or otherwise incompatible with the new learning. Learners may be susceptible to committing systematic errors, if their interpretation of newly presented material is based upon faulty knowledge.

Challen and Brazdil, (2000) reported the usefulness of conceptual change discussion method of teaching in applying newly acquired knowledge thereby consolidating and deepening students understanding of scientific concepts. They also reported that the student to teacher and student to student dialogue that accompanies a good discussion provides valuable feedback to the teacher on the status of the students' comprehension and is particularly valuable in drawing out and exposing misconceptions, many of which would otherwise remain buried, only to surface in later courses, if at all. According to Bennett (1995) conceptual change discussion method of teaching leads to cooperative learning which improves both academic performance and students' interpersonal relationship. In this study the effects of conceptual assignments and conceptual change discussions instructional strategies of teaching on students' misconceptions and academic performance in genetic concepts was investigated.

1.1.1 Theoretical Framework

The study is hinged to Cognitive Constructivitism Theory of Learning. Constructivism is a theory of knowledge (epistemology) that argues that humans generate knowledge and meaning from an interaction between their experience and their ideas. The theoretical framework for this study is based on Ausubel's theory of learning and that of Piaget. The theory gives an explanation to how meaningful learning can be achieved. Ausubel in his theory believed that meaningful learning occurs only when there is interaction between the knowledge that already exists in and the new materials to be learnt. Ausubel called the learners cognitive structure (organization of knowledge) that is necessary for meaningful learning are called subsumers. The subsumer is a general principle or a generalised body of knowledge that the learner already acquired that can provide for association or anchorage for the various components of the new knowledge. Ausubel believes that for meaningful learning to occur, new learning must be linked to the existing knowledge. As new learning must be linked to the existing knowledge to create meaning, Ausubel advocates for the introduction of 'advanced organizer' where relevant subsumers do not exist to link new materials with the previous knowledge on the same concept. Advanced organizers are alternative set of links or 'anchors'. According to Ausubel, meaningful learning can take place by two processes: the use of relevant subsumers when they exist in the knowledge already processed, and the use of advance organizers where the subsumers are absent.

There is broad consensus among researchers such as Read (2011) in the education field that individuals should not be thought of as passive recipients of information during instruction, but rather that learners are active constructors of their own knowledge. Prior to beginning school, children have a wealth of experiences, and these have led them to develop a common-sense understanding of their social and natural environment. This is both a desirable fact as the construction of new knowledge will build on this pre-existing knowledge and a problem arises from the fact that the knowledge taught in schools is frequently incompatible with common-sense understandings, and so can impede comprehension. As a result, a reorganization of existing knowledge is necessary, and it is this process that is usually referred to as conceptual change. The process whereby conceptual change occurs is of central interest in helping us to understand the process of learning, and is also of considerable importance when considering the design of instruction. Since the incompatibility between some common-sense understandings of the world and accepted scientific explanations is inevitable, it is necessary that instructors be able to affect whatever changes are necessary for comprehension of the scientific explanations to develop (Read, George, Masters & King, 2004). The use of activity based instructional strategies like conceptual assignments and conceptual change discussions instructional strategies were advocated for by some science educators to help shift such erroneous conception.

Piaget (1977) emphasized that individuals construct their own knowledge through interaction with their environment. The concepts which are formed during the process constitute the person's personal explanation to these concepts. It is this concept that is referred to as prior knowledge and they form the basis upon which new knowledge is built in the school learning. When learners use everyday and inappropriate prior knowledge to create mental models that comprise their framework (Boulter & Buckley, 2000), the result may be faulty mental models that give rise to misconceptions. This simply means that the knowledge taught in schools is frequently incompatible with common-sense understandings, and so can impede comprehension. This inaccurate prior knowledge is one of the platforms that lead to poor performance in the field of biology. That is, the student poor experience background is not bright to bear, on the field of biology which subsequently leads to their poor performance in their SSCE (Lawal, 2009). When the students have misconceptions, the prior knowledge that is supposed to be the basis upon which new knowledge is built in the school learning is meaningless.

Piaget (1950 & 1985) also suggested that through the processes of accommodation and assimilation, individual construct new knowledge from their experiences. When individuals assimilate, they incorporate the new experience into an existing frame work without changing that framework. This may occur when individuals' experiences are aligned with their internal representation of the world, but may also occur as a failure to change a faulty understanding. When individuals' experiences contradict their internal representations, they may change their perceptions of the experience to fit their internal representations. According to the theory, accommodation is the process of reframing one's mental representation of the mental world to fit new experiences. Accommodation can be understood as the mechanism by which failure leads to learning: when we act on the expectation that the world operates in one way and it violates our expectations, we often fail but by accommodating new experience and reframing our model of the way the world works, we learn from the experience of failure, or other's failure. According to Hewson (1981), Okebukola(2002), Kika (2004), Eryilmaz (2002), these activity methods make use of theories of learning by psychologists like Ausubel and Piaget among others. Therefore, the study adopted the cognitive contructivistic learning theories of Ausubel and Piaget.

1.2 Statement of the Problem

Genetics is the study of the mechanism of heredity by which traits or characters are passed from generation to generation. It is an integral part of biology. Genetics is an interesting aspect of the biology curriculum which is very difficult to teach (Ruiyong, 2004). Genetics is the field of biology that is considered difficult and abstract and much of the content is taught in the unfamiliar context of cell biology(Oke, 2005).Despite the various studies for the purpose of promoting effective teaching and learning of genetics, the problem of underachievement still exists.This is evident in the poor performance of students in biology in WASSCE as presented in Table 1.1 below, irrespective of the large enrolment of students in the subject (Oke, 2005; WAEC Chief Examiner's Report, 2013).The problem that necessitated this study is the fact that most genetic concepts generally are abstract in nature there-by making their comprehension relatively difficult coupled with the fact that formal expository method of instruction often left many of the misconceptions held by some students un-changed with the result that poor performance is recorded each year in the external examinations.

Table 1.1: Six-year Statistics of WAEC SSCE Biology Result 2008- 2013, Kaduna State

Year	Entry	Number Sat	Passed(%)	Failed(%)
2008	1285048	427644	33.94	66.06
2009	12364655	385112	28.59	71.41
2010	1351118	645633	49.65	50. 35
2011	1540250	579432	38.50	61.50
2012	1687788	587044	35.66	64.34
2013	1698188	564138	33.22	66.78

Source: West African Examinations Council (WAEC)2013

The researcher chose genetic concepts because of her personal experience as a WAEC and NECO examiner. She observed that the examination bodies (WAEC & NECO) set questions on genetic concepts yearly (see Appendix M). Students performed poorly in questions on genetic concepts, questions on genetics were the least popular questions and most candidates avoided it, those candidates who attempted it scored low marks as the candidates did not attempt all the sub questions (WAEC Chief Examiners Report 2010, 2012, 2013). Studies carried out so far in science education on some innovative methods such as Cooperative Learning, Concept Mapping and Analog Model, revealed their efficacy in enhancing the students' retention of biology concepts.The persistent poor achievement of students in Biology as revealed by both research results and WAEC Chief Examiners' Reports calls for concern especially for teachers of Biology that teach larger number of students.The problem has to a large extent been attributed to ineffective teaching method employed by the teachers – especially lecture teaching method which is teacher-centered. Lawal, (2009) reported that the use of ineffective methods of teaching, overloaded curriculum, large class size, difficulty of some topics as well as misconceptions students have of some science concepts among others, have resulted in students' learning difficulty and thus poor academic performance.Also, there is a strong indication that lack of awareness of misconceptions by students in the learning of genetics by biology teachers may be a contributing factor in poor academic performance in biology (Lawal, 2009).

Consequently, there is need to improve on the teaching and learning of Biology by exploring the use of some innovative learner-centered teaching–learning methods such as cooperative learning and concept mapping among others since it is believed that meaningful learning may be as a result of active participation by students. Therefore, there is still the need to investigate other innovative learner-centered method. Such a method should enable the teacher to easily diagnose the problems of the individual learner and allows the learners to evaluate themselves, receiving immediate knowledge of result.It therefore becomes necessary to ascertain empirically the efficacy of Constructivist-Based Conceptual Change Instructional Strategies in bringing about the correction of the students' misconceptions, an enhancement of performance and knowledge retention of genetic concepts in Senior Secondary Schools Biology students.

Moreso, the retention of students' learning in science knowledge had remained poor for some decades.This affects their performance at the subjects at secondary school levels as stated in the literature Eze, (2002), Mbajirogu, (2002), WAEC, (2004) and Ogbu, (2005). One of the possible causes of students' poor retention in sciences is inability of mastering scientific concepts (Lawal, 2009). Research in education on the quality of teaching and learning process is increasing because of its place in instructional delivery (Schiefele, Klaus-Peter, Krapp and Enugu (2007).Therefore, to search for teaching method that can promote students high understanding and retention of Science concepts is very timely. Conceptual Change Model of teaching is an innovative instructional model which entails the combination of theory and practical activities during the period of teaching and learning process. It can be described as student-centered instructional model since the students participate actively in the learning process which may lead to improvement of students'retention of Biology concepts. Therefore, the present study was conceived to establish the effects of conceptual change instructional strategies on students' misconceptions, retention and performance in genetic concepts at Senior Secondary School level.

1.3 Objectives of the Study

The study sought to achieve the following objectives:

i. identify the common misconceptions held among Senior Secondary School three(SS3) students in genetic concepts in Rigachukun Zone of Kaduna State.

ii. determine whether conceptual assignments, conceptual discussions and enriched conceptual change discussions with conceptual assignments instructional strategies will correct the identified students' misconceptions in genetic concepts at Senior Secondary School level.

iii. determine the effects of conceptual assignments, conceptual discussions and enriched conceptual change discussions with conceptual assignments strategies on the academic performance of senior secondary school students in genetic concepts.

iv. find out the difference in academic performance of male and female students taught genetic concepts using conceptual assignments, conceptual discussions and enriched conceptual discussions with conceptual assignments instructional strategies.

v. determine the effect of conceptual assignments, conceptual discussions and enriched conceptual change discussions with conceptual assignments instructional strategies on students' retention ability of the genetic concepts at Senior Secondary School level.

vi. determine the effect of conceptual assignments, conceptual discussions and enriched conceptual change discussions with conceptual assignments instructional strategies on male and female students' retention ability of the genetic concepts at Senior Secondary School level.

1.3 Research Questions.

The study investigated the following research questions.

1. What are the common misconceptions held among Senior Secondary School three (SS3) students in genetic concepts in Kaduna State?
2. What are the effects of conceptual assignments, conceptual discussions and enriched conceptual discussions with conceptual assignments instructional strategies in remediating the identified students' misconceptions in genetic concepts at Senior Secondary School (SSS)?
3. What is the difference among the academic performance of students taught genetic concepts using conceptual assignments, conceptual discussions and enriched conceptual discussions with conceptual assignments strategies and those taught the same using the traditional instructional method?
4. What is the difference among the academic performance of students taught genetic concepts using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments Instructional Strategies?
5. What is the difference among academic performance of male and female Senior Secondary School students taught genetic concepts using conceptual assignments, conceptual discussions and enriched conceptual change discussions with conceptual assignments instructional strategies?

6. What is the effect of conceptual assignments, conceptual discussions and enriched conceptual discussions with conceptual assignments instructional strategies on students' retention ability of the genetic concepts at Senior Secondary School (SSS)?
7. What is the effect of conceptual assignments, conceptual discussions and enriched conceptual discussions with conceptual assignments instructional strategies on retention ability of the genetic concepts among male and female Senior Secondary School students?
8. What is the difference in the retention ability among students taught genetic concepts using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments instructional strategies?

1.5 Null Hypotheses

The following hypotheses were tested at $p \leq 0.05$ level of significance.

Ho_1: There is no significant difference among the mean scores of the students taught genetic concepts using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Change Discussions with Conceptual Assignments instructional strategies and those taught the same using the traditional method.

Ho_2: There is no significant difference among the academic performance of students taught genetic concepts using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Change Discussions with Conceptual Assignments instructional strategies.

Ho_3: There is no significant difference among the mean scores of male and female students exposed to Conceptual Assignments, Conceptual Change Discussions and Enriched Conceptual Change Discussions with Conceptual Assignments instructional strategies and those taught using traditional method.

Ho_4: There is no significant difference among the mean retention ability of students taught genetic concepts using conceptual assignments, conceptual discussions and enriched conceptual change discussions with conceptual assignments instructional strategies and those taught the same concepts using the traditional method of instruction.

Ho_5: There is no significant difference among the mean retention ability of male and female student staught genetic concepts using conceptual assignments, conceptual discussions and enriched conceptual assignments and conceptual change discussions instructional strategies and those taught the same concepts using the traditional method of instruction.

Ho_6: There is no is no significant difference among the mean retention ability of students taught genetic concepts using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments instructional strategies.

1.6 Significance of the Study

It is hoped that the findings of this research would be useful significantly in the upliftment of science education in the following ways:

Biology Teacher: Educators have pointed out the fact that science concepts are not taught meaningfully by science teachers which leads to misconception of concepts. This study will provide empirical evidence to confirm if students hold misconceptions of genetic concepts or not. It will also identify the type of misconceptions learners hold and show the areas students have misconceptions and learning difficulties in the genetic concepts. Thus, biology teachers will use the findings to improve in the teaching of the concepts and bring about greater interest by the students in secondary schools and beyond.

Improvement of the Students' Academic Performance in Biology: Students need to learn concepts meaningfully before they can apply the knowledge acquired to solve problems.Genetics includes the interrelated fields of cytology, biochemistry, evolutionary theory and molecular biology. The basic understanding of genetics may enhance proper learning of other aspects of biology like variations, evolution, adaptation, reproduction, crop improvement and animal improvement in Agriculture will hopefully be better understood leading to improved performance in examinations. Hence is the relevance of this study to the teaching and learning of biology. A study of this kind focusing on students' performance in genetic concepts would also diagnose and express students' shortcomings or difficulties in the learning process. Appropriate measures for remedy would be suggested to correct the imbalance. In this regard the study would be useful.

Examination Bodies (WAEC&NECO) and Curriculum Developers:A search into the available literature clearly reveals that despite all efforts to improve students' performance in biology, it has been observed that the educational system is to a great extent not achieving its predetermined goals and objectives due to high failure in public examinations such as senior secondary certificate examinations (Agbowuro, 2008). The high failure in biology as highlighted in West African Examinations Council chief examiners' report is as a result of students' weakness in answering questions relating to difficult concepts such as in the area of genetics. Such weakness induces students' inability to comprehend or represent concepts. The Examination Bodies (WAEC&NECO) and curriculum developers will hopefully use the result of these findings to restructure senior secondary certificate examination and the curriculum in order to correct problems associated with students' understanding of the genetic concepts where applicable.

Teachers' Training Colleges and Institutions: The finding of this study will help teachers' training colleges and institutions like colleges of education and universities to incorporate these instructional strategies into the existing instructional strategies.

Professional Associations:such as Science Teachers Association of Nigeria (STAN), Mathematical Association of Nigeria (MAN) and National Association of Research in Science Education (NARSE) etc that carry out researches and organize conferences, seminars and workshops for the practicing science teachers to build into their activities such effective instructional strategies of teaching science concepts.Moreso, institutions responsible for teacher professional development like, National Education Research Development Council (NERDC), National Teachers Institute (NTI) etc, would find the results of this study useful, thereby incorporate such into their curriculum design processes and instructional innovation programmes in science.

Stakeholders in the Education Industry: Studies that probe into students' academic achievement with the view to improving them often attract the attention of many individuals and organizations who are stake holders in the education industry. In this respect, it is hoped that this study would be of interest to biology teachers, examining bodies like WAEC and NECO, Professional Science Teachers Association and Ministries of Education would also find this study relevant and useful. It is the ultimate expectation that the findings from this study would be useful in enhancing the quality of teaching and learning of genetics in secondary schools and to make experiences to the learners.

Textbooks publishers: Textbook publishers will find the study very useful in their presentation of the subject matter in a form that will facilitate easier and better understanding of concepts in biology by both students and teachers to reduce misconceptions among the students.

Researchers: The findings of this study will stimulate researchers to further undertake studies on other concepts than genetic concepts and genetic engineering with a view to finding out any limiting factor hindering their understanding.

1.7 Scope of the Study

The study is delimited to SS three students in public secondary schools in Rigachikun Education Zone of Kaduna State. This study examined the Effects of Conceptual Change Instructional Strategies on Secondary School Students Misconceptions, Retention and Performance in Genetics in Kaduna, Nigeria. The study sampled co-educational secondary schools in Rigachikun Education Zone, Kaduna, Nigeria. All the secondary schools selected are offering WAEC and NECO examinations where the S.S.S.C.E biology syllabus is used. Only students offering biology as a subject at SS three with or without other science subjects were selected for the study. The concept taught was genetics. This is because many Biology students and teachers consider genetics as one of the most difficult topics (WAEC Chief Examiner, 2016). The SS three Biology students were used because they are not new to the subject and these topics are in SS three Biology syllabus. The SS three Biology students were used because they are not new to the subject and these topics are in SS three Biology syllabus. The four genetic topics as stated in the Senior Secondary School Biology syllabus were considered (Transmission and expression of characters in the organisms, Chromosomes: The basis of heredity, Probability in genetics and Application of the principles of heredity in agriculture and in medicine because they are the topics stipulated for genetics at secondary school level. The topics were taught for a period of six weeks. (FME, 2004; WAEC, 2016) The topics were selected from the Senior Secondary School Biology SS three Textbooks recommended by the Federal Government for teaching Senior Secondary School three students.

1. Ndu F. O. C. A. W. A. Edwards, K. Danquah and M. U. Ezenkwe (2001) Round-up for West African Senior School Certificate Examination Biology Longman Nigeria.
2. Sarojini T. Ramalingam (2004) Modern Biology for Senior Secondary Schools Africana First Publishers Limited.
3. F. O. C. Ndu, P. Asun and J. O. Aina (1991) Senior Secondary Biology Longman Nigeria.

The instructional strategies used were conceptual assignments, conceptual discussions and enriched conceptual assignments and conceptual discussions instructional strategies. The instructional model was Posner et al (1982) conceptual change instructional model.

1.8 Basic Assumptions

The following basic assumptions were made for the study that:

1. Students are taught genetics as specified in the biology syllabus and that the students existing knowledge of genetics (Preconceptions) is basically uniform among the subjects under study and is quite different from currently accepted scientific views on genetics.

2. Conceptual Change Model is not commonly employed in teaching biology at the secondary school level.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This study was aimed at determining the effects of conceptual assignments and conceptual change discussions on students' misconceptions, performance and retention regarding genetics in Senior Secondary School (SSS). In this chapter, the literature reviewed was organized in the following sub-headings-

2.2. Science Teaching Methods

2.3. Students'Performance in Biology

2.3.1. Teaching Genetics at Senior Secondary School Level

2.4. Meaning and Types of Misconceptions

2.4.1. Sources of Misconceptions

2.4.2. Helping Students to Identify, Confront and Overcome Misconceptions

2.4.3. Constructivism and the Teaching of Science

2.4.4. Concept, Conception and Learning in Science

2.5.0. Definition and Description of Conceptual Change

2.5.1. Conceptual Change Model

2.5.2. Cognitive Conflict as a Base for Conceptual Change

2.6. Teaching for Conceptual Change

2.6.1. Conceptual Change Assignments

2.6.2. Conceptual Change Discussions

2.6.3. Cognitive Functioning and the Understanding of Genetic Concepts

2.7. Instructional Strategies and Students' Performance

2.7.1. Instructional Strategy and Students' Retention

2.7.2. Gender and Performance in science

2.8. Overview of Similar Studies

2.9. Implication of the Literature Reviewed on the Present Study

2.2 Science Teaching Methods

Science teaching is very complex involving many activities and concepts. There is no single method of teaching science that is absolute in meeting the learning needs of every individual learner in the classroom. According to Ogenyi (2015) all teaching strategies have their limitations and strengths however Felder and Brent (2005) assert that a more balanced approach that attempt to accommodate the diverse needs of the students in a class and allow for optimum learning is by the direct involvement of students in the teaching- learning process. They further explained that this approach is scientific and conform to the tenets of acquisition of knowledge by doing or direct participation by learners. According to Atadoga and Onaolapo (2008) teaching methods and techniques have to be varied and mixed in the reallife situations. There are several methods that teachers of science employ in the classroom to presentscientific facts, information, principles, skills or concepts to students. Some methods are very specific for some situations and categories of students, while others are generally applied to all categories of students.

Akande (2002) presented activity based methods, namely, research, project, experiment, discussion, demonstration, problem-solving, games and simulations, play-way, role playing, field – work, (and) assignment. He commented that what makes each of the methods valuable is that learners are actively involved in lessons by learning through activity. Sadker and Sadker (2007) presented new directions for effective teaching in four constructs which were considered fundamental to new research on effective teaching, namely, multiple forms of knowledge, significance of deep rather than shallow teaching, importance of priorknowledge, and social nature of learning. They further explained that the amount of content details expected to be reduced to summary so that students may gain in-depth understanding, in deep rather than shallow teaching. Instead of lecturing to cover superficially a vast body of information, teachers need to organize their content around a limited set of key principles and powerful ideas and then engage students in discussing the concepts. The teacher should elicit prior knowledge of students through discussion and high cognitive levels questions. When prior knowledge is made explicit, teacher couldhelp students' link new information to the prior knowledge or guide them to confront and correct prior knowledge that is not accurate. On social nature of learning, the teacher should assume the position of a guide or facilitator that is skillful in conducting discussions, group work, debates, and dialogues among others. Differentiation of instruction is stressed where teachers are asked to carefully consider each student's needs, learning style, life experiences, and readiness to learn.

Miles (2015) also asserted that it is expected of a teacher to implement a range of instructional strategies that will bring academic success to all the science students. For any method to be able to bring good result in the present age, it should be a method that promotes maximum social interaction. Social interaction between students and between teacher and student plays a crucial role in learning (Nguyen, Williams & Nguyen, 2012). These authors further stressed the need for the students to be provided with a supportive, open and interactive environment as this could help them discover knowledge.Demonstration teaching method is a useful method of teaching because it improves students' understanding and retention (McKee, Williamson & Ruebush, 2007). According to Al-Rawi, 2013), the demonstration is effective in teaching skills of using tools and laboratory experiment in science. However, the time available to perform this demonstration is very limited in a classroom setting. Therefore, a demonstration often designed to allow students to make observations rather than through hands-on laboratory (McKee, Williamson & Ruebush, 2007).

Lecture method is often used to deliver a large amount of information to the students in a short period (Berry, 2008). According to Gehlen-Bauum and Weinberger (2014), lectures are designed to deliver a new information to a large group of students. This method is known to be effective in dealing with a large class. However, it could also be used for a small class. Research indicates that this method dominates most of the tertiary institutions (Deslauriers, Schelew & Wieman, 2011). Research shows that students' retention in a lecture-based science courses is weak. According to Bok (2006), an averagestudent only retains 42% of what he or she learned after the end of the lecture and 20% one week later. Research also shows that teaching method like the lecture method commonly used does not help the students to acquire sufficient functional understanding (Bernhard et al., 2007). Berry (2008) argued that lecture method lacks the effectiveness of an active learning approach. In the opinion of Fagen and Mazur (2003), lecture method causes the bad reading habit among the students. Franklin, Sayre, and Clark (2014), students taught in lecture-based classes learn less than those taught with activity-based reformed methods. Lecture method is frequently a one – way process unaccompanied by discussion, questioning or immediate practice that makes it a poor teaching method (Hatim, 2001; Al-Rawi, 2013). Lecture method concentrates on information rather than learners (Al-Rawi, 2013). In the lecture methodthe teacher tells the students what to do instead of activating them to discover for themselves (Miles, 2015)**.**

It is important that science is learnt by acquiring specialized skills, competencies andattitudes which is often tasking but needful for academic excellence and independence. These learner-centered approaches employ the processes of science in gathering, transforming and interpreting data which according to Brekke, (2005) is amajor objective of teaching science in the secondary school. These processes include observing, ability to report accurately good observed information, draw generalizations and testing them, design experiments to check predictions, using models to explain phenomena and ability to sustain inquiry activity on collection of new data (falsification and verification procedures). Anderson and Krathwohl (2001) explained that at either stage of this processes, the student is actively involved in discussion and decision making that they will gradually learn to think clearly, logically, critically and independently. Instructional strategy that encourage this central element in scientific entrepreneur should be consciously preserved and presented to learners as they are guided to discover for themselves those facts and acquire those scientific attitudes (Ogenyi, 2015).

Nevertheless, the teacher is responsible for guiding the teaching –learning process even though the students learn in different ways. In addition, well accepted theories and extensive research illustrate and document learning differences (Okebukola, 2002; Zohar, 2004 & Usman, 2006).They also believe that learners bring their own individual approaches, talents and intereststo the learning situation, and that individual learners' environment, family background and socio-economic level affect his or her learning.

Therefore, the choice of appropriate teaching method is imperative to not only advance the frontier of knowledge but excellent performance in science. Teachers should be able to cater for existing variation among the students in the classroom. For effective dispensation of learning to be enhanced, there are different types of such techniques which include the following:

1. Lecture or Talk and Chalk Method
2. Science Process Teaching Approach
3. Demonstration Method
4. Discovery /Enquiry Method
5. Conceptual Approach
6. Discussion Method
7. Laboratory Activity /investigative Method
8. Project Mehod
9. Field Trip/Excursion Approach
10. Individualized Learning Method
11. Problem Solving and others

Conceptual change discussion is the purposeful, constructive and objective dialogue between the teacher and the learners on a particular concept which can fundamentally change or even replace an existing conception and become the conceptual framework that the learners can use to solve problems, explain phenomena and function in their world. It can also be described has the dialogue between the teacher and the learners in a process of replacing, a misconception with a scientifically acceptable concept. Conceptual change approaches usually are explicit and claim that the learners have to construct knowledge for themselves (Orey, 2010).

Conceptual Assignments is an instructional strategy that substantially provides students opportunity for active participation in thelearning process rather then empty cup to be filled. It has the capacity of enabling the students to construct meaning through interaction. It has four phases which give the students chance and potential to modify misconceptions thus enabling students explain elaborately or defend their positions. Eryilmaz, (2002) noted the importance of homework problems in creating the cognitive conflicts necessary for preparation of the conceptual change. According to Eryilmaz, (2002) some researchers suggested using conceptual assignments to establish the first four steps of the conceptual change strategy. These are Step 1: Awareness or orientation phase, Step 2: Disequilibrium/ Elicitation of ideas, Step 3: Reformation phase and Step 4: Application phase.

Zohar, (2004) opined that though other techniques for teaching science subjects exist, the effectiveness of any technique depends on its unique featuresand on factors such associetal needs as evident in the school curriculum, the structure and natureof the subject/educational field and the domain (cognitive, psychomotor and affective) and teachers' characteristics, such as motivation and the choice of materials. According to Bottom (2004) while achieving some of the objectives of the whole class activities, small group panel discussions, socio-drama, small group discussion helps meet the varying abilities, interests and needs of the total class (Ogenyi, 2015).In this study, the effects of conceptual assignments and conceptual change discussions instructional strategies on students' misconceptions and academic performance in genetic concepts were investigated.

1.3.1 Students'Performance in Biology

The study of biology is essential for the nation's scientific and technological development.Without sound knowledge and wholesome attitude towards biology, the much needed and vouched technological breakthrough may not be achieved. The knowledge of biology contributes to scientific literacy so that people can understand the world around them and enable them to make informal choices about their health care, their environment and the society in which they live (Karen, 2008). For instance, the knowledge of biology is brought to play in the areas of manufacturing and processing industries, medicine, food production and pharmaceuticals among others. Biology is usually regarded as the simplest to understand among all the science subjects and thus it is the one that usually attract the widest enrolment. Ofoegbu (2003) and (Oke, 2005) asserted that Biology has a large student enrolment than any other science subject especially at the upper basic level of the Nigerian education. Despite the fact that Biology is the simplest to comprehend among the science subjects, the level of academic achievement is nonetheless not much different from other science subjects among the students. According to Akubuilo (2004), in spite of the popularity of Biology among students, the failure rate has remained very high.

Poor achievement in biology however has been attributed to a number of factors by several researchers. These factors include unavailability of laboratory facilities, lack of instructional materials, inadequate time allocation, large class size and poor instructional delivery approaches. According to Etukudo (2009), the fall in standard of achievement in biology is incontrovertibly attributed to poor instructional delivery approach adopted by teachers in schools. To support this assertion, Salau (2012) submitted that many researchers have adduced that poor achievement in public examinations is traceable to instructional delivery approaches adopted by teachers. The resultant effect is the low achievement and low retention level in students' outcome both in internal and external examinations. This implies that the mastery of biology concept might not be fully achieved without the use of a good instructional delivery approach.

According to Opara (2011), there is a high rate of failure in biology as revealed by the analysis of May/June SSCE result of 2006-2008. West African Examination Council (WAEC) Chief Examiner's report (2005-2010) states that the persistent poor achievement of students in biology at senior schools' certificate examination leaves one in doubt about the effectiveness of instructional materials and instructional delivery approaches popularly used by the biology teachers for the teaching and learning of biology. Statistics from the West African Examination Council (WAEC, 2010) revealed that achievements in biology in the May/June examinations has been on the decline. Of the total number of students who sat for the examination in the year 2010, the total percentage of candidates who attained credit level and above is 26% while 53.13% failed out rightly. Also, statistics from the National Examination Council (NECO) indicate that the percentage failure in Biology for years 2008, 2009 and 2010 were 55.80%, 57.60% and 55.20% respectively.This trend if not arrested will spell doom for the scientific and technological development of thenation. To this effect, the WAEC chief examiner proffered remedies to solve this problem, one ofwhich is adopting instructional delivery approaches that utilizes instructional materials to help students understand biological concepts.

Lawal, (2009) reported that the use of ineffective methods of teaching, overloaded curriculum, large class size, difficulty of some topics as well as misconceptions students have of some science concepts among others, have resulted in students' learning difficulty and thus poor academic performance.Nwagbo (2006) blamed the poor achievement on the state of science education enterprises in Nigerian Schools. Nwosu (2008) reported that most teachers lacked the knowledge of curriculum objectives as indicated by their failure to implement them.Oke (2005) reported that the most important challenge for biology teachers is teaching biology in an environment that promotes a spirit of inquiry. She further explained that the teaching environment must also cater for learners of different abilities which imply that the biology teachers need to know what material and human resources will be needed to create an environment that will effectively aid the learning of biology concepts.

Shaibu and Usman (2001) reported that emphasis is now centered on developing teaching strategies that have potentials for enhancing students understanding of science concepts and acquisition of requisite skills. Inamulla (2005) reported that interaction between the teacher and student is an essential part of all the teaching and learning processes. This point was further stressed by Oloruntegbe (2010) that interaction in the science classroom has always been a triple-dynamics between the teacher, the learner and the instructional materials.These three variables are expected to interact harmoniously in a way to produce the intended learning outcomes.

In order to address this issue of low achievement in biology, teachers need to be exposed to appropriate teaching and learning approaches whichrequires the use of instructional materials. This will promote imaginative, critical and creative skillsin the learners resulting to better achievement of instructional objectives (Federal Ministry of Education, Science and Technology, 2001). Therefore, this study sought to establish the effect of Conceptual Assignments and Conceptual Change Discussions instructional strategies on students miconceptions, retention and performance in genetic concepts as to whether or not students' misconceptions will be corrected and performanceand retention will be improved.

2.3 Teaching Genetics in Senior Secondary School

In Nigeria, today, teacher's ability to motivate students to learn in a meaningful way is one of the factors engendering students' poor performance. Ezenwa (1974) lamented that many teachers are highly deficient in the subject they teach and thus they have untaught what they are suppose to teach. He stressed further that a good number of our teacher skip certain areas of the syllabus that they find difficult to teach as a result of poor academic background in the area. Infact, some of the teachers handling Biology in some of our schools and colleges may not have the background to enable them teach the subject and there may not be any doubt to note that there are a few graduates without the academic background to handle genetics in our secondary schools and Colleges of Education inclusive. No one can do a job well unless he understands the processes involved (Ahmed, 2007).

Lawal, (2009) reported that the use of ineffective methods of teaching, overloaded curriculum, large class size, difficulty of some topics as well as misconceptions students have of some science concepts among others, have resulted in students' learning difficulty and thus poor academic performance. These according to Okebukola (2002) have to large extent contributed to the massive rates observed failure among science students. These are some of the reasons why the search for explanations as to why students are performing poorly in science would continue to be one of the major areas of focus for research among science educators. Scientists and science educators over the years have been focusing attention on how to improve science instruction in schools by going beyond the stereotypic methods of obtaining knowledge in science. There have been emphases in science teaching and on students' active involvement in doing science. The national policy on education (2004) and the biology curriculum see biology as a practical and inquiry oriented subject that should be taught practically (involving students in the art of doing). When the students are involved in doing science, science process skills such as careful observations, classification, interpreting, predicting events, designing experiment, organizing information, reporting and generalization will be acquired.

Genetics is the area of biological study concerned with heredity and with the variations between organisms that result from it. It is a branch of science that deals with the scientific examination of genes, heredity and variations in organisms. Genetics includes the interrelated fields of cytology, biochemistry, evolutionary theory and molecular biology. The impact of genetic research is far reaching, affecting medical diagnosis and therapeutics, and industry, criminal prosecution and privacy as well as ideas regarding individuality, ethics and responsibility. It also helps with avoiding hereditary diseases, evolution and greater biodiversity/variation (Whitesides, 2011). Genetics also acts as a bridge for the understanding of several other concepts like evolution, variation, competition, adaptation, reproduction and taxonomy (Bichi, 2002). The teaching of genetics begins at the Junior Secondary School level. In spite of the importance of genetics, students and teachers find it difficult to see the relationship between it and biology. Students performed poorly in questions on genetics (Chief Examiners' report 2007). Most students in the senior secondary schools in Nigeria opt for biology in the senior secondary school certificate examinations. Despite the attraction this subject enjoys, students' poor achievement in Biology is alarming.

It has been reported that Nigerian secondary school students found Biology as easier than physics or chemistry (NERDC, 2004). According to Cirfat (2005) Biology is generally conceived by most students as the "easiest" science subject, thus it easily ranks as the most popular. The massive failure received in WASSCE and NECO SSCE does not testify to its being easy (STAN, 2005; WAEC, 2016). As rightly noted by Ladon, (2005) efforts need to be geared toward removing the difficulties that contribute to the failures. One such effort is in the area of the better learning and understanding of difficult concepts. From available researches, genetics has been identified as one of the difficult concepts to learn in biology (Johnstone & Mahmoud, 2000; Oyetunde 2001; Longden 2005 & Okpala, 2005). Mitchell (2000) was of the view that students perceived genetics as either an abstraction that has very little meaning to individuals, or as those magical scientific phenomena. Duit and Treagust (2003) also opined that genetics is the field of biology that is considered difficult and abstract and much of the content is taught in the unfamiliar context of cell biology. As a result, teachers need to use a variety of strategies to make this content easier to understand and provide analogies and models to help bridge the gap between the students' everyday ideas and the scientific concepts intended.

Genetic concepts have been identified as a difficult aspect of biology, the reason being the time and position given to it in the school curriculum (Ndubuizu, 2004). Genetics is an interesting aspect of the biology curriculum but according to Ruiyong, (2004) it is a very difficult and analytical discipline. Nwaorgu, (2005) reported that the laboratory practical approach to the teaching of genetics is difficult as it involves a long term experimental work. She further explained that there is also the belief of people in reincarnation which conflicts with the principles of molecular genetics. Other interpretations made on the laws governing inheritance were based on metaphysics and philosophy, performationists, epigenesis and pangenesis. This division between the practical reality and what is learnt in the classroom is one of the major problems militating against the practical approach to teaching and learning of genetics in secondary schools. This conflict between reality and practices has been blamed to poor teaching method (Nwaorgu, 2005).

Genetics is an area of biology students find difficult to learn. Fakunle (2005) and Smith (2005) also maintained that students have difficulty in understanding genetic concepts. The following concepts have been identified as difficult concepts by both teachers and students, Mang and Piwuna,(2005) Nzewi, Etokebe, Pati and Akpan (2003)

i. Meiosis
ii. Variation
iii. Mendelian laws and latter developments
iv. Genetic crosses and symbolic representation
v. Structure and replication of DNA

vi. Genetic ratios, analysis and probability etc

According to Ndubuizu, (2004) the above concepts and problems, their importance and reasons why they constitute a problem in the teaching and learning of genetics are discussed below.

Meiosis: - Meiosis a major conceptual block in genetics is usually taught separately and not related to genetic topics. Secondly, the stages involved and the behaviours of chromosomes which isquite different from mitosis tend to complicate the processes.

Variation: - explanation and overlapping of examples of different types of variation tend to confuse student e.g physiological, morphological, continuous, discontinuous, hereditary and environmental variations.

Mendelian laws and latter development: - Mendelian laws of segregation, dominance and independence assortment of genes are usually difficult to understand especially when there is lack or poor understanding of the meiotic basics of genetics. Secondly, latter developments on Mendel's work by other scientists are contradictory. Mendelian laws tend to confuse student and make understanding difficult. Examples include incomplete/partial-dominance, co-dominance/equal-dominance, multiple alleles, polygenic inheritance, sex-linkage and sex-determination etc.

Genetic possession and symbolic representation: -Students are usually tempted to use wrong symbols to denote traits, for example T for tallness S for shortness instead of t; Y for yellow and G for green instead of y' S or R for smooth and W, for wrinkle instead of s or r.

Structure and replication of DNA: -The chemical structure and abstract nature of replication is often dreaded by teacher and students.

Genetic ratios, analysis and probability: - Genetics, though not deeply mathematically at 'O' level of numeracy for certain concepts like change or probability, ratios and genetic analysis.

Abstract nature of genetics and non –relation of functions to structures: - Cognitive status of a child determines to a greater extent the level of understanding of any given concept. Most students operate at Piaget's concrete operational stage (Bomide; Gyuse, in Ndubuizu, 2005) and find it difficult to cope with the abstract nature of genetic concepts.

Use of synonyms: - Sometimes two or more genetic terminologies are used to explain or represent one concept. This tends to create ambiguity which may lead to confusion and misuse of terms e.g. pure/true breeding, germ-cell/gametes, chromatids/chromosomes, random assortment etc.

Other problems of teaching and learning of genetics as identified by Deadman and Kelly and Mang and Pwuna (2005) are usually traced to both teachers and students as follows:

i. Abstract nature and inability to relate structure to function
ii. Use of synonyms or many terms for some concepts
iii. Lack of adequate time for practical work in genetics
iv. Lack of confidence and competence in teachers
v. Lack of coherence and association with other concepts in biology
vi. Lack of prerequisite knowledge for genetics
vii. Wrong perception of relevance in the curriculum
viii. Student attitude towards biology
ix. Lack of laboratory equipment and apparatus.

Ndubuizu, (2004) further explained why genetics is perceived as difficult.

Lack of adequate time for practicals: - practical work in genetics requires enough time and patience. Time required for effective practical work in genetics is not usually compatible with the time given to it in the syllabus and the school time table. More so students and teachers lack the patience and courage required. Rather they desire quick results.

Lack of confidence and competence in teachers: - many biology teachers are not adequately exposed to basic genetic concepts during their formative stage. In addition, many teachers are not encouraged to attend workshops and conferences. Consequently, they lack confidence in themselves and tend to shy away from certain genetic concepts topics.

Lack of coherence and association with other concepts in biology: - genetic concepts are quite unique and are rarely related with other concepts while teaching other concepts in biology. As a result, students are not exposed to genetic concepts until much later in their course of study. Meiosis for example when taught in SSII is not given a genetic approach, it is taught as a kind of cell division. Most of thestudents who are poor in science especially chemistry and mathematics, select biology as their only science subject for Senior School Certificate Examination.They erroneously believe that biology lacks chemical and mathematical basis, only to be disappointed when they meet certain aspects of genetics. The time and position given to genetics in the syllabus tend to mislead students and teachers about its importance and relevance.

Student's attitude towards biology: -students generally perceive biology as an easy subject. This enables them to develop a nonchalant attitude to its study in favour of other subjects (Ajewole, 2005). This attitude according to Soyibo, (2005) is one of the reasons for students' poor performance in biology.

Ladon, (2005) identified eight areas of genetics that have been posing difficulty to students and teachers. These include:

DNA and RNA- their structure replication and differences.

Meiosis- regarded as the major conceptual block, Random Assortment. Meiosis is usually taught separately from genetic topics and no attempt is made to help students to relate them.

Symbolic representation- the use of symbolic representation to assist in the exchange of ideas requires an understanding of conventions and rules.

Mathematics– bias of genetics. Not that it is particularly deeply mathematics at the senior secondary level but students have problems with ratio and analysis.

The concept of chance- probability while students prefer certainty and not chance, therefore they resist the probabilities nature of explanation.

Mendelian laws – particularly the historic approach. Many students hate the historic approach while others are more interested in the history than the laws.

Genes, alleles, chromatids and chromosomes-what they mean and their differences.

Terminologies– many terms for the same concepts (i.e. synonyms) these create ambiguity and can lead to misuse of terms. E.g. pure-breeding/true breeding, gamete/germ cell/sex cell etc. He further explained that someterminologies are redundant e.g. chromatids/chromosomes (Longden; Deadman and Kelly; Pearson and Hughes; Radford and Bid-Steward 2005).

In addition, Deadman and Kelly; Radford and Bird Steward (2005), advanced the following reasons for the difficulty.

1. It requires a certain level of numeracy.
2. More analytical approach is required than most aspect of biology. However most of those offering and fearing biology are still descriptive scientists only.
3. Many students selected biology as their only science subject not offering chemistry upon which much of genetics is so heavily dependent especially at higher levels (Ibifiri, 2005).

Okpala, (2005) opine that a fundamental problem many students face in the study of genetics is mostly that of inability to conceptualise the principles, processes and the terms involved. He further explained that one of these terms are “gene and locus”. Lakpini, (2009) observed that without students grasp of genetic concepts, performance of students will persistently remain low in biology. James (2004) ascertained that the primary goal of science education is to engage students in an active process of identifying, constructing meaningful learning of science concepts. Jegede and Okebukola (2002) lamented that majority of science students lack the understanding of even the basic science concepts. This is evident in poor performance of students in WASSCE irrespective of the large enrolment of students in the subject (Nworgu, 2005).

Okebukola (in Okoye and Okechukwu, 2006) reported that between 1991 and 1995 only about 25% of the candidates presented for Biology in the Nigerian senior secondary school examination passed at credit level. However, researchers have blamed the poor state of Biology teaching and students’ performance on factors such as (i) lack of qualified and inadequate practical work, (Ali,1998) (ii)Use of traditional teaching methods (Ollarewayju,2002) and (iii) The highly conceptual nature of biology (Umeh, 2002). Umeh (2002), Okebukola (2002), and Okechukwu (2003), have shown that both teachers and students find ecology, evolution and genetics difficult to understand respectively. These difficulties may arise as a result of misconception.

Odubunmi (2002) reported that for many years the performance of students in biology has been very poor. He further explained that the poor performance of students in biology as observed over the years could have being as a result of students not understanding different concepts in biology. Such concepts are in the areas of physiology, micro-organisms, plant and animal diversity, evolution, ecology, genetics and so on. Yip (2002) revealed that inexperienced biology teachers hold a number of conceptual errors which are prevalent among secondary school students. Studies on genetics such as those of Lakpini (2009) and Lawal (2009) also show that one major aspect resulting to poor students' academic achievement in genetics is misconception of genetic concepts.

The genetic topics as stated in the senior secondary school syllabus are:

1. Transmission and expression of characters in the organisms.
   i. Hereditary variations
   ii. Characters that can be transmitted
   iii. How characters get transmitted
   iv. How characters behave from generation to generation.
   v. Mendel's work in genetics.
      a. Mendelian laws.
      b. Mendelian traits.
      c. Mendelian experimental methods.
2. Chromosomes: The basis of heredity
   i. Location
   ii. Structure
   iii. Role and processes of transmission of hereditary characters from parents to offspring.
3. Probability in genetics

4. Application of the principles of heredity
   i. in agriculture
   ii. in medicine (FME, 2004; WAEC,2012).

Cirfat (2005) opined that to teach genetic concepts well to the understanding of the students, biology teachers should know that most young people are interested in their own heredity therefore it will be a good idea to start the study of heredity with human beings e.g sex chromosomes, determination, linkage, monohybrid cross, and incomplete dominance all in human beings using as many examples as possible. He further explained that students should be engaged in group work and discussion and the teacher should be resourceful. Duit & Treagust, (2003) also opined that teachers need to use a variety of strategies to make this content easier to understand and provide analogies and models to help bridge the gap between the students' everyday ideas and the scientific concepts intended.In this study, the effects of conceptual assignments and conceptual change discussions instructional strategies of teaching on students' misconceptions and academic performance in genetic conceptswere investigated.

2.4 Meaning and Types of Misconceptions

Misconceptions are ideas that differ from the corresponding scientific explanations.Misconceptions are also incorrect ideas about a concept or belief. Misconceptions originate from prior knowledge of everyday experiences or ones obtained from school. Misconceptions are false beliefs in one's mental model. Lawal (2009) described misconceptions as wrong notions of facts learners have on certain scientific concepts. She further explained that they are developed when learners integrate newly learned knowledge that could be abstract with previously held information which results in re-interpretation of the new knowledge to translate them to everyday experiences. Eniayeju, Eniayeju and Lakpini (2004) described misconceptions as idiosyncratic personal ideas, erroneous beliefs or alternative views of scientific principles arising from teaching normal language usage, and everyday experiences of the world. They also see it as the mismatch in students' intellectual development. Misconceptions are usually held by significant proportions of students and are highly resistant to instruction and at the same time, these alternative ideas can serve as anchoring conceptions (Otero, 2000) from which to move to a scientific conception when suitable instructional strategies are developed.Some misconceptions have been found to be not only resistant, but also persistent to change. These categories of misconceptions are called robust misconceptions (Chi, 2008; Lee & Byun, 2011). That is, robust misconceptions are resistant and persistent to change.

Researchers have used different names for misconceptions. Novak (1977) called them preconceptions, Driver and Easley (1978) referred to them as alternative conceptions, Helm (1980) called them misconceptions, Sutton (1980) preferred the term children's scientific intuitions, Gilbert, Watts &Osborne (1982) called them children's science, Halloun & Hestenes (1985b) called them common sense concepts, and Pines &West (1986) called them spontaneous knowledge Eryilmaz, (2002). Kopniek and Watson, Watson and Kopniek and Gunstone in Goje (2007) described preconceptions as personal constructions which are formed on what anindividualfeelsor sees. The other words used to denote misconceptions by educators include misconceived notions, alternative conceptions, prior conceptions, preconceptions, pre-instructional beliefs, alternative frame-work, naïve theories, intuitive ideas, untutored beliefs among others Hopp, (1985), Blosser, (1987), Haslam and Treagust, (1987), Chamber and Andre, (1997), Samba, (1998), Oyedokun, (1998), Davis, (2001) stated that misconception arise from faulty reasoning, this is thus the reason why despite the effort teachers of science put into the teaching of students, many still fail to grasp fundamental ideas taught in the class. Most of the very "good students" give right answers, only using memorized words not fully understanding the underlying concepts (Lawal, 2009).

Misconceptions are those beliefs students have that contradict accepted scientific theories. Strike (1982) suggested that misconception should be regarded as an assumption that is structurally important in the student's belief system. It is something that generates mistakes. It is a piece of student's conceptual ecology that serves to select or reject other ideas or render them more or less intelligible. Blosser (1987) stated that misconceptions arise from faulty reasoning.Misconceptions are at variance with conceptions held by experts in the field. They tend to be pervasive (shared by many different individuals) and are highly resistant to change by traditional teaching methods. Misconceptions sometimes involve alternative belief systems that comprise of logically linked sets of propositions that students have used in a systematic way which sometimes have their roots in historical precedent and are passed on from teacher to students. (Blosser, 1987) suggested that misconceptions belong to a genre of concepts which might be appropriately thought of as the students' conceptual ecology. He further described a student's conceptual ecology as that set of concepts which affect what the student will find plausible, comprehensible, or reasonable. He referred to these as the conceptual niche in which a new idea must survive. According to Strike (1982) misconceptions are important because they are clues to the cognitive capacities possessed by students. These cognitive capacities can be described in a formal, subject matter neutral way and are themselves the key pedagogical phenomena in that they may place limits on what may be understood at a given stage or in that they specify how a given topic may be taught so as to be consistent with a student's current capacity for representing ideas.

Okebukola (2002) categorized misconceptions into five. They are as follows:

Preconceived notions are popular conceptions rooted in everyday experiences. For example, many people believe that water flowing underground must flow in streams because the water they see at the earth's surface flows in streams. Preconceived notions plague student's views of heat, energy, and gravity (Brown & Clement, 1991), among others.

Nonscientific beliefs include views learned by students from sources other than scientific education, such as religious or mythical teachings. For example, some students have learned through religious instruction about an abbreviated history of the earth and its life forms. The disparity between this widely held belief and the scientific evidences for a far more extended pre-history has led to considerable controversy in the teaching of science.

Conceptual misunderstanding arises when students are taught scientific information in a way that does not provoke them to confront paradoxes and conflicts resulting from their own preconceived notions and nonscientific beliefs. To deal with their confusion, students construct faulty models that usually are so weak that the students themselves are insecure about the concepts.

Vernacular misconceptions arise from the use of words that mean one thing in everyday life and another in a scientific context (for example, "work"). A geology professor noted that students have difficulty with the idea that glaciers retreat, because they picture the glacier stopping, turning around, and moving in the opposite direction. Substitution of the word "melt" for "retreat" helps to reinforce the correct interpretation that the front end of the glacier simply melts faster than the ice advances.

Factual misconceptions are falsities often learned at an early age and retained unchallenged into adulthood. If you think about it, the idea that "lightning never strikes twice in the same place" is clearly nonsense, but that notion may be buried somewhere in your belief system (Committee on Undergraduate Science Education).

Okebukola (2002) further explained that vernacular and factual misconceptions can easily be corrected even by the students themselves. The other three, extra effort on the part of the teacher would be required to get it corrected. Research into students understanding of science concept has generally been based on the constructivist perspective (Driver in Goje, 2007). In this perspective, it is acknowledged that learners actively select and order the information to which they will attend and construct or generate meaningful learning. Existing memories, including concept and information processing strategies play a vital role in shaping learning outcomes because they influence new stimuli and the subsequent generation of meaning. Because learning is regarded as a personal construct, there is likelihood that some constructions will be erroneous and that this will adversely affect subsequent learning in form of misconception. In this study, the effect of conceptual assignments and conceptual change discussions instructional strategies on students' misconceptions, retention and academic achievement in genetic concepts in senior secondary schools was investigated.

2.4.1 Sources of Misconceptions

Misconceptions are formed in a variety of ways. Often, misconceptions are passed on by one person to the next. In other cases, students may be presented with two concepts, but combine or confuse them. Some students make what to them seems like a logical conclusion, but is simply drawn from too little evidence or lack of experience. One of the most common sources of misconceptions is the fact that our everyday language is often at odds with science; common vernacular does not always match the precise language used by scientists (Hanuscin, 2011).Misconceptions may originate from category mistakes. Category mistakes occur when a learner mistakenly assigns concepts into wrong lateral or ontological categories (Chi, 2008). A lateral category is a category occupying different branches of the same tree, while an ontological category is a category between different trees. According to Chi, (2008) category mistakes account for robust misconceptions. This implies that a category mistake once it gets registered into a learner's mental framework results in a wrong or flawed mental model.That is, students think of some concepts from different ontological categories from those assigned by scientists. This suggests that conceptual change must involve an ontological change in the student's cognitive structure.The structure of a conception may vary considerably from a relatively amorphous collection of ideas with no strong connection to one which is interrelated and possesses a large measure of internal consistency. Therefore, developing a solid base of knowledge about students' conceptions should be instrumental to providing a framework for considering the learning processes involved in changing students' conceptions, as well as providing a framework for designing instruction that facilitates the expected changes.

Misconceptions may arise from preconceptions held by students, often time they are a result of interaction between the cultural and social beliefs of the society, which the students are exposed to. According to studies conducted by Gertzog, Posner, Strike & Hewson (1982) there are so many factors that affect the teaching of science. These are mainly religious, social and cultural factors and they influence the learner in his process of growing, which eventually culminate in preconceptions, which he brings to the science classroom (Goje, 2007).Strike (1982) opined that many of the concepts that influence scientific belief for good or ill are not themselves scientific concepts. He further explained that culture or politics play important roles on the formation of scientific belief. Some ways of thinking about natural phenomena may be lurking in conceptual organization of the language will learn as children. He further explained that the concepts that select for the misconceptions that our students commonly hold are not other scientific concepts that they inhabit domains from religion and politics, to language and music. Misconception is a child's effort to organize and understand the world around him/her, the success of which will depend both on the developmental stage of the child and the experience to which he/she is exposed (Hanuscin, 2011).

In many cases, students have developed partially correct ideas that can be used as the foundation for further learning (Clement et al, 1989). However, many students have not developed an appropriate understanding of fundamental concepts from the beginning of their studies, and this shortcoming can interfere with subsequent learning. Misconception can occur in students' understanding of scientific methods as well as in their organization of scientific knowledge. (Blosser, 1987).Recent research on students' conceptual misunderstandings of natural phenomena indicates that new concepts cannot be learned if alternative models that explain a phenomenon already exist in the learner's mind. Although scientists commonly view such erroneous models with disdain, they are often preferred by the learner because they seem more reasonable and perhaps are more useful for the learner's purpose (Mayer, 1987). These beliefs can persist as lingering suspicious in a student's mind and can hinder learning (McDermott, 1991).

Atadoga and Onaolapo (2008) explained that learners enter the classroom with certain belief (cultural and religious) from home. Some of which are based on superstition and religion. For example, Nigerians still believe that albinos are produced as a result of sexual intercourse between a man and a woman who is menstruating. The superstition has it that the sperm must have been stained by the menstrual blood and this mars the pigmentation of the skin of the albino child. In biology, we study biological units called genes. The genes dictate the characters of the organism that are produced. In human beings, when the gene that is responsible for the production of amino acid called tyrosine is lacking during pregnancy, the pigmentation of the skin of the child will be affected and an albino is produced (Awokoya; Ogunlana; in Abdullahi, 1982).

Kikas in Lawal (2009) opined that teachers should be aware of the popular misconceptions in their fields and understand the possible reasons for their origin. This he asserted would help the teacher to identify the origin and thus the appropriate means to correct the misconceived notions. The present study intends to identify the misconceptions biologystudents habour in genetic concepts as suggested by Okebukola (2002) and investigate the effects of conceptual assignments and conceptual change discussions in remediating the misconceived concepts.Kikas (2004) classified the misconceptions that inhibit children and adults as well as teachers gaining contemporary scientific understanding of concepts in science into four sources. These are: -

1. Overgeneralization on the basis of analogy. Science teachers use analogies in their teaching to aid understanding of concepts. Here, a well- known domain is transferred into a new domain e.g. creating materialistic models by adding materialistic features to various processes e.g. the flow of light, electric current, heat etc. These analogies are used by the teacher to help relate new information to prior knowledge. However, many of such analogies are taken too far thus giving rise to misconceptions.
2. Concepts belonging to entologically different categories. Scientific concepts that are entologically different from everyday concepts are not easy to be acquired for example force and motion of objects. Force implies motion, the fundamental idea common to both is that objects move due to internal forces as opposed to external forces. According to the Pre-Newtonian theory force can be possessed, transformed and dissipated. Throwing an object is equated with putting force into the object. This naïve concept of force belongs to the ontological category of matter, whereas the Newtonian concept belongs to a different ontological category. Movement and force is another set of scientific concepts that are popularly equated with each other by teachers.
3. Method of presentation of the knowledge in the school textbooks. These could be in form of words used e.g. energy and force, these two words are confused by teachers due to their everyday usage, which differ from scientific meanings. It could also be in the presentation of diagrams or models, where they are properly constructed they give rise to faulty conceptions.
4. The nature and type of teacher training. The knowledge teacher has depended on the way they were taught both content and processes and the way they were taught goes to determine how they too will present it to the learner. Where they have misconceived notions, they transfer same to their students (Lawal 2009).

Kikas cited in Lawal (2009), summarized by saying misconception arise in an attempt to understand complicated knowledge and why these misconceptions develop vary with concrete topics and situations, Osborne and Gilbert (1980) in support of Kikas' categorization of the sources of misconceptions stated that learners hold ideas that are developed during their early days school years and that these may be compounded by the teacher and/or textbook. Trowbridge and Mintzes (1985), added that it is possible that the learner develops parallel but mutually inconsistent explanations of scientific concept i.e one for use in schools and the other for use in real world. Fisher (1985) cited in Lawal (2009), made a list of common characteristics of common misconceptions. She stated that alternative conception or misconceptions are:-

1. at variance with conceptions held by the experts in the field.
2. pervasive i.e shared by many different individuals.
3. highly resistant to change or alteration at least by traditional teaching method.
4. sometimes involved alternative belief systems comprised of logically linked sets of propositions that are used by students in systematic ways.
5. having historical precedence i.e some erroneous ideas put forth by students and
6. arising as a result of:
   a) neurological "hardware" of genetic programming i.e in the case of automatic language processing structures, which may be involved when "reading" and equation.
   b) certain experiences that are commonly shared by many individuals (as with moving objects) or
   c) instruction in school or other settings.

In this study, the effects of conceptual assignments and conceptual change discussions instructional strategies of teaching on students' misconceptions and academic performance in genetic concepts were investigated.

2.4.2 Helping Students to Identify, Confront and Overcome Misconception

Learning science is a cumulative process in which each new piece of information is added to what the students already know or believe about the topic at hand. If the students have a solid foundation, the new pieces of information fit together more easily. However, if the students' preparation is spotty or incomplete, they may find it harder to grasp the new material. If the new material conflicts with earlier misconceptions or firmly held assumptions, the teacher needs to use a strategy that will raise cognitive conflict necessary to enhance their capacity to reorganize or reconstruct correct conceptual framework for their new knowledge. Soyibo (1983) reported that many students often display "incorrect" notions or "misconceptions" in the learning of science concepts which tend to impede their explicit understanding of particular concepts (and related ones) being learned.

Before misconceptions can be corrected, they need to be identified. Many researchers and teachers have compiled lists of commonly encountered misconceptions. Shifting these erroneous beliefs to scientifically accepted ones continues to be a major problem to science educators and and researchers (Lawal, 2009). Driver (1981) suggested that the teacher should try to identify the learners' fuzzy, missing, correct or incorrect knowledge through their previous knowledge. She suggested that if students' prior knowledge is fuzzy, it should be supplied; if it is incorrect, it should be changed and if it is correct, it should be used as the building block for the new knowledge. Driver (1981) concluded by cautioning that students will allow the new concept to replace their pre-existing false concepts only if the new concepts are more valid, more meaningful, more useful or in some other ways preferable to their existing concepts (Lawal, 2009).Before embracing the concept held to be correct by the scientific community, students must confront their own beliefs along with their associated paradoxes and limitations and then attempt to reconstruct the knowledge necessary to understand the scientific model being presented. This process requires that the teachers:

1. Identify students' misconceptions.
2. Provide a forum for students to confront their misconceptions.
3. Help students reconstruct and internalize their knowledge, based on scientific models (Blosser, 1987).

A number of professional societies have developed conceptual tests which allow the teacher to identify students' misconceptions. Additionally, small group discussions and office hours provide effective forums for identifying students' misconceptions. With practice and efforts, a teacher can learn to probe a student's conceptual framework (often by simply listening) without resorting to authority or embarrassing the student. Rowel, Dawson and Lyndon (1990) opined that the transfer of one's commitment from one set of belief to another demands the questioning of reality, abandoning irrelevant ideas that have been long established over a long period, and becoming committed to a new set of ideas that do not go completely with the old ones. It is not suprising to find reluctance on the part of the learners to abandon the past beliefs that are held by their peers because they have served so well previously making sense of the world for new ones when they are exposed to such in the school system. The teacher therefore faces the problem of getting the learners to accept the new sets of beliefs about the world and how things work, that is now being propounded against the background of what the students had previously believed and used to explain the world around them (Lawal, 2009).

A number of strategies have been employed to understand what students are thinking prior, or in response, to instruction. These strategies include various forms of "real type" feedback, which can involve the use of coloured cards or electronic survey systems (clickers). Another approach is typified the strategy known as "Just in Time Teaching". Here students are asked various questions prior to class; the instructor uses these responses to adapt his or her teaching to the students' prior knowledge and misconceptions. Finally, there is a more research-intensive approach that involves interviewing students for the purpose of generating the items that will make up a concept inventory.Okebukola (2002) explained that it would be improper for the teacher to insist that the learner dismisses the preconceived notions already there in their minds, rather the learners should be made to be convinced to discard the preconceived ideas by confronting their own beliefs with their associated paradoxes and limitations, then attempt to reconstruct the knowledge necessary to understand the scientific model being presented. This process Okebukola believes requires that the teacher is capable of identifying the misconception the learner has provide a forum for the learner to confront their misconceptions, then help the learner to reconstruct and internalize their knowledge based on scientific models.

An assessment tool that identifies alternative conceptions of students is desirable for teachers who are striving to promote constructivist learning in their classrooms (von Glaserfeld, 1989; Christianson & Fisher, 1999; Mintzes, Wandersee & Novak, 2000). Whereas experienced teachers are well aware of students' conceptual difficulties, novice teachers are not. In addition, many teachers recognize the need to assess their students' naïve understandings but do not do so because they lack the appropriate tools (Morrison & Lederman, 2000). Thus, a reliable test with excellent content validity is needed to meet a variety of educational needs.It is useful to review and think about misconceptions before teaching a class or laboratory in which new material is introduced. The teacher should use questions and discussion to probe for additional misconceptions. Students will often surprise the teacher with the variety of their preconceptions, so he should be careful to listen closely to their answers and explanations. The teacher can help his students by asking them to give evidence to support their explanations and by revisiting difficult or misunderstood concepts after a few days or weeks. Misconceptions are often deeply held, largely unexplained, and sometimes strongly defended. To be effective, a science teacher should not underestimate the importance and the persistence of these barriers to true understanding. Confronting them is difficult for the student and the teacher. Some misconceptions can be uncovered by asking students to sketch or describe some object or phenomenon.

Strategies for helping students to overcome their misconceptions are based on research about how we learn (Arons, 1990; Minstrell, 1989). The key to success is ensuring that students are constructing or reconstructing a correct framework for their new knowledge. Helping students to reconstruct their conceptual framework is a difficult task, and it may be time consuming. However, if the teacher decides to make effort to help students overcome their misconceptions, he might try the following methods:

i. Anticipate the most common misconceptions about the material and be alert for others.
ii. Encourage students to test their conceptual frameworks in discussion with other students and by thinking about the evidence and possible tests.
iii. Think about how to address common misconceptions with conceptual assignments and conceptual change discussions.

iv. Revisit common misconceptions as often as you can.

v. Use tests to assess and reassess the validity of students' conceptions. The teacher needs to raise cognitive conflicts that will make the students to identify and articulate their ideas, to investigate the soundness and usefulness of their own ideas and those of others, inducing scientists, and reflect on and reconcile differences in those ideas (Champagne, Klopfer and Gunstone, 1982).

In the light of the above steps on how to help students to confront and overcome misconceptions, which is within the constructivist framework, this study investigated the effects of conceptual assignments and conceptual change discussions which are constructivistic in nature on students' misconceptions of genetic concepts.

2.4.3 Constructivism and the Teaching of Science

Learning is a process of conceptual change which involves an interaction between new and existing conceptions with the outcome being dependent on the nature of interaction (Suchocki, 2004).The concept "constructivism" refers to the contemporary learning school of thought which postulates that students create their own maps and theories of the world. The constructivist school of thought views learning as a process in which students actively construct their own knowledge of the situation at hand based on the existing previous knowledge. Constructivism is a theory of knowledge (epistemology) that argues that human generate knowledge and meaning from an interaction between their experience and their ideas. According to the theory, students engage their minds actively in constructing meaning out of their interaction with the environment. They make their own connections between experiences and the words other people are teaching them to use, and they create their own network of relationship and patterns of thinking (Dabson, 1984).

According to constructivist learning theory if the learners construct their own knowledge actively, their understanding will be better comparatively passively acquire (Posner et al. 1982). In every part of the life learning occurs. Learners acquire some knowledge by means of experiences with the life. This knowledge is called existing knowledge. This knowledge may be true or wrong. But learners use their existing knowledge to interpret new information in ways which make sense to them. They build their own conceptual structure in which they incorporate empirical phenomena, they might have to change their minds in ways which may require restructuring of their existing conceptions, rather than simply adding new knowledge (Hewson, 1981, Posner et al. 1982).Learners' interaction with their scholars, parents or members of the community affects the learning. Learning occurs with understanding and learners consruct and transform their own knowledge, so personal construction of knowledge is very important. Constructivism is one of the most effective theories among the learning theories. According to this philosophy, learners construct knowledge themselves. Students construct their own knowledge by experiencing their own ideas which are based on their previous knowledge. They apply it to new situations and integrate the previous knowledge with the new knowledge (Hein, 1991; Taber & Watts, 1997).

A constructivist perspective views learners as actively engaged in making meanings, and teaching with that approach that looks for what students can analyse, investigate, collaborate, share, build and generate based on what they already know, rather than what facts, skills and processes they can parrot. To do this effectively, a teacher needs to be a learner and a researcher, to strive for greater awareness of the environments and the participants in a given teaching situation in order to continually adjust their actions to engage students in learning, using constructivism as referent. Constuctivism is a way of thinking about knowing, a referent for building models for teaching, learning and curriculum (Tobin and Tippin, 1993) Constuctivism argues that students are not passive absorbers, but active constructors of knowledge. They read, watch television, listen to or over hear older students, parents and teachers talking and they make sense of their environment, not necessarily to explain it of course, but certainly to use it to their advantage. If these traits in students can be properly nurtured and directed towards learning, the latter will be more meaningful and fruitful which is the focus of constructivism (Bichi, 2002).The constructivistic view of learning is rapidly gaining ground and is attracting the attention of many researchers in education since the last couple of decades (Oyedokun, in Bichi, 2002). For instance, Hewson and Hewson (1988) outlined an appropriate conception of teaching science, a conception which is based on constructivism and the model of learning as a conceptual change. Earlier, Wittrock (1985) and Von Glosserfeed (1983) shared two views with Piaget- that learning is an "active construction process" and that learning is possible only on the basis of already acquired knowledge. Good and Brophy (1997) observed that the construction of new knowledge goes more smoothly when learners can relate new content to their existing background knowledge.

Piaget (1977) suggested that through processes of accommodation and assimilation, individual construct new knowledge from their experiences. When individuals assimilate, they incorporate the new experience into an existing framework without changing that framework. This may occur when individuals' experiences are aligned with their internal representation of the world, but may also occur as a failure to change a faulty understanding. When individuals' experiences contradict their internal representations, they may change their perceptions of the experience to fit their internal representations. According to the theory, accommodation is the process of reframing one's mental representation of the mental world to fit new experiences. Accommodation can be understood as the mechanism by which failure leads to learning: when we act on the expectation that the world operates in one way and it violates our expectations, we often fail but by accommodating new experience and reframing our model of the way the world works, we learn from the experience of failure, or other's failure (Wikipedia, the free encyclopedia, 2011).Piaget (1977) also emphasized that individuals construct their own knowledge through interaction with their environment. The concepts which are formed during the process constitute the person's personal explanation to these concepts. It is this concept that is referred to as prior knowledge and they form the basis upon which new knowledge is built in the school learning. Prior knowledge is one of the platforms that lead to poor performance in the field of biology. That is, the student poor experience background is not bright to bear, on the field of biology which subsequently leads to their poor performance in their SSCE. When the students have misconceptions, the prior knowledge that supposed to be the basis upon which new knowledge is built in the school learning is meaningless.

Dabson (1984) carried out a research on students' learning in constuctivistic way and reported that students do not sit and wait until they are told enough to understand electric current properly, they get on with it as best as they can, constructing an internally consistent system that allows them to deal with torches, bicycles dynamos, transistor radios, etc. in what is generally quite successful manner. As the students get older, Dabson argues, they developed a more serious interest in physics and their "construct system" becomes capable of explaining a wider variety of experience.Another finding of Dabson's (1984), study is that students develop two systems of explanation- one for themselves to be used in solving real life problems and the other to be used for "satisfying the examiner". The Assessment of Performance Unit (1984) extended Dabson's study further and found out that a large majority of students at age 15 adopt the first alternative, holding firmly to the ideas they first thought of at an early stage. Other studies on constructivitic learning include those of Ausubel (1968); Wittrock (1974); Driver (1983); Shayer and Adey (1981); Brook and Driver (1985); Brook and Briggs (1983); Oshorne and Freyberg (1985). Hand and Treasust (1989) reported that constuctivistic learning strategy has an advantage of increasing the students' self- confidence in relation to science, generate a more active participation in science activities and lead not only to greater understanding but also greater interest in the subject.

Dogru and Kalender (2007) compared science classrooms using traditional teacher-centered approaches to those using student-centered constuctivist methods. In their initial test of student performance immediately following the lessons, they found no significant difference between traditional and constructivist methods. However, in the follow-up assessment 15 days later, students who learned through constructivist methods showed better retention of knowledge than those who learned through traditional methods.In the light of the advantages of learning within the constructivist framework and the realization to make science teaching and learning more effective and meaningful, this study investigated the effects of conceptual assignments and conceptual change discussions strategies on students' misconceptions, retention and academic performance at the senior secondary level which is constuctivistic in nature.

2.4.4 Concept, Conception and Learning in Science

The term concept has been defined by several scholars and it means different things to different scientists. Abimbola (1992) defined concept as the meaning attached to a given symbol or label. He categorized concept into three: empirical, theoretical and relational. According to Abimbola (1992), empirical concepts are concepts of inspection. These are concrete, observable concepts whose examples include cell, pulley, aluminum etc. Theoretical concepts are concepts by definitions. They are abstract, unobservable concepts; examples include molecule, absolute zero and so on. Relational concepts according to Abimbola (1998) are concepts that relate to two or more concepts together; such concepts cannot exist on their own. For example, less, more, equal, inversely proportional and so on. According to Piaget (1977) conceptions are formed by the individuals through the process of equilibration. Conception can be seen as the idea the learner already has about a phenomenon. Conception is the individual's construct of ideas around himself or herself, which he or she uses to explain the world around him/her meaningfully to himself /herself. Samba (1998) sees conception as personal explanatory knowledge about how the world or how things around operate.

Herbert in Goje 2007)define concept as ordered information about the properties of one or more things objects, events or processes that enables and particular thing or class of things to be differentiated from and also related to other things or classes of things. Abdullahi (1982) define the term concept as a word, or group of words and /or symbols which may represent the meaning or definition given to an object or phenomenon. Rosser and Nicholson in Goje, 2007) state that concepts are categories we impose on the stimuli in our environment. They provide organizational schemes for assimilating new stimuli and for determining relationships within and between categories and on the basis of this statement; concept is defined as abstraction that represent a class of objects, event activities or relationships that have attribute in common. They however are of the opinion that no single opinion can reveal the richest meaning of concept that student require, since concept are internal representations of a class of stimuli they cannot be observed, they must be inferred from the behaviour.

Psychologists believe that concepts are vitally involved in thought process and that an understanding of concepts leads to the formulation of principles and generalizations which make for efficiency for solving problems (Nacino– Brown, Oke& Brown, 1982). Even though we can provide a verbal definition of a concept, a definition does not reveal all the relationship between the concept and others. There are many, different types of concepts. Some are related to classes of concrete object such as metal. There are others which refer to on – going processes, for example growth, ageing and learning. Others again show how objects, persons or events are related in time or space, for example above, below, before, and after (Nacino – Brown, Oke & Brown, 1982).According to Abdullahi, (1982) in science, two kinds of concepts exist. Empirical concepts, which are observable or demonstrable and may be defined operationally. They can be measured in a relatively simple direct way. Examples are diffusion, freezing point, volume, pressure, plant and so forth.Theoretical concepts are non-observable and cannot be perceived or measured in a relatively simple direct way. Examples are atoms, electrons, molecules, genes, protons and so forth.In science, we come across concepts like evolution, food chain, food web, thermodynamics mole, chemical equilibrium, senescence adaptation, electromagnetic waves, osmosis, growth, gametogenesis, genetics etc. These science concepts serve as a bridge towards proper understanding of the Science phenomena and a catalyst that facilitates the increase of students' interest in science.

Glynn and Duit (1995) viewed conceptions as learners' mental models of an object or an event. Conceptions can be regarded as the learner's internal representations constructed from the external representations of entities constructed by other people such as teachers, textbook authors or software designers. From a conceptual change learning perspective, learners need to be able to make different representations of entities to make difficult concepts intelligible. Learning always involves some ways of representing information and science teachers use different representational techniques such as voice, writing, and gestures in the classroom to communicate ideas to students. Representations are ways to communicate ideas or concepts by representing them either externally, taking the form of spoken language (verbal), written symbols (textual), pictures, or physical objects or a combination of these forms or internally when thinking about these ideas. Students come to science classes with pre-instructional conceptions and ideas about the phenomena and concepts to be learned that are not in harmony with science views. Furthermore, these conceptions and ideas are firmly held and are often resistant to change (Duit, 2007).

Learning is a dynamic process in which learners actively construct knowledge, the acquisition and organization of information into a series of increasing complex understanding influenced by context (Holt, in Ngozi, 2008). One of the overriding objectives of biology teaching is to ensure that students learn biological concepts meaningfully. Meaningful learning as explained by Ausubel in Albert (1989) results when a learner consciously and explicitly relates new knowledge to relevant concepts or propositions which he already possesses. Meaningful learning therefore provides evidence that an individual has been able to internalize a new stimulus and is reflected in his ability to apply the new knowledge to other situations. Meaningful learning is active, constructive, intentional, authentic and cooperative (Jonassen, Peck& Wilson in Agbowuro, 2008).

Science concept learning or science concept formulation is understood to mean the acquisition of concepts related to science. Abdullahi, (1982) opined that empirical and theoretical concepts can be taught at any level. That it is the teacher that determines the level of mastery as each concept may be taught at classification, comparative or even quantitative levels depending on the background of the pupils.A person's conceptual view never ceases to change as he or she matures and gains in experience. Concepts are modified and revised to take into account new information the individual has assimilated. As Cronbach (1966) said; the depth of understanding, the range of application of a concept, and the precision with which it is learned can grow for years after the definition is learned. This growth can be likened to an ever widening spiral, narrow at the bottom and broad at the top. Thus, a secondary school student's conception of a human cell is likely to contain some elements of misconception, moreso than a biochemist who has spent many years researching on cells (Nacino –Brown, Oke & Brown, 1982).

The significance of acquiring knowledge on how to teach or how students learn scientific concepts has prompted science educators into various researches that have shed more light and brought about considerable improvement on curriculum development and new science teaching methodologies.One of the scholars who have studied how science concepts are learnt is Robert Gagne. Gagne (1963) describes the scientific enquiry as a set of activities characterized by a problem-solving approach in which each newly encountered phenomenon becomes a challenge for thinking. Such thinking begins with a careful set of systematic –observations, proceeds to design the measurement required, clearly distinguishes between what is observed and what is inferred, invents interpretations which are under ideal circumstances brilliant leaps, but always testable, and draws reasonable conclusions (Gagne in Goje 2007).

2.5.0 Definition and Description of Conceptual Change

Conceptual change is generally defined as learning that changes an existing conception (i.e. belief, idea or way of thinking). This shift or restructuring of existing knowledge and beliefs is what distinguishes conceptual change from other types of learning. Learning for conceptual change is not merely accumulating new facts or learning a new skill. In conceptual change, an existing conception is fundamentally changed or even replaced, and becomes the conceptual framework that students use to solve problems, explain phenomena, and function in their world.Westbrook and Rogers (1992) defined conceptual change as a process of using instructional strategies to bring children's thinking into line with that of scientists. Westbrook & Rogers (1992) stated that the process of using "strategies to bring children's thinking into line with that of scientists is known as conceptual change." Also, Stofflett (1992) wrote that "research on scientists' cognition identifies the process of conceptual change as a necessary prerequisite for the formation of scientifically validated theories." Moreso, Tobin (1992) states that "conceptual change is learning, which is a social process of making sense of experience in terms of extant knowledge since all learning occurs in a social milieu, all learning is inherently social (Hewson, 1992).

Conceptual change, according to White and Gunstone (1989), is a principle or belief change, a change in a metaphysical belief. Conceptual change in this study is taken to be a student's change in reasoning

patterns on moving from one level of understanding to another. That is, tracing the movement of a student from one level of understanding to another. Hence,conceptual change is viewed from the social context. By extension, conceptual change is primarily brought about by way of thinking about learning, that is, it is something that a learner does as an intentional act, rather than something one by a teacher (Hewson, 1992). So, in summary, conceptual change is a change or modification or rejection of one's conceptual beliefs when presented with an anomalous situation. Discussion of conceptual change needs to consider the nature of conceptions. Glynn and
Duit (1995) viewed conceptions as learners' mental models of an object or an event. Conceptions can be regarded as the learner's internal representations constructed from the external representations of entities constructed by other people such as teachers, textbook authors or software designers. From a conceptual change learning perspective, learners need to be able to make different representations of entities to make difficult concepts intelligible. Learning always involves some ways of representing information and science teachers use different representational techniques such as voice, writing, and gestures in the classroom to communicate ideas to students. Representations are ways to communicate ideas or concepts by representing them either externally, taking the form of spoken language (verbal), written symbols (textual), pictures, or physical objects or a combination of these forms or internally when thinking about these ideas. Students come to science classes with pre-instructional conceptions and ideas about the phenomena and concepts to be learned that are not in harmony with science views. Furthermore, these conceptions and ideas are firmly held and are often resistant to change. While studies on students' learning in science that primarily investigate conceptions of the content level continue to produce investigations of students' conceptions at meta-levels, namely, conceptions of the nature of science and views of learning, also have been given considerable attention in the past two decades (Duit, 2007).

Duit (2007) opined that many teachers hold conceptions of science concepts and processes that are not in accordance with the science view and often are similar to students' pre-instructional conceptions. It became evident that many teachers hold limited views of the teaching and learning process and of the nature of science. Hence, teachers' conceptions of various kinds also need to undergo conceptual changes.

Basically, the same conceptual change frameworks for addressing students' conceptions have proven valuable to develop teachers' views of science concepts (Hewson, Tabachnick, Zeichner, Blomker, Meyer, Lemberger, Marison, Park & Toolin 1999).Conceptual status classifies a conception as being intelligible, plausible or fruitful (Hewson and Thorley, 1989) and is particularly useful for assessing changes in students' conceptions during learning. When a competing conception does not generate dissatisfaction, the new conception may be assimilated alongside the old. When dissatisfaction between competing conceptions reveals their incompatibility, two conceptual events may happen. If the new conception achieves higher status than the prior conception, accommodation, which Hewson (1982) calls conceptual exchange, may occur. If the old conception retains higher status, conceptual exchange will not proceed for the time being. It should be remembered that a replaced conception is not forgotten and the learner may wholly or partly reinstate it at a later date. Both Posner et al. (1982) and Hewson (1982) stress that it is the student, not the teacher, who makes the decisions about conceptual status and conceptual changes. This position is in harmony with constructivist learning theory and the highly personal nature of conceptions viewed as mental models (Norman 1983).

All students enter classroom with a wealth of knowledge about their physical, biological and social worlds. They construct their own ideas about how the world works and explain scientific phenomena in terms of these ideas. These kinds of notions are referred to as naïve beliefs, misconceptions, alternative conceptions; such preconceptions seldom match the scientific explanations that are taught in science courses. When "novice" learners use everyday experience and inappropriate prior knowledge to create mental models that comprise their conceptual framework (Boulter & Buckley, 2000), the result may be faulty mental models that give rise to misconceptions. These are individuals scientifically inaccurate interpretations of the world that can neither explain not predict phenomena. Misconceptions are not prevalent only among school age children. Even after several years of science instruction, adults maintain incorrect ideas about scientific phenomena.

Effective pedagogy is necessary to displace faulty mental models and associated misconceptions by stimulating cognitive processes that act to achieve conceptual change and alter students' conceptual framework (Krause, 2007). Students are not the only potential targets of conceptual change strategies.Hewson, (1992) opined that just as students develop conceptions of everyday events, prospective teachers can similarly be expected to develop conceptions of teaching based on their own experiences as students in many different classrooms, from courses in teacher education programs, and as student teachers. Thus, they can be expected to build conceptual structures in which they incorporate classroom events, instructional concepts, socially accepted behaviors, and explanatory patterns. These structures include, possibly implicitly their rationale for teaching and their view of knowledge, learning and science, their disciplinary knowledge, and the ways in which they teach, along with detailed specific information on content, students, school procedures, etc which he called conception of teaching science (Hewson & Hewson, 1988). He further explained that teachers' knowledge, skills, and attitudes are likely to be very different in kind, serving different purposes, and not necessarily being coherent.

In order to identify the characteristics of a conception of teaching science appropriate for conceptual change teaching, Hewson and Hewson (1988) reviewed research on students' conceptions of natural phenomena, conceptual change, science teaching and teachers' thinking. They concluded that science teachers should:

a. know the phenomena, the methods, and the concepts, principles, and theories that constitute the science they are teaching;
b. know what conceptions their students hold about the units to be taught, and the extent to which they are scientifically acceptable;
c. be aware of the role played by students' existing knowledge in understanding new material;
d. be convinced of the need to use conceptual change strategies particularly when students' existing conceptions conflict with those being taught; and
e. be able to plan and perform teaching actions that give effect to these strategies.

In addition, Smith (1983) suggested that teachers also must change their conceptions if students are to change theirs. He further explained that two sorts of teacher conceptions are relevant. First, the teachers' own conception of scientific theories they teach must be correct, if they are expected to mediate student learning. Since many teachers particularly at the lower educational level lack the extensive science background necessary for accommodation, they are likely to hold many of the naive conceptions their students do. Second, Smith and Anderson, (1983) pointed out that teachers' conception of teaching require fundamental change if they are to produce accommodation in their students. They further explained that to bring about conceptual change in students, teachers need to change their conceptions to a conceptual change view of teaching and such a view requires the teacher to bring out the students' preconceptions, provide a base of relevant experience and observations, challenge the students' misconceptions with appropriate questions and evidence, clearly present the scientific alternative conception, and help the student to realize the greater power and usefulness of the new conception (Smith & Anderson, 1983).

Strike (1982) explained that the essence of the idea of conceptual change is that learning is not just a matter of gaining knowledge directly from experience or indirectly from words. He said learning involves an interaction between experience and information and a student's current concepts. He further explained that the character of those concepts will determine what is learned from experience or information and how it is understood. Moreover, learning is not just a matter of adding to our current concepts, but of changing and reorganizing them. Conceptual change occurs effectively when students construct their own knowledge to achieve conceptual change through modification of their conceptual framework (Driver, 1994; Krause, 2007). This happens when cognitive conflicts necessary for conceptual change are raised, the learners construct or reorganize their thoughts in line with the new ideas. The framework is comprised of mental models, which are transformed representations of real-world systems and phenomena called modeled target systems or phenomena (Norman, in Krause, 2007).

Modeled target system is a preliminary solid representation of the world or phenomena. Mental models are defined as simplified, conceptual representations that are personalized interpretations of modeled target systems or phenomena in the world around us. Thus, the transformed modeled target systems or phenomena become the mental models which are more visible or comprehensible to an individual (Gilbert, 1995). In conceptual change, learning requires that existing conceptions be restructured or even exchanged for the new. A central prediction of the conceptual change model is that conceptual changes do not occur without concomitant changes in the relative status of changing conceptions. Learning a new conception means that its status rises, i.e., the learner understands it, accepts it, sees that it is useful. If the new conception conflicts with an existing conception i.e., one that already has high status for the learner, it cannot be accepted until the status of the existing conception is lowered. This can be done by raising the cognitive conflicts necessary for the learners to construct or reorganize their thoughts in line with the new ideas. Useful mental models allow us to understand, explain, and predict behavior of systems and phenomena, whereas faulty mental models, which lead to misconceptions, cannot. After revealing and characterizing students' misconceptions, conceptual change discussion method can be designed to displace them.

Challen and Brazdil (1999) opined that the student to teacher and student to student dialogue that accompanies a good discussion provides feedback to the teacher on the status of student comprehension and is particularly valuable in drawing out and exposing misconceptions, many of which would otherwise remain buried, only to surface in later courses, if at all (Blanchard, 2011). For an individual to want to adopt a new concept, it should also be intelligible, plausible and fruitful (Posner, strike, Hewson & Gertzog, Hewson in Krause, 2007). Different pedagogies can vary in their effectiveness to enhance conceptual change. Some instructional strategies have used activities that include group discussions (Kobayashi, 1994); writing activities and group collaboration (Fellows 1994); laboratory experiments, group work and vee diagrams (Ebenezer & Gaskell, 1995); Computer – Aided Learning (Biemans & Simons, 1995); and concept sketches (Johnson& Reynolds, 2005).

Although traditional instructional methods have a significant effect on students' misconceptions, it is far from being sufficient in remediating students' misconceptions that are persistent and highly resistant to change (Brown and Clement, 1987; Clement, 1982; Eryilmaz, 1992; Halloun & Hestenes, 1985a; Viennot, 1979). Some of the common suggestions to remedy students' misconceptions include teaching physics conceptually, and by conceptual discussion methods (Brouwer, Posner et al in Eryilmaz, 2002). A number of lines of evidence suggest that the recognition and revision of students' misconceptions involves active, rather than passive, involvement with material. A common approach to instruction involves meta-cognition that is to encourage students to think about their thinking about a particular problem. In part this approach requires students to verbalize, defend and reformulate their understanding (Baker, 2004). Conceptual assignment can deliberately be used to obtain desired results.In this study an investigation was made on the effects of conceptual assignments and conceptual change discussions on senior secondary school students' misconceptions, retention and academic achievement in genetics

2.5.1 Conceptual Change Model

There are varieties of models for learning which are all based upon children's conception at various ages. Scott, Asoko and Driver (1991) affirmed that some of the models derived their strategies from epistemological literature such as (Posner et al 1982), others from cognitive psychology example (Osborne & Wittrock 1983). However, they all have strong implications for classroom practices and approaches to teaching, which recognizes children's alternative conceptions. They have been developed and tested. The model of conceptual change as presented in Posner, Strike, Hewson and Gertzog (1982) and Hewson (1980) as shown in figure II described the process of "accommodation" (or "conceptual exchange''), distinguishing this process from "assimilation" (or "conceptual capture"). The difference between these two types of conceptual change centers on the degree to which old and new conceptions are reconcilable and, therefore, the degree to which a new conception can be integrated into an existing conceptual context. The four conditions for accommodation are as follows:

1. There must be dissatisfaction with existing conceptions. Scientists and students are unlikely to make major conceptual changes until they believe that less radical changes will not work. The first is the condition (dissatisfaction, intelligible, plausible, and fruitfulness [DIPF]) to be met (or not met) for a

learner to experience conceptual change. Dissatisfaction is a state of dislike for an old concept, which will pave the way for the learner to assimilate the new one. Posner and colleagues (1982) considered the phase of conflict generated by dissatisfaction with the existing concepts as a first step to achieving conceptual change. In this phase of dissatisfaction, students realize that they need to reorganize, restructure, or change to some extent their existing ideas or concepts. It seems that to change something, an individual needto recognize the need for a change and to be willing to do it (Limon, 2001).

2. A new conception must be minimally understood. That is intelligible (clear enough). The individual must be able to grasp how experience can be structured by a new conception sufficiently to explore the possibilities inherent in it. In intelligibility, the learner knows what the concept means and understands the terms symbols and syntax of the mode of expression. Here too, the learner constructs or even identifies a passage or theoretical propositions. For example, students with the naive conception that heat and temperature are the same will, at this point, understand that they are not really the same and, in addition, know why.

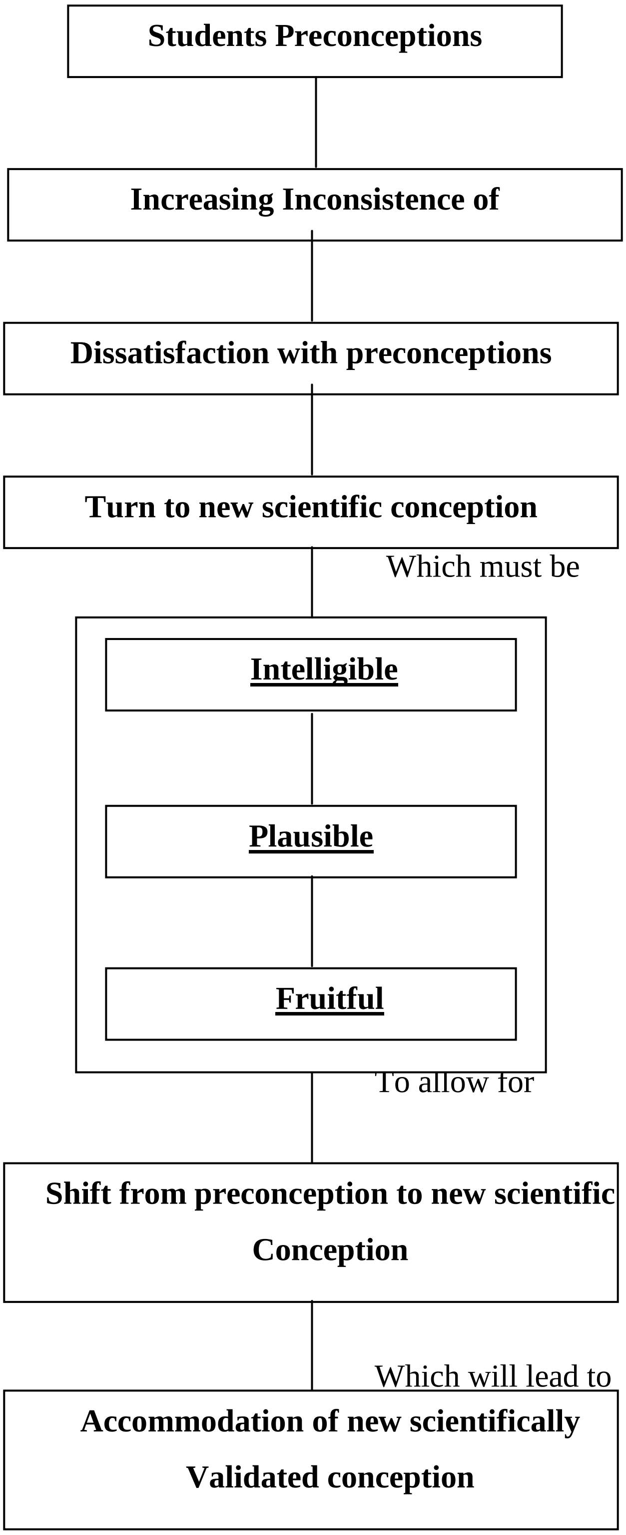
3. A new conception must appear initially plausible (reasonably true). Any new conception adopted must at least appear to have the capacity to solve the problems generated by its predecessors, and to fit with other knowledge, and experience. Otherwise it will not appear a plausible choice. Plausibility is the state of believing in something on the grounds that it is true. At this stage, according to Hewson and Hennessy (1992), the learner believes that the concept is true and consistent with other conceptions accepted by the learner.

4. A new conception should appear fruitful (potentially productive). It should have the potential to be extended, to open up new areas of inquiry and to have technological and/or explanatory power (Posner, Strike, Hewson & Gertzog, 1982, and Hewson 1980). Fruitfulness occurs when a newly accepted conception/ idea can solve previously insoluble problems, or suggests new possible

directions or ideas. The new conception becomes fruitful and accommodation of it seems fruitful (Hewson & Hennessy, 1992; Posner et al., 1982). Posner and colleagues (1982) summarized the Conceptual Change Model by noting that learning proceeds smoothly when the learner meets the conditions for conceptual change. This implies that to learn a new concept the learner must understand it, accept it, and see it as useful. For example, when a learner encounters a new concept that conflicts with his or her conceptual beliefs, the learner may first feel dissatisfied, but then on checking the intelligibility of that concept, its plausibility and fruitfulness, the learner accepts it by replacing the old wrong concept. Without this, the learner rejects the new concept.

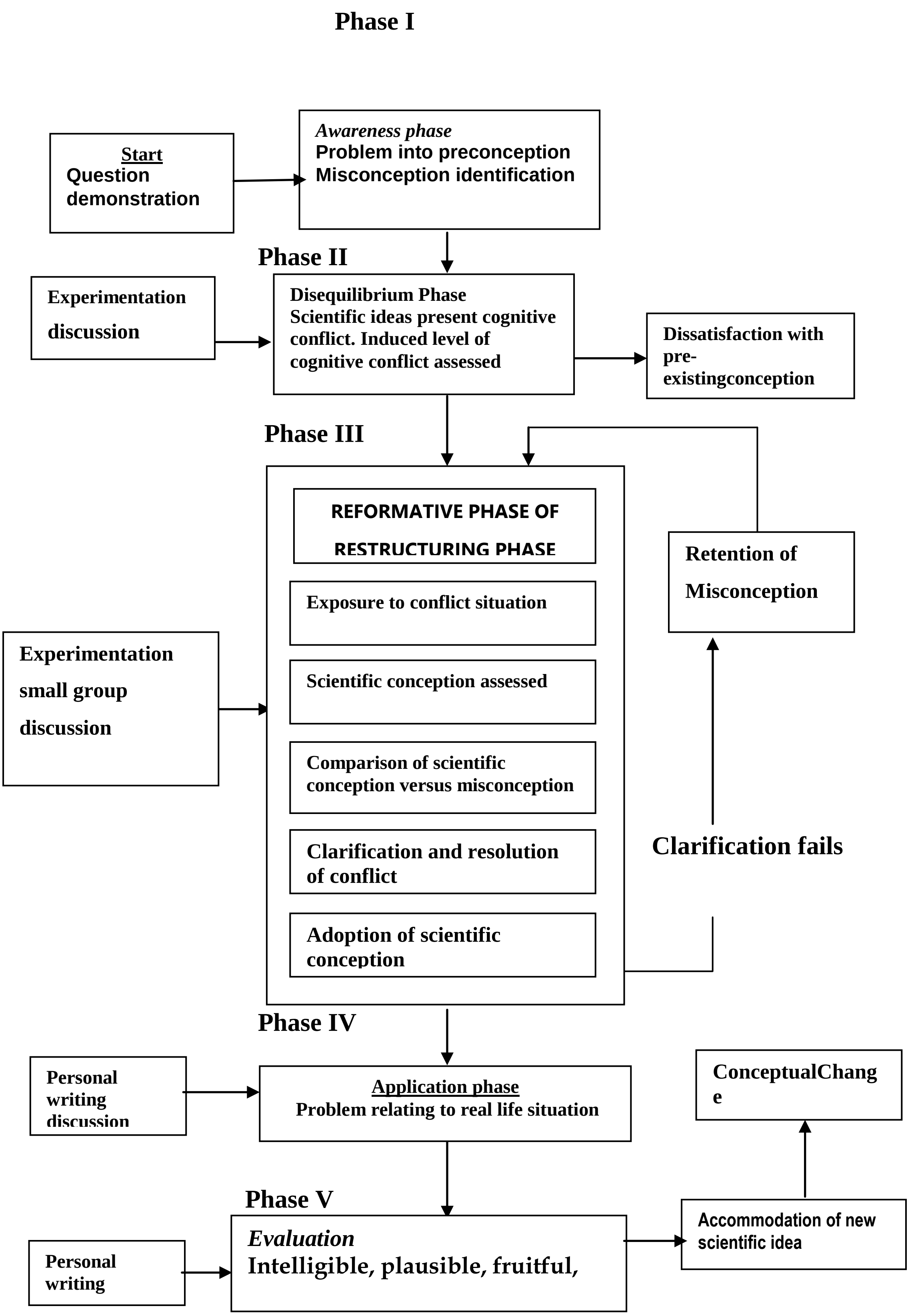
The second component of conceptual change is a person's conceptual ecology. Conceptual ecology may be seen as the learner's previous knowledge, or the alternative cognition of the learner. Conceptual ecology provides the context in which the conceptual change occurs. It influences the change and gives it meaning.If the new concept conflicts with an existing conception within the learner's conceptual ecology, it cannot be accepted until the status of the conflicting conception is lowered. Depending on the exposing event which the teacher presents, the learner may make only moderate changes to his or her conceptions and this is called "conceptual capture" (Hewson, 1981), or "weak restructuring" (Carey 1985). But if the prior knowledge need to be abandoned so as to accept a new conception this is a more radical change and is called "conceptual exchange" (Hewson,1981) or "radical restructuring" (Carey 1985).Posner *et al* also added that for the new conception to be assimilated or accommodated, it must be intelligible (clear enough), plausible (reasonably true) and fruitful (potentially productive). He and his associates further added that these cognitive conditions must be met during the learning process as the teacher leads the learners towards creating cognitive conflicts to make the learner dissatisfied with his/her existing conception. This is necessary because a misconception that disorganizes and constraints learning is highly resistant to change due to the web-like links it has formed with the artefacts within the learner's conceptual ecology. Therefore, the process of changing one concept requires a corresponding change in the other related concepts in ways that resemble a kind of paradigm shift (Hewson, 1992).

Conceptual ecology consists of many different forms of knowledge, the most important of which may be epistemological commitments (e.g., to consistency or generalizability), metaphysical beliefs about the world (e.g., the nature of time), and analogies and metaphors that might serve to structure new information (Hewson, 1992). However, to understand the conceptual change components requires an instructional model that can stimulate and enhance students' conceptual change. This is because some instructional models have been found to be defective in changing students' concepts in science. Examples of such models are traditional teaching methods (for example., the lecture method).In this study an investigation was made on the effects of conceptual assignments and conceptual change discussions on senior secondary school students' misconceptions, retention and academic achievement in genetics.



Source: Posner et al (1982)

Figure 2.1: A Flowchart of the Posner et. al (1982) General Conceptual Change Instructional Model



Source: Adapted from Posner et al in Lawal (2009)

Figure 2.2: A Flowchart of GeneralConceptual Change InstructionalStrategy Used for the Study

Scot, et al (1991) came up with three pedagogical steps to be followed in using the conceptual change strategy in teaching.

They are :-

a. A learning environment, which will be supportive of conceptual change learning, such environment should provide opportunity for discussions and consideration of alternative viewpoint and argument.
b. selection of teaching strategies i.e. the overall plan which guides the sequencing of teaching and
c. Learning tasks that fits into the framework provided by the selected strategy and it must address the demand of the particular science domain under consideration.

To make a decision about an appropriate teaching strategy, Scott, et al (1991) declared that four factors are needed to be considered. These include;

- Students' prior conceptions and attitudes.
- The nature of the intended learning outcomes.
- An analysis of the intellectual demands involved for learner todevelop or change their conceptions and
- The possible teaching strategy which would be most appropriate in helping learners from their existing viewpoint towards scientific view.

Scott, et al (1991) reviewed researches based on their work on the above four factors and they came up with two categories, they are: -

1. Cognitive conflict and the resolution of conflicting perspectives.
2. Strategies that build on learners' existing ideas and extends them through for example metaphor or analogy to a new domain.

The research-based, six-phase Conceptual Change Model (CCM) was synthesized by Stepans (1985) and used successfully by thousands of teachers and students over the past two decades.The CCM instructional format helps students to learn by actively identifying and challenging their existing conceptions and skills. CCM lessons place the students in an environment that encourages them to confront their preconceptions and then work toward resolution and conceptual change. As they learn, their meta-cognition also develops.The diagram below presents a basic overview of the Conceptual Change Model. The six phases of the CCM lead learners from explicit discovery of their own existing knowledge and the views of their classmates, through a set of targeted challenges and opportunities, to a new level of understanding that is reinforced through application and extension of ideas and skills. Ultimately, students are invited to come up with their own ideas and questions to test.CCM lessons engage students in active learning, from the first step. In some cases, the challenge presented at the outset of a lesson is one for which students make reasoned predictions and estimates, or describe strategies they would use to approach the problem. They also are asked to support their views with a written statement, drawing, or physical model.

The task of confronting their views may be one that permits students to acher. Collaborative learning is an essential component of the process. Students are encouraged to come up with and explore multiple ways of organizing and carrying out an investigation learning to think and take leadership and ownership of an activity rather than just following strict instructions that maypresent only one way of doing something.

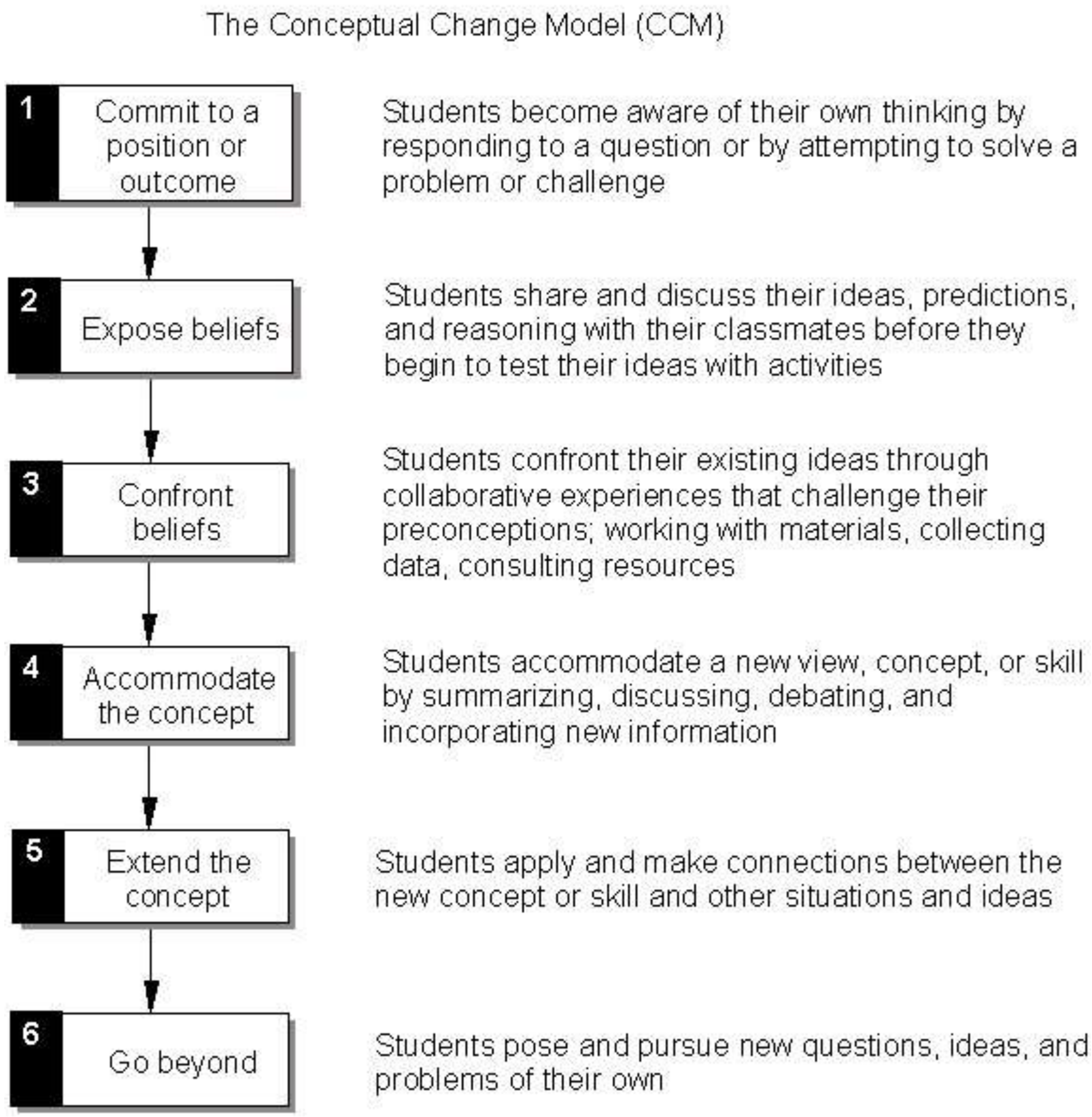


Figure 2.3: Six-Phase Conceptual Change Model (CCM) Synthesized by Stepans (1985)

Cosgrove and Osborne (1985) proposed a Generative Learning Model of Teaching (GLMT), which had a strategy organized into four phases.

i. **Preliminary phase:** Here, the teacher first understands the scientific view, the learners' view and his/ her own view as a teacher.

ii. **Focus phase:** Opportunity for pupils to explore the context of the concepts i.e. learner to engage in clarification of own view.

iii. **Challenge phase:** Learners debate the pros and cons of their current views with each other and the teacher introduces science view (where necessary).

iv. **Application phase:** Opportunities for application of new idea across a range of contents.

Cosgrove and Osborne (1985), pointed out that an alternative science view may not be received with enthusiasm until it can be rendered intelligible and plausible by experimentation, demonstration or reference to analogy. They however stressed the importance of the preliminary phase in preparing for teaching. The model was used in teaching about current flow in electric circuits to a group of 11-14 age range. The authors reported its success in helping the learner move from a view of electricity as "being used up" to adopting a view of current being conserved around the elect a rich circuit.

The other strategy is that of Champagne, Gunstone and Klopfer (1985). They proposed a dialogue –based strategy, they called it Ideational Confrontation which is specifically designed to alter students' declarative knowledge with a specific domain e.g. motion of objects. It is made up of the following steps: -

- Students make explicit the notions they used to explain or make predictions about a common physical situation.
- Students develop an analysis that supports his/her predictions and presents it to the class.
- Students attempt to convince each other of the validity of their ideas, discussing and arguing results and each student becoming explicitly aware of his /her ideas.
- The instructor demonstrates the physical situation presenting theoretical explanation using science concepts.
- Further discussions allow students to compare their analysis with the scientific one.

The authors suggested that discussions which consider the views of others and relating a situation under consideration to other real-world phenomena are significant in promoting change of views, also that students must be motivated and quality of arguments be improved over the course of instruction.

Rowell and Dawson (1985) proposed a strategy in which resolutions between students' prior ideas and new conceptions occur after new conceptions have been introduced. Their approach also draws on the theory of equilibration of Piaget (1977) and based upon the following premises; -

a. a theory is only replaced by a better theory and not discarded on the basis of the contradictory evidence alone.
b. the construction of a better theory need not involve an immediate confrontation with the knowledge that an individual spontaneously considers relevant.
c. although cognitive change involves both strategies and metastrategicknowledge, Kuhn (1983), they need not to construct together.

The approach they describe is made up of six steps and they are as follows: -

1. the ideas which the students consider relevant to the problem situation are established.
2. `discussions are retained in a "paper memory" for subsequent consideration.
3. students are told that a theory is going to be taught to them which may solve the problem and that their help will be required both in its construction and later, its evaluation against the alternatives they have proposed.
4. the new theory is then presented by linking it to basic knowledge already available to the class.
5. students are asked to apply the new theory to problem solution, in order to indicate its construction by individuals. Written work must form a part of this procedure to provide a second paper memory for each student.
6. each student then compares the paper memories from steps 1-5 and quality of the ideas is examined. The initial examination is then directed to the stimulus problems used in the tests, to which the paper memories related. Subsequently examination is broadened to cover as many relevant situations as possible, that is, the student is involved in gaining meta-strategic knowledge (Lawal, 2009).

Clement, et.al (1987) developed and tested teaching strategy whose aim is to "increase the rangeof application of the useful intuitions and decrease the range of application of the detrimental intuitions".

Here, the strategy assumed that conceptual change can be encouraged by providing opportunities for students to build up qualitative-intuitive understandings of phenomena before mastering qualitative principles.Such understandingsare developed by forming analogy relations between a misunderstood target case and an “anchoring example” which draws upon intuitive knowledge held by the students. They used the bridging strategy which consisted of four steps: -

1. The students’ misconception that is relating to the topic under consideration is made explicit by using a target question.
2. The instructor suggests a case which he/she views as analogous and which will appeal to the students’ intuition.
3. The instructor asks the students to make an explicit comparison between the anchor and the target cases in an attempt to establish the analogy relation.
4. If the student does not accept the analogy, the instructor then attempts to find a bridging analogy or a series of bridging analogies conceptually intermediate between the target and anchor.

The use of strategy in overcoming misconceptions about static forces, frictional forces and Newton’s third law for moving objectshave been reported to produce significantly greater test gains than for control groups (Lawal, 2009). Neidderer (1987) based his strategy on the new philosophy of science which aims not to replace students’ theories related to everyday life thinking by the scientific theory but to allow them to arrive at a conscious knowledge of both and to learn scientific concepts by learning the differences between everyday life thinking and scientific thinking. The strategy is reported as consisting of six steps:

1. **preparation:** The teaching process which precedes the intervention and which may contain tools and concepts that may be drawn on.
2. **initiation:**An open-ended problem is posed.
3. **performance:** i.e. formulating questions or hypotheses, planning and performing experiments making observations, theoretical discussions, formulation of findings.
4. **discussion of findings:** in a class forum.

5. **comparison with science:** class findings are compared with similar historical theories or modern ideas. Differences are stated and possible reasons for those differences are discussed.
6. **reflection:** students are encouraged to look back on the process of performance and to consider particular questions or difficulties, which has arisen (Lawal, 2009). Niedderer used this strategy to teach the unit of "force" in which the students learnt all about distance, time, velocity, acceleration etc and questions were asked. He found out that after practically working through the steps, students generally arrived at solutions to their particular problems (Lawal, 2009).

Lilly and Sirochman as reported in Eniayeju, et.al (2004) modified the Generative Model and came up with a model called Powerful Ideas of Physical Sciences (PIPS). This model has the following steps:

1. Eliciting and elaborating the students' ideas.
2. Testing and comparing the ideas with nature.
3. Resolving the discrepancies between ideas.
4. Review and application of ideas (Lawal, 2009).

A thorough study of all the different conceptual strategies used by different science education researchers reveal one common principle that is the impotance of acknowledging the learners existing ideas and understandings in any teaching /learning exercise. In addition, all the strategies involved phases where the learner has the opportunity to make clear their own views. The differences between the learners' ideas and scientific viewpoints are both identified. The strategies also worked on the ideas of the learner in subsequent teaching to bring about a change in the learner's conception.

The study therefore used an adapted model of Posner et.al (1982) to examine the effect of conceptual assignments and conceptual change discussions instructional strategies on misconceptions, retention and academic performance on genetics among senior secondary school students. ThePosner et.al. model is preferred to other conceptual models discussed in this study because the major theme in their model is that learning is a rational activity.The model is logical and comprehensive. Above all, it puts into consideration the prior knowledge of the learner, which the constructivist believes is the best way to make sense of what is seen, heard and therefore learnt. The new concept studied is therefore studied in relation to the already known one. This is the fundamental issue in constructivist approach to learning. Also, they argued that for a student to abandon one framework for another, four conditions are necessary. These are:

1. The learner must be dissatisfied with existing conceptions. He must have lost confidence in the ability of the existing conception to solve new problems.
2. The new conception must be intelligible.
3. It must be plausible and;
4. It must be fruitful.

2.5.2. Cognitive Conflict as a Base for Conceptual Change

Cognitive conflict is a perceptual state in which one notices the discrepancy between one's cognitive structure and the environment (external information), or among the different components (for example., the conceptions, beliefs, substructures, among others.) of one's cognitive structure (Lee & Kwon, 2001). Cognitive conflict in classical theory is a "revolutionary" process believed to make learners either accept the scientific conception by dissatisfying them with their AC or retaining their conception if unable to satisfy the conditions for the scientific conception. Cognitive conflict occurs when a student's mental balance is disturbed by experiences (referred to as "anomalous data") that do not fit into their current understanding (Foster, 2011).The resolution stage is an external response behavior (Lee et al., 2003). Response behaviors include ignoring, rejection, uncertainty, exclusion, abeyance, reinterpretation, peripheral and theory change.The cognitive conflict strategy was derived from the Piagetian view of learning in which learner's active part in reorganizing their knowledge is central. It involves promoting situations where the students existing ideas about some phenomena are made explicit and challenged in order to create a state of cognitive conflict.

According to Baser, (2006) students' alternative conceptions that are grounded in everyday experiences are resistant to change (Harrison, Grayson, & Treagust, 1999; Driver, 1989; Hameed, Haekling, & Garnet, 1993; Osborne & Freyberg, 1985). High school students have difficulties with energy concepts, the particle model, and the distinction between heat and temperature (Kesidou & Duit, 1993). He further re-explained that some students completed thermodynamic courses with many of their alternative conceptions unchanged (Carlton, 2000; Thomaz et. al., 1995). It can be concluded that the instruction they receive unaffected their alternative conceptions. Moreover, scientists also have difficulties with heat and temperature concepts (Lewis & Linn, 1994). Although they may make more accurate predictions than students, they have difficulty in explaining everyday phenomena (Lewis & Linn, 2003; Tarsitani & Vicentini, 1996).

The cognitive conflict strategy involves (a) identifying students' current state of knowledge; (b) confronting students with contradictory information that is usually presented through texts and interviewers, thus making explicit the contradiction, or guide the debate with the student or among peers (small groups or the whole classroom); and (c) evaluating the degree of conceptual change between the students' prior ideas or beliefs and a posttest measure after the instructional intervention (Hewson & Hewson, 1984). To understand cognitive conflict, knowledge of the cognitive conflict process model is imperative. The reason is because itexplains the stages in which cognitive conflict occurs and how to resolve the generated conflict(s).

Lee and Kwon (2001) developed a three-stage cognitive conflict process model, which includes preliminary, conflict, and resolution. The preliminary stage represents a process in which a student who has belief in preexisting conception accepts an anomalous situation (for example., experimental results obtained by a teacher) as genuine. If the students do not have a strong confidence in a well-formulated conception or if they consider the anomalous situation as deceptive, they do not experience cognitive conflict. Thus, the preliminarystage is the stage before cognitive conflict (Lee et al., 2003). In this model, the cognitive conflict process occurs when a learner (a) recognizes an anomalous situation, (b) expresses interest or anxiety about resolving the cognitive conflict, and (c) engages in cognitive reappraisal of thesituation. For instance, when learners recognize that a situation is incongruous with their conceptions, they become interested in or anxious about this situation (Lee et al., 2003). Relating this to heat and temperature, where a student, who originallybelieves that a sense of touch can be used to measure the temperature of a substance, now observes through an anomalous experiment that the sense of touch does not reliably measure temperature of a substance, the student becomes interested or anxious about the situation and now cognitively reappraises his or her previously held misconceptions and accepts the scientific conception of the use of thermometer to measure the temperature of a body.

Use of a conceptual change learning models is one way of closing the gap between children's science and scientists' science (for example., Posner et. al., 1982; Hewson, 1981). Most of the conceptual change models are grounded on Piaget's ideas and notions of constructivism (Gega, 1994; Hynd et al., 1994; Stofflett, 1994; Hewson & Hewson, 1983; Posner et al., 1982). These methods suggest creating dissatisfaction in student's mind with his alternative conception, called cognitive conflict, followed by strengthening the status of the preferred scientific conception. On the other hand, peer/social interaction and group discussion are important factors leading conceptual change as social constructivism insists (for example., Uzuntiryaki, 2003; Brophy, 1986; Vygotsky, 1978). According to constructivist learning approaches knowledge is socially constructed (Duit, 2002) and intrinsic motivation that can be generated via group discussion, play an important role on knowledge construction (Pintrich, Marx, & Boyle, 1993). The learning method used in this study considered the importance of both cognitive conflict and peer interaction.

Since 1990's, cognitive conflict based instructions have been extensively used in science education. Several studies concluded that cognitive conflict has an important/positive effect on conceptual change (for example.,Stavy & Berkovitz, 1980;Hashweh, 1986;Thorley & Treagust, 1989;Niaz, 1995;Kwon, 1997; Druyan, 1997;Stern, 2002;Kim, Choi, & Kwon, 2002; Lee et al., 2003;). Lee et al. (2003) & Kwon (1997) are insisting the need for cognitive conflict in order for conceptual change takes place. Kwon & Lee (1999) demonstrated that students who had higher level of conflict showed very high rate of conceptual change from unscientific to scientific conceptions, while the low-level conflict group showed very little improvement. Ting and Chong (2003) concluded that cognitive conflict fosters conceptual change. Zohar and Aharon-Kravetsky (2005) found that students with high academic achievements benefited from the cognitive conflict teaching method. On the contrary, there are some researchers who dispute the effectiveness of cognitive conflict on conceptual change (Limon, 2001; Hewson, Beeth, & Thorley, 1998).Some researchers (Dekkers & Thijs, 1998; Elizabeth & Galloway, 1996; Dreyfus, Jungwirth & Eliovitch, 1990) argued that instruction based on cognitive conflict do not necessarily promote conceptual change. Students often refuse to accept ideas in direct conflict with their alternative concepts (Bergquist & Heikkinen, 1990).

Attempt to resolve the conflict leads to the first step to subsequent learning.The use of discrepant event was the first, which was used by Nussbaum and Novick (1982). Here the sequence which draws on Piagetian notion of accommodation was used and it involved the following;

1. Initial exposure of students' preconceptions through their response to an exposing event.
2. Sharpening students' awareness of their own, and otherstudents' framework.
3. Creating conceptual conflict by attempting to explain a discrepant event.
4. Encouraging and guiding cognitive accommodation and the invention of new conceptual model consistent with the accepted science view. -

The above sequence which was used by Nussbaum and Novick (1982) was successfully used as it created cognitive challenges and motivation for learning. However, they acknowledged that the instruction did not lead to the desired total conceptual change in all students. They added that the major conceptual change does not occur through resolution but rather by nature which is an evolutionary process.The second method is the use of conflict between ideas. Stavy and Berkovitz (1980) identified two of training by conflict.

i. A conflict is produced between a child's cognitive structure related to a certain physical reality and the actual physical reality.
ii. A conflict is produced between two different cognitive structures related to the same reality.

The strategy used a combination of worksheets and practical work designed to make the learner become aware of the conflict existing within their thinking. The researchers worked with a group of 10yearold children. They worked individually and in groups. They found that training by conflict did improve children's understanding of the concept of temperature both in individual and in classroom training situation.In this study, the effects of conceptual assignments and conceptual change discussions on senior secondary students' misconceptions, retention, and academic performance in genetics was investigated.

2.6 Teaching for Conceptual Change

Conceptual change is the shift or restructuring of existing knowledge and beliefs. Learning for conceptual change is not merely accumulating new fact or learning a new skill. Conceptual change is the learning that fundamentally changes or even replaces, an existing conception and becomes the conceptual frame work that student uses to solve problems, explain phenomena, and function in their world (Orey, 2010). Many teaching studies in recent years have attempted to take into account research on students' conceptions of natural phenomena and a number of different features have emerged from these studies as characteristic components of what can be called conceptual change teaching (Hewson, 1991). He further explained that there are different stages in conceptual change teaching which include:

Diagnosis or elicitation. Does the teacher use any diagnostic technique to elicit students' existing conceptions and reasons why they are held?

Status change: Does the teacher use strategies designed to help students lower the status of existing problematic knowledge, and raise the status of other, competing ideas? Are there other application sites where the new conceptions can be used?

Evidence of outcome: Is there evidence that students' learning outcomes are based, in part, on an explicit consideration of their prior knowledge?

Hewson, (1991) further explained the particular features that are present during different stages of conceptual change teaching. These include:

Meta-cognition: are students encouraged or able to "step back" from one or more ideas held by themselves or others in order to think about them and express an opinion about them?

Classroom climate: is there an attitude of respect by both teacher and students for the ideas of others, even when they are contradictory?

Role of teacher: is the teacher able to provide opportunities for students to express themselves without fear of ridicule, and to ensure that he or she is not the arbiter of what counts as an acceptable idea in the classroom?

Role of learner: are students willing to take responsibility for their own learning, to acknowledge others' ideas, and to change their views when another seems more viable to them? Can students monitor their own learning?

This model has direct implications regarding how to construct instruction to achieve conceptual change. Instruction should be designed to present anomalies so as to create cognitive conflict. This will create a disequilibrium (in the Piagetian sense), which leads to dissatisfaction with the existing concept, and ultimately to a willingness to accommodate a new concept. According to Posner et al. (1982), this requires the teacher to adopt the additional role of an "adversary in the sense of a Socratic tutor. In this role, the teacher confronts the students with the problem arising from their attempt to assimilate new conceptions." This method of instruction can certainly be used to correct some simple misconceptions.

The conceptual change model can be used qualitatively to identify reasons for conceptual change to explain why some common misconceptions are persistent and difficult to change. For example, the Bohr model of the atom is commonly taught to science students in junior high schools in Australia and overseas. It leads to the widely-held misconception that atoms have electrons circling them like planets around a star" (Horton, 2001) – a misconception that is reinforced by diagrams found in many textbooks, such as the illustration of a sodium atom, and the "diagram of the Bohr orbits and the corresponding energies for an electron in the hydrogen atom, in which each arc represents a portion of an orbit" from Cotton, Wilkinson & Gaus (1987).

According to Smith, (1983) students are not the only potential targets of conceptual change strategies. He suggested that teachers also must change their conceptions if students are to change theirs. He further explained that two sorts of teacher conceptions are relevant. First, the teachers' own scientific theories must be in accord with those they are teaching, if they are expected to mediate student learning. Since many teachers particularly at the lower educational level lack the extensive science background necessary for accommodation, they are likely to hold many of the same naive conceptions their students do. Second, Smith and Anderson, (1983) pointed teachers' conception of teaching require fundamental change if they are to produce accommodation in their students. They further explained that to bring about conceptual change in students, teachers need to change their conceptions to a conceptual change view of teaching and such a view requires the teacher to bring out the students' preconceptions, provide a base of relevant experience and observations, challenge the students' misconceptions with appropriate questions and evidence, clearly present the scientific alternative conception, and help the student to realize the greater power and usefulness of the new conception (Smith& Anderson, 1983).

Teachers should help their students build understanding of complex scientific concepts by disassembling this concept into component part according to the level of intellectual development of their students. This process, however, is only half of what needs to be done to facilitate students' correct understanding. Students come to school with their own explanation of natural phenomena. The teacher must ascertain students' prior and naïve or inaccurate conceptual understanding must be addressed at the same time as new concepts are being taught in the science classroom.Steadfastly, students hold on to theirown ideas about the way the world works, may be little influence by instruction with a contrary perspective. Research has show that all learners hold on to their ideas tenaciously even in the face overwhelming evidence. Even after what appears to be a well taught lesson, students in variably hold to the explanation they had already constructed before teaching began. Even after intensive re-teaching of the accurate, scientific concepts, the student will still persist in their own uninformed explanations. Teaching for conceptual change takes time as students need to identify and articulate their ideas, to investigate the soundness and usefulness of their own ideas, and those of others, inducing scientists, and reflect on and reconcile differences in those ideas. (Champagne, Klopfer & Gunstone, 1982).

Even if the teacher recognizes the many advantages of incorporating new material into a student own context, most teachers do not take time to assess what their student have learned from prior experiences. If teachers do not assess and challenge a student's theory, then the scientific theory or explanation will co-exist with the one already held by the students. This creates a confusing mass of facts and fictions. Students on their own almost never logically argue or recognize the internal contradiction between their naïve or ideas and those of expert, it is the teachers task to ensure that students do not leave classrooms with their alternative explanations intact or with new ideas and explanations that they do not understand. Students will more readily discard misconceptions that they have defended than those that have not been examined at all. Students should be encouraged to look for inconsistencies between ideas they have and what their observations and exploration reveal to them. Some students will find this frustrating and will continue reasoning that justifies their old beliefs; for others, this experience will change their thinking.

How do teachers go about ascertaining their students' misconceptions? Communication both oral and written is essential. The teacher should provide a base of relevant experience and observations, challenge the students' misconceptions with appropriate questions and evidence, clearly present the scientific alternative conception, and help the student to realize the greater power and usefulness of the new conception (Smith & Anderson, 1983). These can be done by the teacher using questions to elicit students' prior knowledge in the lesson's engagement before explorations takes place. The teachers should also listen to students' explanations of their conjectures when they are working collaboratively with their peers and the teacher should ask such questions as how will you explain what you have observed? When students are explaining the results of their investigations, students should be interviewed in formal and informal ways.

According to Smith (1991) four conditions must be present to bring about conceptual change:

a. The student must be dissatisfied with the current understanding
b. The student must have an available intelligible alternative.
c. The alternative must seem plausible to the student.

d. The alternative must seem fruitful (useable) to the student (Eryilmaz, 2002).

Smith (1991) opined that to teach for conceptual change, teachers should use teaching methods that emphasize constructivist philosophies. That is deemphasizing cook book-like activities in favour of open-ended investigations that engage students in discussions of scientific ideas in cooperative group work. Teachers should provide opportunities for students to confront their own beliefs with ways to resolve any conflicts between their ideas and what they are now experiencing in a laboratory activity and /or discussion, thereby helping them accommodate this new concept with what they already know. Make connections between the concepts learned in the classroom with everyday life. Help students make concept maps as both a teaching /learning strategy and also an assessment tools.In this study, the effects of conceptual assignments and conceptual change discussions on senior secondary students' misconceptions, retention, and academic performance in genetics was investigated.

2.6.1 Conceptual Assignments

Conceptual change is the learning that changes an existing conception that are beliefs, ideas or way of thinking. This shift or restructuring of existing knowledge and beliefs is known as conceptual change. The process of replacing a misconception with a scientifically acceptable concept is called conceptual change. Assignment is that part of the lesson that tells students what to do after school hours and is related to what they have already done or what they still have to do in class. It is a set of tasks or a specific task which students are expected to complete in a given time. It may be a project, a series of problems to be solved, some questions to be answered, a chapter to be read and summarized, a story to be outlined, or a review of past lessons (Atadoga & Onaolapo, 2008). Assignments could be given to individual students or to groups depending on the type and the time available to students to complete the tasks. Simple and smaller units of work may be given to individual and larger units to groups. Individual assignments may be the ideal, but not only are they time consuming, but they also require a genius of a teacher to be able to cater for individual needs, interests, abilities and experiential background when giving assignments (Atadoga & Onaolapo, 2008).Conceptual assignment can be defined as the system of learning in which the teacher uses his skilful organization to give responsibility to the learner for his learning in order to replace a misconception with a scientifically acceptable concept. Conceptual change assignment can also be described as a set of task or specific task which students are expected to complete in a given time to cause a shift or restructuring of existing knowledge and beliefs.

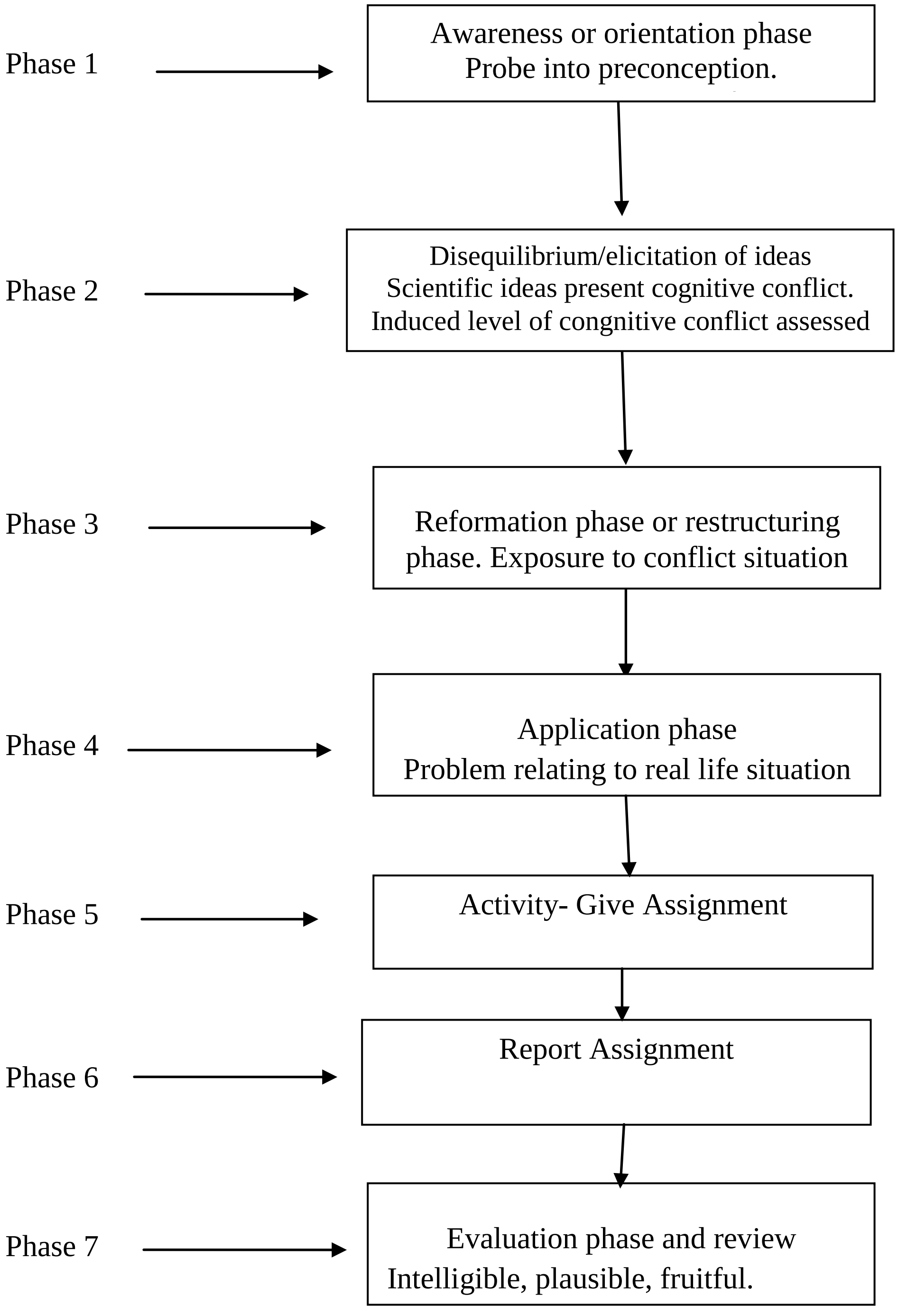
Group assignments may be for smaller groups or for the entire class. The assignments given to small groups are tailor-made to suit the needs, capabilities and interests of each member of the group. The class assignment involves giving the same piece of work to everyone in the whole class. Assignments may be given daily either as a follow up activity after the development of a lesson, or as a preparatory exercise to help build the aperceptive basis for new lessons. They can also be given on a long-term basis; larger units of work can be assigned for completing over a longer period. Educational research has shown the superiority of giving fewer assignments covering larger units of study over numerous small isolated ones. This implies that the desirability of providing moresmall group assignments where each member can perform an individual task while recognizing that his work is very closely tied with the other members'. The learner is fully aware of the ultimate goal to which his particular contribution is directed (Atadoga &Onaolapo, 2008).When carefully planned and properly given, the assignment can perform the following functions.

i. To serve as a follow-up activity to what has already been learned in the classroom
ii. To prepare students for the next day's lesson
iii. To provide direction and guidance for independent study.
iv. To develop a positive attitude towards extra work and good study habits.
v. To provide an excellent means for developing the other higher order mental processes
vi. It encourages initiative and independence and provides the learner with the maximum amount of individual practice.
vii. By giving the learner an occupying task, the teacher is free to give individual attention to those learners who most need his help.

According to Nacino–Brown, Oke and Brown, (1982) the following are some useful pointers that should help the teacher to improve the technique.

1. Assignments should be clear and definite.
2. Assignments should be closely related to the lessons under study.
3. Assignments should be adopted to students' capabilities.
4. Whenever possible assignments should be differentiated to suit individual differences in the class.
5. Assignments should be interesting and stimulating to raise cognitive conflicts that will re-direct students' thinking and possibly provoke new thinking that will cause a shift in the cognitive framework of the students.
6. Enough time should be allotted for the giving of assignments.
7. The time available to students to complete assigned tasks should be considered.
8. Assignments should be evaluated promptly.
9. Assignments should always produce a result that can be seen so that the learner can see what he has achieved and the teacher can assess the learner's progress (Nacino-Brown, Oke& Brown, 1982).

Conceptual Assignments is an instructional strategy that substantially provides students opportunity for active participation in thelearning process rather then empty cup to be filled. It has the capacity ofenabling the students to construct meaning through interaction. It has four phases which give the students chance and potential to modifymisconceptions thus enabling students explain elaborately or defend theirpositions. Eryilmaz, (2002) noted the importance of homework problems in creating the cognitive conflicts necessary for preparation of the conceptual change. According to Eryilmaz, (2002) some researchers suggested using conceptual assignment to establish the first four steps of the conceptual change strategy. These are Step 1: Awareness or orientation phase, Step 2: Disequilibrium/ Elicitation of ideas, Step 3: Reformation phase and Step 4: Application phase. The teacher gives conceptual and thought provoking questions and activities to the students. The instructional package containing the instructions that learners suppose to use should be provided in order to prevent any bias that might arise from socio-economic background of the subjects. Instructional aids should also be provided to carry out all the activities related to each topic. The students should be properly instructed on how to answer the various questions and carry out the activities individually and submit the assignments to the teacher for marking.



Source: Adapted from Posner et. al (1982) and Eryilmaz (2002)

Figure 3.2: A Flow Chart of Conceptual Assignments Instructional Strategy used forthe Study

2.6.2 Conceptual Discussions

Conceptual change can be defined as learning that fundamentally changes or even replaces an existing conception and becomes the conceptual framework that students use to solve problems, explain phenomena, and function in their world (Orey, 2010).Atadoga and Onaolapo (2008) defined discussion as a dialogue between two people or two groups. In teaching and learning of science, discussion is a purposeful, constructive dialogue between the teachers and the learners of science. It is one of the teaching techniques employed in teaching and learning materials with the aim of achieving learning objectives (Atadoga & Onaolapo, 2008). According to Abdullahi in Atadoga and Onaolapo, (2008), discussions is taking over subjects from various points of view and that teacher's; central role is that of a moderator. Challen and Brazdil (1999) define discussion method as a teaching strategy in which the teacher brings students face to face as they engage in verbal interchange of ideas. The teacher in his interactions with his learners performs a variety of roles. He is firstly a teacher whose business is to transmit knowledge, and in doing this he specifies the objectives of his lesson and examines the needs and background of the students for relevance of the topic and its suitability. Importantly too, in applying the discussion strategy to the teaching-learning process, the teacher plays the role of a manager, guide, initiator, referee and a summarizer.

The discussion teaching method is a design that provides opportunity for discussion between teacher and students, and students to students. It is a strategy that centers on shared conversations, discussions, and exchange of ideas in class. It gives opportunity for all to sit and listen, as well as talk and think, thus emphasizing the process of "coming to know" as valuable as "knowing the right answer". In other words, students in a discussion class are not passive listeners neither is the teacher a sole performer. Students are allowed to develop critical thinking ability, learn to evaluate ideas, concepts and principles, procedures and even programmes and policies on the basis of clearly set criteria. For instance, a student who participates in a discussion lesson learns to support his views rationally, based on facts, too. He appreciates the need to argue logically, define clearly--concepts and terms, and examine critically rules, principles and constructs. Such a student learns to develop value processing skills in relation to changes that occur in his society.Essentially too, the discussion strategy encourages cooperative team work between teacher and students and amongst students. It emphasizes the need for all to work cooperatively while developing societal relationships. Students see themselves as contributory members of the group, instead of separate and odd. According to Bennett (1995), such cooperative learning improves both academic achievement and students' interpersonal relationship. He goes on to argue that in most cases all students (including high, average and low achievers) tend to benefit from cooperative learning and team work. In the same vein, Johnson, Johnson and Holube (1988) have affirmed that such cooperative spirit in learning help students work together to complete a task successfully. This is also important in promoting students' independence.

Generally, in the interactive nature of the discussion teaching method, that cooperative spirit of learning inherent is quite crucial. It emphasizes (students) individual and group accountability, with the teacher giving the feedback. Also, through such shared learning students develop shared responsibilities for leadership functions. Significantly too, interaction in the discussion strategy encourages rational arguments and logical reasoning. In doing this, the teacher helps to develop in his learners' skills in conflict management and listening. Johnson and Johnson (1987) have also suggested that such interactions in the classroom that promote cooperative learning are successful strategy for reducing stereotyping and social rejection across disability, race and gender lines. In other words, all see themselves as members of a group as they participate in discussions, listen to each other, resolve differences, make suggestions and critically examine issues for the benefit of all. As students formulate their own views in the act of give and take, they also learn to resist the influences of their personal prejudices, commitments, stereotypes; likes and dislikes, at the same time continue to focus attention on the theme of problems at hand. Besides its emphasis on a high level of interaction for possible cooperative learning, the discussion method is quite important in bringing about meaningful increase in students' achievement.

Discussions when carefully handled provide healthy open-ended classroom interaction between the teachers and the learners. By the adoption of science process skills in the teaching science, discussion groups as learning materials are identified as obvious as learners attempt to provide answers or solutions to the identified problems. As learners work in various groups to find solutions to problems, the teacher goes round to assess the learners' level of understanding and participation (Atadoga& Onaolapo, 2008). Discussion in its real sense implies that the discussants have background knowledge that provides them with few points. Discussion in science class provides the learners freedom of expression. Discussion encourages learners' active participation in learning activities and builds confidence in the learners as they express their views. It enhances communication skills in the learners and healthy competitions among learners. It enhances special interpersonal relationships as learners sometimes work in groups. When properly used as entry behaviour, it serves as motivator among the children. It also makes the teacher's work in the classroom easier as they serve as; moderators. It broadens the students' knowledge through the vigorous preparation the students will be involved in and during the discussion (Atadoga & Onaolapo, 2008).

Challen and Brazdil,(1999) opined that discussion method of teaching provides a format in which students can apply newly acquired knowledge, thereby consolidating and deepening their understanding of it. Additionally, students develop their skills in communicating scientific information, exercise and strengthen their problem-solving abilities, learn to appreciate the connections between apparently isolated chunks of material, and see the utility of what they have learned in realistic situations. Practitioners of the art point to numerous studies indicate that students are more motivated and internalize material more effectively when they participate actively as learners in the classroom (Blanchard, 2011).Brookfield and Preskill (1999) opined that discussion is a way of teaching which is an indispensable aspect of democratic education. They presented fifteen benefits of the discussion method as follows: (1) helping students to explore diverse perspectives (2) students' awareness of and tolerance for ambiguity or complexity is increased (3) students receive assistance to recognize and investigate their assumptions (4) attentive, respectful listening is encouraged (5) new appreciation for continuing differences is developed (6) intellectual agility of students is increased (7) students become connected to a topic (8) respect for voices and experiences of students is shown (9) students learn the processes and habits of democratic discourse

(10) students are affirmed as co-constructors (co-creators) of knowledge (11) capacity for clear communication of ideas and meaning is developed (12) habits of collaborative learning are developed (13) breadth of students is increased and it makes them empathic (14) skills of synthesis and integration are developed in students, and (15) discussion leads to transformation (Kukuru, 2006).

Shulman (2007) indirectly referred to discussion as an exposition that the image of teaching involves exchange of ideas (inter-action) between the teacher and learners through questions and probes, answers and re-actions, and praise and criticism. Pollard et al., (2008) included discussion as one of four types of class or individual dialogues. Discussion was perceived as exploratory talk where participants explore ideas and feelings together; it makes absolutely fundamental contribution to learning, and is relevant for learners of all ages. The specified features of discussion method are questioning, listening, and responding, in a unit form, were nevertheless wanting. Arends (2009) stated that patterns of discussion were in three forms, namely, the teacher asking a question about the lesson; next, is response where learners raise their hands and reply; and finally, teacher evaluates learners' responses with praise and corrects their responses. With respect to conducting discussion, this author identified five points for whole class discussion, namely, clarify aims and establish set, focus the discussion, hold the discussion, end the discussion, (and) debrief the discussion. The authors stressed frequency, equitable distribution, wait time, and prompting with respect to questioning. It may be remarked that questioning is the key element in the three features as it alerts for listening, and listening for responding. Wiles and Bondi (2011) asserted that teachers should not base their practice on imparting information alone but must help learners learn how to learn. This assertion in a perspective implies assisting learners to be independent. Developing thinking skill through discussion is a good means to achieving that independence. Equally embedded in these authors' assertion is the issue that imparting information had become a practice for teachers. This practice should be consciously discouraged because it only ensures shallow teaching and dwarfs thinking skill of learners. A question would send cognitive signal to learners to listening and thinking, and listening and thinking would elicitresponding; the same features should be perceivable even outside classroom (Kukuru, 2006).

Conceptual change discussion can be defined as the purposeful, constructive and objective dialogue between the teacher and the learners on a particular concept which can fundamentally change or even replace an existing conception and become the conceptual framework that the learners can use to solve problems, explain phenomena and function in their world(Orey, 2010; Blanchard, 2011). It can also be described has the dialogue between the teacher and the learners in a process of replacing, a misconception with a scientifically acceptable concept. Conceptual change approaches usually are explicit and claim that the learners have to construct knowledge for themselves. This view considers that learners need to be active and to have a certain intention to learn. Studies by Sinatra and Pintrich (2003) explicitly address this issue by suggesting that the learner should play an active intentional role in the process of knowledge restructuring. In this situation, conceptual change depends, then, not only on cognitive factors such as the recognition of conflict, but also on meta-cognitive, motivational and affective processes that can be brought under the learner's conscious control and may determine the likelihood of change". The notion of intentional conceptual change is in some ways analogous to that of mindfulness (Salomon & Globerson, 1987), a "construct which reflects a voluntary state of mind, and connects among motivation, cognition and learning." Conceptual change discussions can consciously be used to yield desired objectives.

Blanchard, (2011) opined thatdiscussion method is one in which the students and the instructor exchangetheir ideas in order to get a better understanding of a topic. It can be a wholeperiod or be a part of a lesson.Thediscussion method, when used properly, is a good way to stimulate thinking onthe part of the student. It can be used to advantage when the students have a background knowledge of the subject being discussed. The instructor should prompt everyone to take part, thus allowing the students the opportunity to learnfrom everyone in the group. The discussion method is interaction centered andis student centered, and can be held in either a large or smallgroup. Interaction techniques capitalize on the human desire to talk and shareone's thoughts. Personal activity permits greater involvement in the lesson. Some of the advantages and special uses of the discussion method include:

1. expands the cognitive and affective domains of students.
2. can be used to solve problems and develop interest in the topic.

3. emphasizes main teaching points.
4. utilizes student knowledge and ideas.
5. results in more permanent learning because of the high degree of studentinvolvement.
6. determine student understanding and progress.
7. everyone has a chance to get involved.
8. teaches how to come to an agreement within a group without arguing.
9. permits students are teacher to get acquainted.

Challen and Brazdil (1999) opined that the student to teacher and student to student dialogue that accompanies a good discussion provides valuable feedback to the teacher on the status of student comprehension and is particularly valuable in drawing out and exposing misconceptions, many of which would otherwise remain buried, only to surface in later courses, if at all (Blanchard, 2011).

Ogunniyi (in Atadoga&Onaolapo, 2008) out lined hints to improve discussions as follows:

i. The topic to be discussed must have set objectives;
ii. The topic must be of interest to the students;
iii. The topic must be well informed about the topic in question;
iv. The topic should be controversial;
v. The teacher should set up safe guards to prevent discussion from wandering away from the topic;
vi. The topic being discussed must not be too familiar. It should be sufficiently stimulating otherwise students will easily get bored;
vii. Ask thought provoking questions that will propel the discussion further towards the goal in other to make the students' alternative frameworks explicit prior to designing a teaching approach consisting of ideas that do not fit students' existing conceptions and thereby promoting dissatisfaction in which a new framework is then introduced based on formal science that may explain the anomaly (Posner et. al 1982).
viii. Avoid situation in which a student dominates a discussion. Let the students learn how to listen to contributions made by others;

ix. Encourage shy students to participate in the discussion. This can be done by asking such students stimulating questions;

x. Do not allow an argument to reach a point that result in an out- burst of emotions;

xi. Ensure that the physical arrangement of the room is suitable for discussions;

xii. Emphasize important point at the end of the discussion.

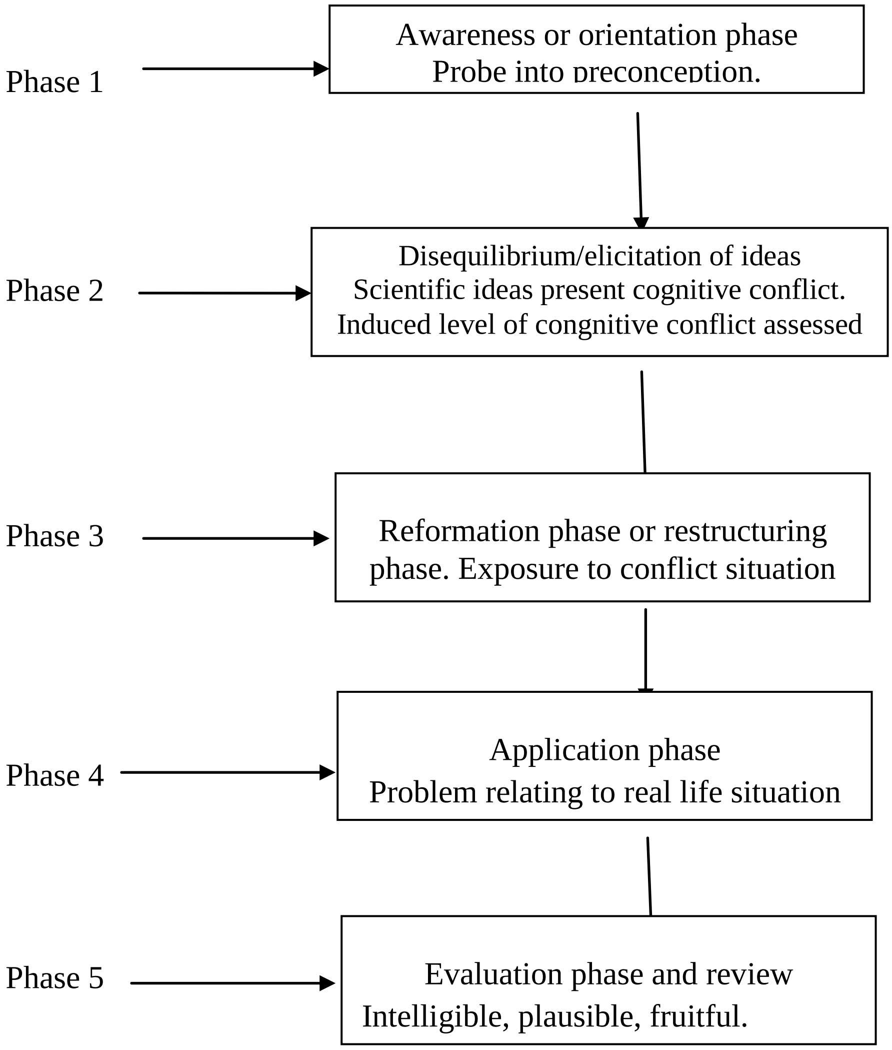
This elicits a more participatory teaching which can stimulate imaginative and conceptual thinking among students (Omatseye, 2011).

However, students' conceptual progress towards understanding and learning science concepts and principles after instruction frequently was still limited, with most studies showing that initial new ideas are only used in particular contexts (Duit& Treagust 1998). Usually the best that can be achieved is a peripheral conceptual change (Chinn & Brewer. 1993) in that parts of the initial idea merge with parts of the new idea to form some sort of hybrid concept (Jung, 1993) or synthetic model (Vosniadou & Brewer, 1992).In the classical conceptual change model that emphasized students' epistemologies (Posner, et al. 1982), student dissatisfaction with a prior conception was believed to initiate dramatic or revolutionary conceptual change and was embedded in radical constructivist epistemological views with an emphasis on the individual's conceptions and his/her conceptual development. If the learner was dissatisfied with his/her prior conception and an available replacement conception was intelligible, plausible and/or fruitful, accommodation of the new conception may follow. An intelligible conception is sensible if it is non-contradictory and its meaning is understood by the student; a plausible conception is considered believable in addition to the student knowing what the conception means; and, the conception is fruitful if it helps the learner solve other problems or suggests new research directions. Posner et al. insist that a plausible conception must first be intelligible and a fruitful conception must be intelligible and plausible. Resultant conceptual changes may be permanent, temporary or too tenuous to detect.

In this learning model, resolution of conceptual competition is explained in terms of the comparative intelligibility, plausibility and fruitfulness of rival conceptions. Posner et al. claimed that a collection of epistemological commitments called the student's conceptual ecology (Toulmin, 1972) mediated conceptual intelligibility, plausibility and fruitfulness. Strike and Posner (1985) expanded the conceptual ecology metaphor to include anomalies, analogies and metaphors, exemplars and images, past experiences, epistemological commitments, metaphysical beliefs and knowledge in other fields.In addition to the enumerated points, Atadoga and Onaolapo (2008) opined that science teacher should do the following:

a. form small andmanageable groups of students for discussion;
b. provide the student with learning task for discussions;
c. collect ideas from the various group for further discussion;
d. all students in the various groups should be encouraged to participate actively, and all views be noted and respected.

It is this area of interaction between conceptual assignments and conceptual change discussions that this study seeks to examine, to see how the two teaching strategies may help better understanding of genetic concepts in senior secondary schools. The implication of this study to science teaching is to help students to dispel misconceptions, acquire cognitive understanding of biological knowledge and concepts and also a mastery of the skills for their private studies in science. The study therefore examined the effect of conceptual assignments and conceptual change discussions instructional strategies on misconceptions, retention and academic achievement on genetics among senior secondary school students.



Source: Adapted from Posner et. al (1982)

Figure3.3:A Flow Chart of Conceptual Discussions Instructional Strategy used for theStudy.

2.6.3 Cognitive Functioning and the Understanding of Genetic Concepts

The term "intelligence" is defined as the ability to benefit from experience, learn new ideas or new sets of behavior easily and to apply what one learns especially in new situations. The study of the development of intelligence is known technically as cognition which is a general term for processes of thinking, reasoning, understanding interpreting, relating, inferring and judging (Okon, 1988).Intellectual development involves the ability to handle hypothetical events and concepts, not just the real or concrete phenomena of the earlier stage. A formal operation task often involves multiple analyses and the ability to use ratios as opposed to simple differences (Goje, 2007).

Reasoning comes with intellectual development which according to Piaget (1972) is divided into four stages. The four stages are sensory motor-birth to 2 years, Pre- operational - 2years to 7years concrete operational – 7years to 11years and formal operational (abstract thinking) – 11years and up. Each stage has major cognitive tasks, which must be accomplished. In the sensory–motor stage the mental structure are mainly concerned with the mastery of concrete objects and intelligence takes the form of motor actions. The mastery of symbols takes place in the preoperational stage and it is intuitive in nature. In concrete operational stage, the children learn mastery of classes, relations, and number and how to reason and the cognitive structure is logical but depends upon concrete referents. The final stage of formal operations involves abstract thinking and deals with the mastery of thought (Evans in Goje 2007; Ndubuizu 2004). Cognitive status of a child determines to a greater extent the level of understanding of any given concept. Most students operate at Piaget's concrete operational stage (Bomide; Gyuse, in Ndubuizu, 2005) and find it difficult to cope with the abstract nature of genetic concepts. Ndubuizu (2005) opined that the application of the concept of cognitive structures in our secondary and tertiary institutions of learning with respect to the teaching and learning of genetics implies the use of concrete examples, activities and illustrations within the students' environment in order to provide basis for abstract thinking required of their stage (formal operations).

According to Ndubuizu (2005) the theory of genetic epistemology refers to the process of development of knowledge in human organism. She further explained that the concept of cognitive structure is central to the theory and that cognitive structures are patterns of physical or mental action that underline specific acts of intelligence and correspond to stages of child development. The teaching and learning of genetic concepts reveals a reflection upon the basic principles of Jean Piaget's theory of genetic epistemology which is stated as follows:

1. cognitive development is facilitated by providing activities or situations that engage learners and require adaptation (that is accommodation and assimilation).

2. learning materials and activities should involve the appropriate level of motor or mental operations for a child of a given developmental stage: teachers should avoid asking students to perform tasks that are beyond their current cognitive capabilities.
3. use of teaching methods that actively involve students and presentchallenges.

In addition, Ndubuizu (2004) suggested an activity based instructional method and follow up questions to stimulate students' thought process. Furthermore, Piaget (1977) noted that cognitive development though associated with characteristic age spans, vary for every individual and that each stage has many detailed structural forms. This fact points at the individual differences that exist amongst students the same class and age range. She opined that the implication of the above fact for teaching and learning involves:

i. identification of the students' learning difficulties including their misconceptions;
ii. selection of appropriate learning materials in line with the level and interest of the students;
iii. building upon the students' entry behaviour for specific concepts;
iv. giving the students the opportunity (in form of activities) to explore their immediate environment by themselves;
v. use of vocabularies within the cognitive structure of the students. Piaget (1972) also postulated that cognitive structures change through the processes of adaptation, assimilation and accommodation. Assimilation involves the interpretation of events in terms of existing cognitive structures, whereas accommodation refers to changing the cognitive structure to make sense of the environment.

A central component of Piaget's development theory of learning and thinking is that both involve the participation of the learner. Knowledge is not merely transmitted verbally but must be constructed and reconstructed by the learner. Piaget shows that each stage of cognitive development always builds upon the proceeding levels and successive stages also incorporate previous structures. For instance, the preoperational intellectual behavior is built upon the cognitive ability the children acquire during the sensory – motor period. This shows clearly that the early sensory motor development is the foundation or bedrock upon which later cognitive development is built. If the infant is unable to represent objects symbolically because of some reasons – ill health (malnutrition), mental illness, e.t.c. – that may affect his later cognitive development. This suggests the vital need for parents or parent – figure to provide the infant with maximum care, protection, support and healthy surrounding so that he may be able to reach the formal operations and achieve the ability for solving a wide variety of problems (Okon, 1988).

Piaget emphasizes the importance of experience and environment in creating intelligence even though many other people feel that heredity sets the limit of individual intellectual abilities.It is important to bear in mind that one is born with a capacity for the development of intelligence or intelligent behaviour.Several factors appear to facilitate or limit a person's intellectual behavior and development. They include among others some form of parental defect or disorders, disease may injure the central nervous system, physical damage may injure the central nervous system, physical damage may destroy a part of the brain, various birth injuries, common childhood diseases very often accompanied by prolonged high fever, the inability of the sense organs to function effectively, malnutrition and severe physical deprivation over a long period of time. In various ways, these conditions may limit what an individual perceive in the environment and may at the same time limit an individual's intellectual behaviour and development (Okon, 1988).

One's environment, whether it is rich or poor, may also facilitate or limit a person's intellectual behaviour and development. Where an individual is coming from, his home, or cultural background, and experiences may influence what he perceives. We do not perceive everything at once; rather we select certain objects to perceive while ignoring others. Two pupils in the same classroom may perceive things presented by the teacher differently. Cultural background and intellectual ability may cause variation in the length of stages, but the cognitive development follow patterns with all children as do teething and walking.The way in which an individual perceive is determined not only by nature of the stimulus but also by inner (personal) factor. Personal factors include motives, emotions, values, attitudes, and also a system of related categories (a frame of reference). An individual's background and where he is comingfrom may encourage him to seek certain values and goals and this in turn may influence what he perceives. The ideas individuals have about themselves (self concept) may also influence what they perceive and whether they behave intelligently or otherwise (Okon 1988). Okon, (1988) opined that if a child or an adolescent suffers serious threats to himself for long periods of his life or if he is seriously deprived of affection and love from his parents or parent figures over a period of years such threatening situation can influence what he `perceives and can result to his behaving irresponsibly and unintelligently. He further explained that if effort is made to remove such threatening experiences, he probably would behave more effectively and intelligently. Maximum development of the youngsters comes through providing an emotional climate and environment that encourages, assists and permits positive healthy attitudes and feelings. The home and school environment should be minimally repressive so that individuals may be able to develop more effectively.

Intellectual growth involves three fundamental processes, assimilation, accommodation and equilibrium.The filtering or modification of the input is called assimilation. It involves the incorporation of events in the pre-existing cognitive structure. Modification of internal schemes to fit reality is called accommodation. Accommodation means existing structures change to accommodate the new information.The central theme in Piaget's theory is that the child's growth in understanding depends largely on his active involvement and participation in the process of learning. The theory suggests the need for teachers to allow learner organize and adapt experiences in their own ways. If the learners are allowed and encouraged to use their own experiences when they are learning, they will be able to deal with new situations as they arise.The theory suggests the need for teachers to provide healthy, conducive and stimulating school environment for learning. It encourages teachers as well as parents to provide a wide variety of meaningful experiences at home and school for learners. The theory makes it clear to teachers that learners learn best by doing rather than by just sitting still listening or by being told. The theory shows clearly that the qualitative changes that take place in children's thinking as well as they move from infancy to late adolescence is primarily due to a dynamic interaction between the individual and his environment.

The theory strongly suggests the need for teachers to develop appropriate and meaningful curriculum materials to take appropriate instructional decisions and to use a variety of teaching methods consistent with children's levels of conceptual development. The need to provide the learners at different educational levels with appropriate and relevant learning activities and teaching aids is suggested by the theory. Such experiences with concrete objects at the nursery and primary school levels always form the foundation for sensori-motor development and later cognitive development. The theory suggests the need for teachers to use the curriculum wisely to help the learners at different school levels become more aware of things and events in their environment. It helps teachers to determine when to teach what at various educational levels. In this connection, Wadsworth (in Okon 1988) writes: "Curriculum sequence should be designed with children's changing cognitive status in mind. If curriculums do not take into account children's level of conceptual development, learning is going to be inefficient. Children will not learn (develop schemata) if they do not have the pre- requisite cognitive skills.

Readiness to learn is of particular concern to educators of elementary school children, though it should be of concern at all levels of education. According to Piagetian theory, a child is "ready" to develop a particular concept when, and only when, he has acquired the schemata that are necessary (pre – requisite)".The implication of this for education is that curricula should emphasize a learner centered strategy. The teaching of genetic concept at the senior secondary school level should be rooted on activities that will ensure that the students'understand the concept involved through meaningful learning so as to attain good academic output in biology at this level and beyond.

2.7 Instructional Strategies and Students' Performance

Available literature reveals that many studies have been carried out to investigate the relative effects of different instructional strategies on students' academic achievement. The teacher has been found to be very important factor in the implementation of any curriculum (Nneji, 1999; Okoye, 1999; & Umeh, 2002). According to Okebukola (1997) what a learner learns depends not only on what the learner is taught but also on how the learner is taught as well as the developmental level, interest and experiences the learner. Science education researchers believe that much closer attention needs to be paid to methods chosen for the presentation of learning materials to the learners (Okebukola & Clement, 2003). Method of teaching to a large extent could either positively or negatively influence the performance of the learner (Lagoke, 1994; Geary, 2005). Awodi, (1984) and James (1991) confirmed lecture method to be an inappropriate method and which is mostly used in science teaching.

One of the reasons adduced for students' conceptual difficulty and subsequent poor achievement in certain areas of the Secondary School Certificate inorganic chemistry is its method of teaching, which most of the students find uninteresting (Eze, 2002). Poor teaching method have been predominantly being in use for a long time in the teaching of chemistry (Ezeudu, 1995). Method, such as demonstration, guided inquiry, discovery method could be result oriented but have been reported to have made students fail to see the inter-dependent relationship that exist between academic content of chemistry courses offered while in school and their reallife applications (Njoku, 2009), consequently, Nzewi (2011) proposed the need for a search of better instructional method for the attainment of improved learning outcomes. Notable among such innovative approaches is the Context-Based Teaching Strategy (CBTS). Context Bases Teaching Strategy (CBTS) involves the connection of the teaching of particular concepts with its context are still connecting the concept and context to student lives in their real world (Pearsal, 1999). Bennett (2003) also stated that context and applications of science are used as the starting point for the development of scientific ideas; these contrasts with more traditional approaches that cover scientific ideas first before looking at applications. Furthermore, evidence in related literature (Egbo, 2005) shows that some factors have been shown to either single or in combination with instructional method influence students achievement in the subject.

Research findings of science educators like Jegede and Taylor (1998), Okebukola (2002), Tsui and Treagust (2002), revealed that those teaching methods that are activity- oriented and that involved the learner taking active role in the teaching/learning process result in better learning and understanding of science concepts on the part of the learner. Moreso, researches in science education have shown the inadequacies of lecture method of teaching and learning of science concepts. Lawal (2009) opined that the overall picture resulting from the use of this approach in the teaching of students is that the students tend to come out with large number of misconceptions which result in poor performance and as such poor interest in science and science related courses.

Ajaja and Kpangban (2000) asserted that what the students know or do not know depend mainly on the teacher. The biology teacher should therefore be equipped with the right strategies for effective learning to take place. Oke, (2003) opined that biology teachers need to know what material and human resources will be needed to help create an environment that will effectively aid the learning of genetic concepts. In addition, the teaching approaches to be used also have to be effective. It has been shown that students' collaboration in learning activities that are relevant enables them to learn in positive ways (Conley, 2002). Adeyemi (1990) investigated the effects of two instructional procedures on students' process skills achievement in biology. The findings of this study revealed that students in the guided inquiry group performed better than students in the expository group in biology process skills achievement.

Okebukola (1992) investigated the relative effects of three instructional strategies on the teaching of Senior Secondary School Biology. He used a sample of 147 students divided into three groups. One group was taught Biology using concept mapping, the second group was taught using collaborative concept mapping while the third group was taught with lecture/demonstration method and served as the control. The results showed that students taught biology using concept mapping and collaborative concept mapping performed significantly better than those taught using the lecture method.

Akale and Usman (1993) examined the effect of intensive practical activities on students' achievements in integrated science. The population sample was 312 JSS 11 students randomly assigned to experimental and control groups. The results of their findings show the experimental performed significantly better than the control.Ezenwa, (1993) compared the effectiveness of concept mapping and guided discovery teaching strategies on students' retention of some chemistry concepts. The results showed a significant difference between the concept of mapping and guided discovery post test scores in favour of concept mapping. It follows that the concept mapping method enables students to have better understanding of concepts taught and retained more knowledge of chemistry concepts than the guided discovery method.

Esiobu and Soyibo (1995) investigated the effects of instructional strategies on achievement in Biology. They used 9 experimental classes and 9 control classes. Both groups were exposed to the same curriculum materials; the difference was that the experimental groups were taught using concept mapping while the control groups were taught using the lecture method. Pre-test and post-test results were analysed on the basis of which the following conclusions were made:

a. the experimental group achieved significantly better than the control group on the Biology Achievement Test (BAT) administered to them.
b. There was no significant difference between performance of males and that of females.

Oyedokun (1998) investigated the effects of two instructional strategies –conceptual change teaching strategy and the traditional teaching strategy on students' achievement and retention of biology concepts. The result of her study show that students taught using conceptual change teaching strategy performed better than their counterparts exposed to traditional method.Amedu (1998) investigated the relative effectiveness of collaborate concept mapping and lecture method on achievement of mixed ability biology class. The results showed a significant difference in achievement in favour of concept mapping.

Martins (in Bichi, 2002) tested the effect of lecture method and inquiry method on the cognitive performance of Nigerian Integrated Science Students and concluded that inquiry method yielded greater achievement than the lecture method.Bichi (2002) investigated the effects of problem solving strategy and enriched curriculum on secondary school students' achievement in evolution concepts. He suggested a radical change from the traditional learning activities characterized by rote learning, meaningless memorization and verbalism to a more effective and meaningful learning theory that is rapidly gaining ground known as constructivism as it yields permanent and meaningful learning whose products are understanding and retention.

Eryilmaz (2002) investigated the effects of conceptual assignments and conceptual change discussions on students' misconceptions and achievement regarding force and motion. The findings of this study showed that conceptual change discussion was an effective means of reducing the number of students' misconceptions about force and motion. The conceptual change discussion was also found significantly effective in improving students' achievement in force and motion.

Okoye and Okechukwu (2006) examined the effect of concept mapping and problem solving teaching strategies on achievement in genetics among Nigerian secondary school students. One hundred and thirteen senior secondary three (SS 111) randomly selected from three mixed secondary schools were used for the study. The experimental group was taught selected topics in genetics using concept mapping and problem solving strategies while the control group was taught using the traditional lecture method. The result of the study showed that the experimental group performed significantly better in genetics than the control group and that gender does not affect student' achievement in genetics.

Bello, (2011) investigated the outcomes of using group instructional strategy on learning of Physics in senior secondary schools in Nigeria and also determined whether group instructional strategy will improve the performance of below average ability students. By the use of purposive sampling, 365 senior secondary school year one Physics students were selected from a school of science, in Ile-Ife, Osun State, Nigeria for the study. The study revealed that those exposed to group instructional strategy performed better than those exposed to individual learning treatment; the below-average students exposed to group instruction have gain score over what they scored when not exposed to this method, which shows that there was improvement in their performance hence, more understanding of the Physics concept.

Khurshid and Ansari (2012) investigate the effects of innovative teaching strategies on the performance of students of grade 1. The experiment was done on the teaching of science subject to the students of grade

1.A sample of 50 students (boys and girls) was selected randomly out of the population of 100 students in grade 1 from an English medium school of Islamabad. One group was taken as a control group which was taught science by the teacher who used conventional method of teaching while the other i.e the experimental group was taught by theteacher who used innovative teaching techniques. After one month's time of teaching, a post-test was conducted. It was found that after one month the students (n=25) who were instructed using modern teaching techniques achieved significantly higher scores on science test than did the students (n=25) whose instructions were done on traditional/conventional method.In this study the conceptual assignments and conceptual change discussions and the traditional lecture method was used to teach genetic concepts to senior secondary school three biology students. Pre-test and post-test were used to assess students' performance and the results were compared to find the effectiveness of each instructional strategy.

2.7.1 Instructional Strategies and Students' Retention

Retention is the ability to retain and consequently remember things experienced or learned by individual at a later time. It takes place when learning is coded into memory. Thus, appropriate coding of incoming information provides the index that may be consulted so that retention takes place without an elaborate search in memory lane (Oyedokun, 1998). The nature of material to be coded contributes to the level of retention. Materials are related to the quality of retention in terms of their meaningfulness, familiarity, concreteness and image evolving characteristics (Adeniyi, (1997). Permanent and meaningful learning is the ultimate target of our educational endeavour.Retention is defined by Kundu and Tutoo (2002) as a preservative factor of the mind. The mind acquires the materials of knowledge through sensation and perception. These acquired materials in the mind need to be preserved in form of images for knowledge to develop. When a stimulating situation occurs, retained images are revived or reproduced to make memorization possible. Hence, biology concepts need to be presented to the learners in a way or method that touches their sub consciousness which can trigger quick recalling of the concept being taught or learnt.

According to Hornby (2001), retention is the ability to remember a thing. Retention can also be defined as the ability to keep or retain the knowledge of biology contents learnt and to be able to recall it when required. Understanding and retention are products of meaningful learning when teaching is effective and meaningful to the students (Bichi, 2002).Martin (1993) speculated that educators could improve retention of concepts and information by explicitly creating memorable events involving visual or auditory images through the use of projects, plays, simulations and other forms of active learning. Retention drops rapidly in the first weeks after instruction and then levels off. Whatever students have retained about 12 to 24 weeks after instruction, they may retain forever (Slavin, 1997). Also, the more time that passes after learning,the less will be remembered. This form of forgetting is often referred to as "time decay" (Woolfolk,1998). For instance, neural connections, like muscles grow weak without use.Okoye (2003), refers to retention as the process of maintaining the availability of newmeanings or some part of them. It may be suggested that the amount of the original meaning thatwill be retained at any given point in time is a variable quantity. Therefore, forgetting represents adecrement in the availability of an acquired meaning. That is, it describes the loss in availability that occurs between the original establishment of the meaning and its later reproduction.Considering the two terms, retention is seen as referring to the positive aspects of memory whileforgetting refers to the negative aspects. Frequent reviews and tests, elaborated feedback and active involvement of students inlearning projects have all been associated with longer retention.

Cope (2011), stated that active participation during instruction increases learning and retention. Lecturing is still a common way for instructors to communicate information. However, it does not allow for much interaction between learners and teacher and as a result, the instructor may falsely assume that the students fully understood the concepts that he presented. In order words, students learn more efficiently by participating in instruction. To further support this idea, (Iji,2002, Chianson,2008) stated that retention in biology is not acquired by mere rote learning but through appropriate instructional delivery approach. Therefore, using a variety of instructional approaches can significantly improve learning and retention in students of all ages.

Okoye (2003), identified three methods of measuring retention which include; the recall method, the recognition method and the relearning or saving method.

1. **The Recall Method:** this seems to be the method that is most familiar to every teacher. It requires the learner to recall as much as he can of the skills he has acquired. The measurement of vocabulary in a foreign language such as French may be measured by a recall test. In this test, the foreign (French) words may be presented and people are asked to give their English translation. Alternatively, the English words are given to be translated into French. Essay test typically calls for recall skills. Such a recall procedure is the least sensitive one available for measurement of retention.
2. **The Recognition Method:** this method applies to the measurement of cognitive skills as arelearnt in the academic classrooms. When this method is applied, the subjects demonstrate retention by recognizing a correct response. The objective type of examination is the most widely used example of this method of measuring retention. Every pupil and teacher knows that it is much easier to recognize the right answer than it is to produce an answer. In the recognition method of measuring retention, many cues are provided, but in the recallmethod, there are very few present to elicit the response. The difference in the number ofcues present accounts for the difference in sensitivity of the recognition method incomparison with the recall method.
3. **The Relearning or Saving Method:** some sensitive techniques have been developed that can

demonstrate that there has been retention even though all the ordinary test of retention used in schools indicate that there has been none. A very sensitive technique widely used in laboratories is known as the saving method. In this method, the subject learns the material toa certain level of proficiency. If he is learning a list of words, then he may learn them to thepoint where he can repeat the list back perfectly on three successful occasions. If twenty-five repetitions might be required in the initial learning series to reach the point of perfectrecall, only five repetitions might be required at later time to reach the same point oflearning. Now, since on relearning, five instead of twenty-five repetitions were required, itmight be said that on relearning, there was a "saving" of eighty percent. This is how themethod got its name. In some studies, it has been the only method so far developed that issensitive enough to provide evidence that there has been some retention of the originalmaterial learnt. Having briefly examined the three major methods of measuring retention, it becomes necessary to relate these ideas to the present study. The recognition method is used in this study because the achievement and retention test will call for recognition of the subject matter learnt inthe lessons.

Crider, Goethals, Kavanaugh and Solomon (1983) explained that retention has to do with memory, that the memory stores information or activities learnt and the storage could beinthe form of sensory, short term or long term. They further explained that the messages or information received through sensory memory using one or more of the sense organs are not easily remembered, unless they are stored in short- term memory. Also, that short- term memory lasts for about twenty seconds and has the capacity to hold about seven separate pieces of information at a time. They described long- term memory as a relatively permanent storehouse of knowledge, which has the capacity to store enormous amount of information for over long period of time even as long a lifetime.

Information stored in this long-term memory can be described as information retained. The process of retention has been described as the ability to remember ideas and facts. Derville (1997) opined that retention many a times carries the idea of memorization and rote learning. Derville (1997) is of the opinion that retention could be measured through performance, as it is how much of the learnt items that can be remembered long after the learning as taken place. Houston (1981) in his book wrote that retention can be measured through recall which involves reproduction/repetition of learnt materials, which could be verbatim or results from reconstruction and recognition.

Several factors are known to influence retention. Blair et al (1968) reports that anything that aids learning should improve retention while things that lead to confusion or interference among learned materials decrease the speed and efficiency of learning and accelerates forgetting. Interferences may exist in several forms such as retroactive inhibition, proactive inhibition, motivational inhibition or emotional inhibition.Retroactive inhibition results when anything is learned, the use of that learning usually occurs after a passage of time. In the intervening period, many other things are learned. These interpolated learning interfere with the memory of the original material, and this interference is known as retroactive inhibition (Blair et. al in Bichi, 2002).

A very convincing experiment that shows the existence of retroactive inhibition was reported by Jerkins and Dallenbach (in Bichi, 2007) using college students. One group of the students was given a list nonsense syllables to learn, and then immediately went to bed. Another group learned the same list of syllables but followed it with their ordinary activities for the next eight hours. When retested on the list, the group which slept after learning remembered more than did the group which had been active and awake.Proactive inhibition results when something new is learned, it competes with older learning so that when the new learning is required, it is distorted by what had gone before. Ausubel and Blake (1958) reported an experiment in which students were given passages of Buddhism to read. Later tests revealed that the memory of Buddhism had been distorted in a predicted direction because of previous knowledge of Christianity. This clearly suggests that practice affects/influence retention among students.

Motivation condition at the time of learning can either facilitate or interfere with its success, i.e can enhance retention or facilitate forgetting. In a similar way, emotion can interfere with retention. Studies showed that painful experiences are intentionally forgotten or repressed (Cross; Ezenwa, Adeniyi in Bichi, 2002). High anxiety at the time that an individualattemptstorecall something he has learned also blocks remembering (Mckeachie et al in Bichi, 2002). Thinking style of individuals had also been studied in relation to retention. It has been observed that fast learners are superior in both short term memory and long term memory (Cross; Martinsin Bichi, 2002).When teachers link new information to a student's prior knowledge, they activate the student's interest and curiosity and infuse instruction with a sense of purpose (Barton, 1998; Falk & Adelman, 2003; Tobias, 1994). They can link curriculum, instruction, and assessment to students' experiences, language, and culture. By tapping into students' prior knowledge in science, teachers can plan lessons that will clarify incomplete or problematic prior knowledge, decide on the appropriate pedagogy for the topic, and make necessary adjustments to activities and assessment of materials.

Hands-on experiments and discussions during instruction allow students to gain and retain more knowledge because students have more opportunities to connect prior knowledge, practice, and relearn new knowledge (Burkhardt & Schoenfeld, 2003; Hake, 2004; Semb & Ellis, 1994). It is believed that one of the keys to achieving long-term memory may be the richness of the connections between students' prior knowledge and new knowledge. The more connections, the easier it is to remember. It is also believed that when new information gets hooked up with a particularly rich and well-organized portion of memory, it inherits all the connections that already exist. This is why it is much easier to learn new science concepts that are connected to experiences than to learn decontextualized concepts.

Retention level in relation to age has been investigated by several researchers. Cross, (1974) reported that retention increases from infancy throughout the teenage years followed by a slow recession in middle age. Student's rate of retention drops off significantly after the first 10-15 minutes of a lecture and picks back up at the end. In addition, the retention rate for a lecture is about five percent after 24 hours. In comparison, the rate of retention for active learning goes up dramatically.Lagoke, (1992) investigated the retention ability of two groups of students. The experimental group was taught biological concepts using the analogical linkage strategy while the control group was taught same concepts using the traditional teaching method. The results showed that the experimental group performed better than their counterparts in the control group.

Ezenwa, in Bichi (2002) compared the effectiveness of concept mapping and guided discovery teaching strategies on students' retention of some chemistry concepts. Analysis of the results showed a significant difference between the concept mapping and guided discovery post test scores in favour of concept mapping. It follows that the concept mapping method enables students to have better understanding of concepts taught and retain more knowledge of chemistry concepts than the guided discovery method.

Oyedokun, (1998) compared the effectiveness of conceptual change teaching method and traditional with reference to achievement, retention and attitude. She found that students'exposed to conceptual change teaching method have higher cognitive achievement, more positive attitudes and higher retention level than their counterparts taught using the traditional method.Crowl, Kaminsky and Podell (1997) suggested techniques to help students retain information in long-term memory. They are:-

7. Beginning lessons with activities that require students to draw upon existing knowledge.
8. For certain types of information, have students engaged in repetition to encourage long-term retention, also show students how to use acronyms and other mnemonic devices to remember various kinds of information.
9. Ensure you clarify the relationships between concepts, if students understand how concepts are related, they can conceptualize information in meaningful ways and may not have to rely on memorization.
10. Re view previous taught topics often to ensure that students have not forgotten what they learnt previously. At the appropriate time, previously learnt materials should be integrated with ideas presented more recently.

They are of the strong opinion that when a teacher notes these and adhere to them strictly in the process of teaching, the learner learns and is able to retain a lot of what is learnt.

Udogu and Njelita (2010) used quasi-experimental, non-equivalent group control design involving twointact classes to determine the effect of constructivist-based instructional model-Generative Learning Model (GLM) on students'conceptual change and knowledge retention in chemistry. Effect of GLM ongender is also monitored. Performance of students taught with the above instructional model was compared with those taught with Expository Method(EPM). The sample for the study consisted of 170 SSII Chemistrystudentsfrom four secondary schools purposeful selected from all the secondaryschools in Idemili South Local Government Area of Anambra State. Students from two schools – (one male and the other female) were randomly assigned to experimental group while the other two schools one male and the otherfemale was assigned as control group. A Teacher Made Achievement Test inChemistry Tests (TMATC) was used. Three sets of these tests weredeveloped 1, II and III. Pre-test was administrated to both groups todetermine their entry level. At the end of the treatment Post-test was administered to both groups to determine their achievement after treatment.The third test was administered after an interval of four weeks to measure students' knowledge retention. ANCOVA statistical tool was used to analyzethe data collected using pre-test as a co-variant. From the findings, it was very clear that experimental group performed better than the control group.This is an indication that the constructivist based method (GLM) is very effective in enhancing meaningful learning among students.

Chukwu, (2011) investigated the effect of Integrated Model of Teaching on retention of Students' in biology. The study was guided by two research questions and three null hypotheses. A quasi experimental non-equivalent control group design was used. 351 SS II biology students were drawn from a population of 1406 SSII Students of four selected schools in the study area. Multi-stage, stratified random sampling technique was used. Data Collection was madeusing Biology Teacher Made Retention Test (BTMRT). Reliability coefficient of 0.72 was established with Kudder Richardson formula 20(K-R20). Mean (x) and standard deviation(s) were used to answer research questions while analysis of covariance was used to testhypotheses at 0.05 probability level. Because of the importance of retention in the learning of science, in this study, the retention level of students taught genetic concepts using conceptual assignments and conceptual change discussions was investigated and compared with that of students taught same concepts using the traditional lecture method to see the result.

2.7.2 Gender and Academic Performance in Science

Gender is a socially ascribed attribute which differentiate feminine from masculine.Umoh (2003) conceptualized gender as a psychological term used in describing behaviours and attribute expected of individuals on the basis of being born as either male or female.One of the most topical issues in current debate all over the world has been that of gender differences and academic achievement among students in schools. Over the years, there has been a growing awareness of the role of women at home, in the school, and community in general. However, worries have equally been expressed about the role of women in the political, social, cultural, psychological, economical, spiritual, scientific and technological development of the nations (Abdu-Raheem, 2012). Numerous studies have been carried out on gender and social role; gender and work role; gender, science and technology and gender and achievement. This study focusedon gender and academic performance in genetics.The influence of gender on students' achievement in science, has for a long time been a concern to many researchers and science educators. Many of them sought to determine whether it is true that, there is male superiority in science achievement or not. Male supremacy and gender stereotyping are factors among others that were identified to influence occupational choice (Ogunleye and Babagide, 2011). Longe and Adedeji (2003) are of the opinion that science and technology is a male-dominated subject and that the females tend to shy away from scientific and technological fields. Boys, therefore, appear to have a natural positive attitude to technical and science subjects while girls show negative attitude.

Studies conducted across African countries, including Nigeria, have reported disparity in the education of girls and women in science and technology (Iyang and Ekpeyong, 2000). Females are grossly under-represented and many of them are noted to under-achieve in the science and technology (S & T) discipline (Nzewi, 2010). According to Okeke (2001), the under-representation and under-achievement of females in S & T disciplines are historical and have been brought about by several inter-related socio-cultural and inter-acting school factors which act singly and jointly to depress female interest, enrolment, participation and achievement in S & T subjects at various levels of Nigerian Education System. Adigwe (1999) investigated the pattern of classroom interaction in two classrooms each of Biology, physics and chemistry. He found that teachers asked the male students more academic and procedural questions than they asked the female students; while the females had more social interactions with the teacher than the males. The study by Nzewi and Onimisi (2008) threw up the same pattern of interaction in science classes. Adigwe (1999) then concluded that male and female students have unequal opportunities for learning science in Nigeria classrooms. He added that the low number of females offering Biology, Physics and Chemistry might be a direct result of their experiences with their science teachers.

Njoku (2001) confirmed that researches indicated that girls believe that science is too difficult and not important for their future. He explained that the teaching methods used do not assist girls to understand science. He also reported further that primary science and technology teachers agreed that, they pay more attention to boys than girls. He also observed that there are more male science teachers and professionals than female role models in science and technology. The under-representation of women in science and technological manpower pool may likely be a reflection of low participation and under-achievement of girls in Science and Technology in schools. Gender inequality is also reflected in enrolment into science and admission to higher institutions of learning. Obanya (2005) confirmed that the enrolment of boys out-numbered that of the girls in science, Technology and Education in Nigerian Universities, Polytechnics and Technical Colleges. The UNESCO World Science Conference held in Budapest in 1999 gave attention to the issue of women in scientific research. Among the points they emerged at theconference was that inadequate preparation at the secondary level remains a handicap for young women seeking a scientific career. The gender inequalities are also the product of a failure to recognize women's knowledge and know how, in order words, a failure to recognize that women are responsible for half of the human knowledge and technical expertise as agriculturalists, gardeners, animal-breeders, forest users, managers of their community water, needs and resources and also as technological innovators and agents of change. According to UNESCO (2011), research has shown that globally, 39 million girls of lower secondary age are currently not enrolled in either primary or secondary education while two-thirds of the world's 796 million illiterate adults are women. Only about one-third of the countries have achieved gender parity at secondary level. This evidence shows that something needs to change.

Oakley (1993) 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. Biological differences exist between a man and a woman but the extent of differences and their significance is further rooted in the societal and cultural expectation of the two. A number of explanations attribute gender differences in educational achievement to biological differences between males and females. These explanations propose that gender differences in behaviour, skills and cognitive abilities are determined by biological factors such as brain organization, hormones and genetics, and that these biologically determined differences in behaviour and abilities are responsible for gender differences in educational achievement. For example, Kimura and Hampson (1994) reported that fluctuations in testosterone in males and oestrogen in females were correlated with performance on a range of tests of cognitive ability. A number of studies have reported gender differences in brain structure and function (Halpern, 1997; Cahill, 2006) and in some cases this has been interpreted as evidence that gender differences in educational achievement are biologically determined (Biddulp, 1997; Gurian, 2001; Sax, 2005).

According to gender theory, males and females enter the educational system with different sets of behaviours, attitudes and values. These gendered behaviours, attitudes and values are the result of childhood socialization in line with the cultural norms of masculinity and femininity (Biddulph, 1997; Epstein et al., 1998; Weaver-Hightower, 2003). It is proposed that, in educational settings male behaviour, values, attitudes interfere with males' educational achievement. Warrington, Younger and Williams (2000) found that boys were more likely than girls to be ridiculed by their peers for working hard in school, and frequently resorted to 'laddish' behaviour such as challenging authority, drawing attention to themselves and pretending not to care about school work in order to gain acceptance from their peer group. Gibb, Fergusson and Horwood, (2008) reported that there was a small but pervasive tendency for females to score better than males on standardized and to achieve more school and post school qualifications. They further explained that the differences could not be explained by differences in cognitive ability as males and females had similar I Q scores. Teacher ratings of classroom behaviour revealed that males were more prone to inattentive, restless, distractible behaviours, aggressive, anti-social and oppositional behaviours than females.

Halpern (2000) opined that the most comprehensive reviews of the research in the area of gender differences have shown very few true differences in math and verbal ability between men and women. He also explained that the research has shown only two gender differences in specific sub-areas of spatial and verbal abilities, three-dimensional mental rotation (favouring men), and speech production (favouring women). He further explained that other research has shown a decline in the differences between the genders in the past few decades on standardized tests, suggesting that the more exposure that women are getting to mathematics and science classes, the better their scores.

Work by Eccles, Lord, Roeser, Barber, and Jozefowicz (1997) found that gender differences in enrolment in advanced mathematics courses in high school are mediated by gender differences in expectations for success in mathematics and physics and perceived value of competence in math. Jacobs, Lanas, Osgood, Eccles, and Wigfield (2002) found that self concept of ability and task value in math decline for both genders between first and twelfth grades with no real difference between girls and boys trajectories over time. They further explained that by the twelfth grade, girls valued math more than boys when controlling for self-concept of ability in math. They also explained that even though women have made great strides in law, medical, and social science professions, very few can be found in graduate programs or professions in mathematics, computer science, physics, engineering, or information technology jobs (Eccles, 2001). Many ideas have been put forth on why high achieving women may not be entering these professions, including discrimination, gender-typed socialization, self-concept of ability in these areas, and the value and interest women have in these professions (Eccles, 2001).

Specifically, some studies have been carried out to find out the influence of gender (Anidu, 2007) on student achievement in science generally and on the student achievement in chemistry in particular. Unfortunately, the findings seem to be inconclusive. For example, Ogbu (2005) revealed that there was no significant different in the achievement of male and female students in chemistry while Egbo (2005) observed significant difference in achievement due to gender.Psalidas *et al.* (2008) examine the effect of gender, scientific process and context on thestudents' performance at PISA science component; by applying paper-and-pencil test for 94 Greek students. They include three scientific processes (interesting scientific evidence and conclusions; describing, explaining; and predicting scientific phenomena) and three contexts (earth and environment; life and health; and technology), and use statistical test for differences in means (t-tests, Friedman and Wilcoxon). They find that the difference in average performance by gender and scientific process are not statistically significant.

Jegede and Inyang (1990) worked on gender differences and academic achievement in integrated science in junior secondary schools. They confirmed that males performed better than females. Also, Arbogast (1997) reported that boys performed significantly better than girls in SSCE physics examination. Similar findings were reported by Lagoke et al (1992), Oakley (1993), Whitehead (1996), and Anyanwu et al (2004), Usman (1992) and (2000) in a research on the effect of practical activities on achievement in integrated science. Similarly, Lentz (1992) observed that boys are more mechanically and scientifically inclined than girls. They affirmed that males demonstrated significantly more positive attitudes towards science than females. Schibbeci (1984 in Abdu-Raheem, 2012) also noted that females exhibit positive attitudes towards biology and males towards physics. Owuamanam and Babatunde, (2007) noted that the girls tend to go for courses that do not require more energy and brain tasking such as home making while boys looked for jobs in management, engineering, banking and other brain tasking professions.

In African culture, girls are not familiar with toys that promote interest in science andtechnology. Their major duty is home management and child-bearing. They are expected to cook and clean while the boys engage in activities such as playing football, making bows and arrows, playing with catapults, flying kites and so on. Bozimo (1991) noted that these activities promote scientific knowledge and thus give them an edge over girls. Babalola and Adedeji (1997) also confirmed that women, throughout the ages and everywhere in the world, have always been considered inferior to men. Also, as seen inTemitope (2011), due to African culture and traditions, males are more inclined towards the sciences while females tend to tilt more to the arts. Scottish local authorities did not introduce gender policies until the early 1990s (Ridwell 2000). Jekayinoluwa (2005) lamented that schools and the nation at large are making profound contribution to the creation of positive learning environment that could motivate learning achievement more in boys than girls.

Osler (2002) in her own research carried out in London, confirmed that girls excluded or self excluded from formal education were rampant among African girls than White girls. In another research carried out in

London, Claire (2005) highlighted the high number of black girls being excluded from school and also looked at the way language is used in education. Both ethnicity and social classes are factors which combined with, and interacting with gender, are seen as having a direct bearing on achievement (Plummer 2000 and Arnot 2003). Archer (2003) noted that gender inequalities are interwoven with social class, ethnicity, sexuality and disability. Another factor identified as influencing attainment is ethnicity (Arnot, 2003).

Murphy, (2001) in his findings, linked academic achievement with pattern of behaviour. He noted that there are signs of boys being vulnerable to becoming disaffected. He explained further that boys tend to be less careful about rules and more indifferent to being reprimanded. Head et al (2002) revealed that boys are also more likely to be referred to behavioural support services. Younger et al (2005) cautioned by pointing out that there are many boys who continue to do well in school and only few of them become affected.Of particular interest is the fact that girls, to a large percentage, avoid physical science subject when choice is offered. Studies indicated that girls are more satisfied life and their school-related attitude is more positive than those of boy (Balogun, 1983 and Yoloye, 1983). They explained further that the intellectual potential of girls' attainment for boys are lower than those of girl at all stages and across almost all England and Wales (Younger et al 2005).

Greenfield, (1996) investigated gender, ethnicity, science achievement and attitude among Grades 3 –12 student in Hawaii, United state. In the study, science achievement and attitude were assessed for a series of student in representing four major ethnics group in Hawaii. The result of the study showed that more differences were accounted for by ethnicity that by gender, in addition there was little interaction between ethnicity and gender. With respect to ethnicity, Greenfield (1996) reported that Caucasians and Japanese – America student outscored Hawai –ians and Filipino-America at all grade levels. With respect to gender, there were no consistent differences in science achievement. The major differences were that male reported more experiences with physical science activities and also expressed a more male-stereotyped view of science than females.

Abdu- Raheem (2010) opined that in Social Studies, sex factor has no influence on the academic achievement of students and that their achievement is based on their levels of understand and commitment. Akinbote (1999) in his study on differences in cognitive achievement Social Studies, confirmed that there is no significant different between the cognitive achievement and attitude towards Social Studies of boys and that of the girls. Adeosun (2002) in his own contribution confirmed that there is no significant difference in the achievement score between males and females while conducting studies on effects of multimedia packages on students' achievement and retention in Social Studies. Abdu-Raheem (2010) also concluded that gender does not play any significant role on students' achievement in Social Studies.

In relation to gender difference in the learning of life sciences, some scholars have indicated that there is no significant difference between boys and girls (Lappan, 2000 and Dimitrov 1999) while others have reported significant gender differences (Young & Fraser 1994; Okeke 1996; Soyibo 1996). The study carried out by Dimitrov (1999) revealed that there was no significant difference between girls and boys with respect to life sciences. Moreso, Okeke and Ochuba (1999), Nwaiwu and Audu, (2005) and Lorchugh, (2006) have reported that there is no significant difference between boys and girls with respect to achievement in biology test while some studies (Ndirika, 2013; Aniodoh & Eze, 2014) reported that boys did better.The difference in biology achievement due to gender has caused a lot of concern to educationist. Adegboye (1998) explained that many parents do not want to spend as much on female education as that of male children because of their social or cultural environment which affects gender stereotype in schools.

Okoye (2016) investigated the influence of gender and cognitive styles on students' achievement in biology in senior secondary schools in Anambra State. Result showed among others: that gender and cognitive styles has no significantinfluence on achievement scores of students in biology.Other studies confirmed the superiority of female over the male in achievement. Driver (1980) reported higher achievement of girls in mathematics and physics than boys. Klainin et al (1989) reported that the performance of girls is significantly better than that of boys in chemistry and physics in Thailand. Moreso, Soyibo (1996) has shown that girls significantly performed better in a test of errors in biology labeling. In another research by Mari and Shauba (1997), they revealed that female students had a better understanding of science process skills when compared to the male students. They suggested that the view that seems to have established itself that boys are better than girls in science education needs to be approached and interpreted with great caution. Similarly, Godpower-Echie and Amadi (2013) in a research work involving four hundred (400) senior secondary (SS) 2 chemistry students found out that there was a positive correlation between gender and students' achievement in chemistry. Females tend to perform better in areas of standardized science assessment that address the human application of science such as life science, (Ingels and Dalton, 2008).

Another study conducted by Young and Fraser (1994) revealed a significant gender difference in biology achievement of 14 and 17years old Australian students in favour of the boys.In a research by Olaf, Jurgen & Kai (2010) involving 602 students in Germany, they found out sex differences in achievement in favour of boys in mathematics achievement, they also found out that interest had no significant effect on learning from grade 7 to grade 10 but affected their course selection. It was seen that interest at the end of grade 10 had a direct and indirect effect (via course selection) or achievement in upper secondary school. This means that high achievers showed more interest than low achievers. Allen and Robbins (2010) tested the effects of interest and motivation on timely degree completion they foundout that interest had a direct effect on timely completion while motivation had an indirect effect. These findings show the importance of interest on students' achievement.Jegede (1990) in a survey of junior school boys and girls on the influence of gender on interest in science argued that there is a gender gap concerning students' interest and achievement in science. Both male and female students perform well in science in the junior secondary school but by the time they begin their course of study in the polytechnics and universities the female students do not retain their interest in science.

Furthermore, Erickson (1994) reported gender related differences in biology in favour of male students.Bichi (2004), Adedayo (2004), Atadoga (2005) studies are not in complete agreement with boys trend in sex differences with regard to achievement in science. In their various fields of study, they concluded that there were no gender differences with regard to achievements in science.Further, in Azman (2014), according to a survey carried out in selected educational institutions in Sub-Saharan Africa, the issue of gender played a major role in the choices students made and also their performances in core science subjects.

Wonu & Anackwe (2014) found out no significant difference in the mathematic achievement of male and female students. Abiam & Odok (2006) in their research work found that there was no significant gender difference in the achievement of students in number; numeration statistics and algebraic process. In a similar vein Josiah & Etuk- Iren (2014) found a non significant relationship between gender, age, mathematics anxiety and college students' achievement in algebra. Babalola and Fayombo (2009), found out that there was no statistically significant difference in the students' science achievement based on gender. Fredrick (2008) opines that there was no statistical difference between boys and girls in the ability to manipulate the apparatus/equipment take observations, report/record results correctly, and compute/interpret/analyse result during chemistry practicals and that both male and female students perceived interpreting/analysing results to be most difficult skill to perform during chemistry practical. Ikenna (2009), found out that gender alone has no effect on academic achievement but could act in conjunction with other variables to affect learning outcomes. Therefore, an investigation into the effects of conceptual assignments and conceptual change discussions on gender differences, academic performance and retention of genetic concepts among the senior secondary school students examined was timely and worthwhile.

2.8 Overview of Similar Studies

The research investigated the effects of Conceptual Assignments and Conceptual Change DiscussionsInstructions on Secondary School Students'Misconceptions, Performance and Retention in Genetics in Kaduna State. The overview of similar studies were carried out as follows:

Lawrenz (1986) carried out a study on in-service elementary school teacher. The researcher worked on their understanding of some elementary physical science concepts. She used a questionnaire developed using items from the physical science questions administered to 17-year-old students as part of National Assessment of Education Progress Science Studies. She found out that of the 31 items, only 11 were answered correctly by 50% or fewer of 333 teachers surveyed. She concluded that some of the errors were due to lack of content knowledge, but that others were indicative of serious misconceptions. She concluded that if teachers do not understand Elementary Physical Science Concepts, how would they teach their students? In this study, some misconceived genetic concepts were identified.

Haslam and Treagust (1987) diagnosed secondary school students' misconceptions of photosynthesis and respiration in plants using a two-tier multiple choice instrument. They used 434 students made up of 137 from year eight, 88 from year nine and 99 from year twelve. They found a consistently high level of misconceptions in students' understanding of the two concepts in plants. The result showed that the misconceptions of these two concepts are retained throughout secondary years despite the fact that these concepts are taught each year as a topic or as related to or incorporated with other science topics. In this study, it was discovered that Conceptual Assignments, Conceptual Change Discussions and Conceptual Change Discussions with Conceptual Assignments instructional strategies are capable of correcting and reducing students' misconceptions of genetic concepts.

Haider (1997) also carried out a study on prospective teachers' conceptions of the conservation of matter and related concepts. He used a total of 9 senior prospective chemistry teachers; 6 males and 3 females, with average of 22 years, they were interviewed on conservation of matter. The second part of the study involved the use of 173 prospective chemistry teachers. He administered to them questionnaire that was prepared based on the results obtained at the earlier stage.The subjects comprised 83 senior and 90 junior prospective chemistry teachers. He found that 61.85% of the subjects held misconceptions concerning atomic mass, while 15.03% had no understanding at all. Only 11.56% had sound understanding of the concepts. The most common misconceptions, is “the mass of an iron atom 55.85g”. Only 43.93% of the subjects held misconception here.The researcher thus concluded that prospective chemistry teachers do not have an appreciation of the small size of atoms, which according to Haider may affect the teachers' understanding of the concept of conservation of atoms. Thus, there was no meaningful learning about the atomic mass by most of the subjects used for the study. He went on to say that the subjects appeared to have stored the chemical terms in their memories, without internalizing it with their knowledge structure, which according the researcher is thecommon case when students do not understand given concepts. He inferred that students' misconceptions of atomic mass can be traced to defective instructionin which students are used to memorizing information from their Chemistry courses to answer questions related to the field of Chemistry. In this study, it was discovered that most of the subjects held misconceptions concerning genetic concepts.

Kikas (2004) carried out a study on the prevalence of misconceptions and consistency of their use across different tasks and topic areas and difference between various groups of subject teachers. The group of subject teachers he used were Physics and Chemistry (which he called Science teachers), Biology teachers he referred to as experts, primary teachers, trainee teachers and lastly the fifth group made up of a heterogenous group of teachers (History, Mother tongue and foreign language, Art, Music and Sports). These he called the Humanities. They acted as the control group, as according to her the humanities do not need the knowledge of science in their daily work. Her sample comprised of 30science, 28 experts, 57 primary, 32 trainees and 51 humanities. He used questionnaires which were made up of evaluation tasks and problem tasks for data collection. He found that too many misconceptions were found among trainees and primary teachers.The result of this studyshowed that most of the subjects held misconceptions concerning genetic concepts.

Oyeyemi, (1991) conducted a survey study on conceptions of genetic concepts held by senior secondary school students in Kwara state. One hundred and sixty (160) senior secondary 11 biology students, 80 males and 80 females were selected from some Local Government Areas of Kwara state. A fifteen (15) item Biology achievement test was administered to the respondents. Multiple Analysis of Variance (MANOVA) and Chi-square (X^2) statistical procedures were used to analyze the data collected. The study revealed a very low achievement in genetics by the respondents. The study further revealed that academic ability and subject area of specialization of the teacher had influence on students' achievement in genetics. The researcher advocates that teachers' area of problem be identified and that teachers should use appropriate instructional strategies to teach the learners, so that this can improve their teaching as well as their students learning. The result of this study, showed that Conceptual Assignments, Conceptual Change Discussions and Conceptual Change Discussions with Conceptual Assignments instructional strategies are capable of correcting and reducing students' misconceptions of genetic concepts.

Lakpini, (2005) in her research work correlates students' misconceptions in selected concepts under genetics and its implications for teaching. The objectives of the study were:-

i. to expose the misconceptions which students have in selected concepts in genetics;

ii. to highlight the implication of misconceptions to learning and teaching.

In her research work forty SS3 students comprising 23 males and 17 females were randomly selected prior to instruction. The subjects were given a set of ten validated questions on genetics to respond to by writing down their misconceptions.The result showed that for all the concepts the subjects had wrong explanations, which are misconceptions. In very few of the concepts, few students had fragments of acceptable biological explanation but these too were misconceptions. The most important implication of the study to teaching is that teachers must recognize that students come to science class with ideas, which are often different from those of scientists, and such ideas should be confronted through instruction. The implication of her study is that in biology, teachers must recognize that students come to science class with ideas and some of their ideas are often, different from those of scientists. If these ideas are not confronted, they can interfere with the learning of scientifically accept viewpoints. The result of this study showed that Conceptual Assignments, Conceptual Change Discussions and Enriched Conceptual Change Discussions with Conceptual Assignments instructional strategies are capable of correcting and reducing students' misconceptions of genetic concepts and improve students' performance in genetic concepts.

Gusau (1989) in his research work used Mole Concept Test (MCT) to predict students' performances in chemistry examination on selected schools in chemistry examination on selected schools in Plateau and Sokoto states presented a two-tier multiple choice test mole concept tests to predict student's performance in chemistry. The findings indicated a high positive relationship ofr = + 0.76 between students scores in mole concept test and their school chemistry assignment. And there is no difference in understanding of mole concept between SSII and SSIII students. The difference was significant at F ratio, calculated 5.70 and tabulated 4.07 at $P \leq 0.05$ level of significance. Comparatively, SS III students perform better both in factual knowledge and understanding in solving mole concept related problems. The studies found out that class attainment does not determine performance in mole concept test. That students' factual knowledge is not directly proportional to their reasoning ability in solving mole concepts related problems as most students gave correct answers requiring factual knowledge but failed to give correct reasons for selecting the answers.

It has been reported that Nigerian secondary schools'students found Biology as easier than Physics and Chemistry (NERDC). Mitchell (1992) was of the view that students perceived genetics as either an abstraction that has very little meaning to individuals, or as those magical scientific phenomena. Cirfat, (2005) also reported that biology is generally conceived by most students as the easiest science subject, thus it easily ranked as the most popular. He further explained that the massive failure received in WASSCE and NECO SSCE does not testify to its being easy (STAN, 2005; WAEC, 2005). As rightly noted by Ladon, (2005) efforts need to be geared toward removing the difficulties that contribute to the failures. He further explained that one of such effort is in the area of promoting the better learning and understanding of difficult concepts. From available researches, genetics has been identified as one of the difficult concepts to learn in biology (Johnstone and Mahmoud, 1982; Longden, 1982; Okpala, 1991 and

Oyetunde, 1982). The result of the present study showed that most of the subjects held misconceptions concerning genetic concepts.

Many researchers have worked on the difficulty of genetic concepts to teachers and students of biology. Abimbola, (1998) investigated the biology content area that biology teachers perceived as important but difficult for them to teach and reasons they gave for their perceptions. The investigator used a 50 items questionnaire designed from WAEC syllabus in Biology National Core Curriculum and some other textbooks for gathering his data. The researcher sampled teachers in Kwara state. Two hundred questionnaires were given out to teachers of biology but only 112 were filled and returned. The mean score and standard deviation were computed for each content area on their importance and difficulty. Some of the genetic topics were perceived tobe important and difficult to teach. His results coincided with the findings of Finley, Stewart and Yarroch (1982), Johnstone and Mahmoud (1980), and Longden (1982).The result of the present study showed that most of the subjects held misconceptions concerning genetic concepts which can becorrected and reduced by Conceptual Assignments, Conceptual Change Discussions and Enriched Conceptual Change Discussions with Conceptual Assignments instructional strategies and are capable of improving students' performance in genetic concepts.

Makanjuola (2002) also identified difficult topics in the senior secondary school certificate biology syllabus as perceived by students. The researcher used a Biology Topic Assessment Questionnaire (BITOAQ) consisting of 27 topics, which was administered on 93 students, made of 53 boys and 40 girls. Average Weight Response (AWR) of each topic was computed to determine a difficulty level. Simple percentage method was used to analyze the reasons for difficulty, while a t-test was used to test the gender difference in the perception of difficult topics at $P < 0.05$. The result showed that students identified 12 difficult areas while 15 topics were identified as not difficult. Sex had no effect on the perception of difficult topics. The researcher therefore, recommended that teachers should always try to complete the syllabus and use appropriate teaching strategies for their students' understanding of their teaching.

Okoye and Okechukwu (2006) examined the effect of concept-mapping and problem-solving strategies on achievement in genetics among Nigerian secondary school students. One hundred and thirteen senior secondary three (S.S III) students randomly selected from three mixed secondary schools located in Delta North Senatorial District of Delta state, Nigeria were used as subjects for the study. The experimental group was taught selected topics in genetics using concept mapping and problem-solving strategies while the control group was taught using the traditional lecture method. The result of the study showed that the experimental group performed significantly better in genetics than the control group and that gender does not affect performanceof students in genetics.

Goje (2007) in his study investigated the misconception of mole concepts and its relationship with academic achievement among chemistry students in senior secondary schools. He used samples of 211 senior secondary 111 chemistry students that were randomly selected. Five null hypotheses were used in his study. Two instruments, the Chemistry Achievement Test (CAT) and Mole Concept Test (MCT) were used in the collection of data.The data collected were analysed using Pearson Product Moment Correlation Coefficient (PPMCC) and t-test at 0.05 level of significance. He obtained the following results.

(1) There is significant relationship between students'understanding of the mole concept.

(2) There is significant relationship between male academic achievement and understanding of the mole concept.

(3)There is significant relationship between female academic achievement and the understanding of mole concept.

(4) There is significant difference between male and female students in the MCT and CAT at the SS111 level chemistry.

The researcher on the basis of his findings made some suggestions on the ways of improving understanding of the mole concept with a view to promoting better academic achievement in chemistry at senior secondary school levels and beyond. He further explained that lecturers of chemistry should concentrate on the effective teaching of concepts through meaningful learning as it has direct impact on academic achievement in chemistry and female students should be given special attention when teaching these concepts. The result of this study showed thatthere is significant difference in the mean scores of students taughtgenetic concepts usingconceptual assignments, conceptual discussions and enriched conceptual change discussions with conceptual assignments instructional strategies and those taught the same using the traditional instructional method. That is,the experimental groups performed significantly better in genetics than the control group.

Eryilmaz (2002) investigated the effects of conceptual assignments and conceptual change discussions on students' achievement and misconceptions about force and motion. The study was conducted with six physics teachers and their 18classes, consisting of 396 high school physics students. The teachers administered the Force Misconceptions and Force Achievement Tests to their physics students as a pretest. The results obtained were used to match the 18classes statistically. Students assigned to the conceptual assignment protocol completed five conceptual assignments about force and motion.

Students assigned to the discussion method participated in the conceptual change discussions.At the end of the 8-week treatment period, the same tests were administered to all the students as a posttest. The data were analyzed by using multivariate analysis of covariance, followed by protected univariate *F* test and step down analysis. The statistical results showed that the conceptual change discussion was an effective means of reducing the number of misconceptions students held about force and motion. The conceptual change discussion was also found significantly effective in improving students' achievement in force and motion.The result of this study also coincided with the findings of Eryilmaz (2002).

Baser (2006) in his study investigated the effectiveness of cognitive conflict based physics instruction over traditionally designed physics instruction on pre-service primary school teachers at grade 2. The subjects were 82 (27 boys, 55 girls) second grade pre-service teachers in two classes. One of the classes (42 students) was randomly assigned as experimental and the other class (40 students) assigned as control group. Both groups were taught by the same instructor. While the experimental group received cognitive conflict based physics instruction, control group were taught by traditionally designed physics instruction.

The data were obtained through Thermal Concept Evaluation test (TCE). Prior to instruction, students in both groups were pre-tested by TCE in order to determine their initial understanding of heat and temperature at the beginning of instruction. The same tests were applied as posttest after the instruction. Independent samples t-test on pre-test scores showed that there was no statistical significant difference between experimental and control group at the beginning of the instruction in terms of understanding of heat and temperature concepts. ANCOVA results showed that mean scores on the post-TCE of students in experimental group were significantly higher than those of the control group. While interaction between gender difference and treatment made a significant contribution to the variation in achievement, gender difference did not.The result of this study showed that there was no significant difference in the academic performance of the male and the female students who were taught using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Change Discussions with Conceptual Assignments instructional strategies.

Okoye (2016) investigated the influence of gender and cognitive styles on students' achievement in biology in senior secondary schools in Anambra State. One research question and one null hypothesis tested at 0.05 levelof significance guided the study. A causal comparative research design and a populationof 12,000 (SSII) biology students in sixty-four government – owned secondary schools in Awka Education zone. The sample of the study consisted of 265 SSII biology students (141 males and 124 girls) drawn from four government owned schools comprising of two (2) boys and two (2) girls' school in Awka education zone. The sample was drawn using disproportionate stratified random sampling technique. Two instruments were employed for data collection namely: Group Embedded Figure Test (GEFT) and Biology Achievement Test (BAT). GEFT was used to assess the cognitive styles of students as either field -dependent or field independent. It is a standardizedinstrument with a reliability of 0.89 on a test re-test method. BAT content validity was ensured by a test blueprint while face validity was ensured by two biology educators and one expert in measurement and Evaluation from the Science Education Department, University of Nigeria, Nsukka. The reliability coefficient of BAT was established using Cronbach Alpha which gave 0.86. Mean and standard deviation was used to answer the research question while one-way Analysis of variance (ANOVA) was used to test the null hypothesis. Result showed among others: that gender and cognitive styles has no significantinfluence on achievement scores of students in biology.The result of the present study showed no significant difference in the academic performance of the male and the female students who were taught using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Change Discussions with Conceptual Assignments instructional strategies.

Lawal (2009) worked on the effectiveness of conceptual change instructional strategy in remediating misconceptions in genetic concepts among senior secondary school students in Kano State. The study was set to identify common misconceptions that Senior Secondary Two (SSII) Sudents of Biology habour about the concepts of genetics, and to ascertain whether conceptual change instructional strategy would remediate these identified misconceptions. The study sample of 218 SSII students was drawn from two girls' and two boys'secondary schools, randomly selected from all secondary schools in Kano metropolis. The subjects were divided into two groups: the experimental group of 118 and the control group of 100 students.The study adapted the pretest-posttest experimental and control group design. A pretest was administered before the treatment to establish the equivalence of the experimental and control groups. The subjects in the experimental group were then exposed to the treatment using conceptual change instructional strategy, while the control group was exposed to the traditional instructional strategy for a period of six weeks. The topics covered were cell, cell structure and function and cell division. The researcher emphasized that these topics have been established by researchers to be difficult for students to learn (Johnson and Mahmood, 1980 Tsui and Treagust, 2002).Misconception Test in Genetic Concepts (MTGC) Genetic Concept Achievement Test (GCAT) Instuctional Attitude Change Questionnaire (IACQ) were the three instruments developed and used for data collection. Seven null hypotheses were tested. The data collected were analyzed using t- test, independent sample statistic was used to test the hypotheses on achievement and retention. Mann –Whitney U test was used to test attitude change of the subjects to the conceptual change instructional strategy used. The statistical results showed that:

1. senior secondary II students in Kano metropolis habour a number of misconceptions in genetics.

2. the misconceptions can be shifted positively using conceptual change instructional strategy to teach the biology concepts.

3. there was a significant difference in the retention ability of the students taught genetic concepts using the conceptual change instructional strategy compared to those taught the same using traditional instructional strategy.

On the basis of her findings, the researcherrecommended that the use of conceptual change instructional strategy should be encouraged among secondary school teachers of biology. She further explained that this would help shift positively misconceptions students habour about concepts in biology and science in general.

1. This present research work is unique in that itwas aimed at remediating identified misconceptions using conceptual assignments and conceptual change discussions instructional strategy.
2. The use of conceptual assignments and conceptual change discussions is new so the findings of the study will be instructive on the possibility of adopting the strategies in teaching as well as in correcting misconceptions among students in Nigerian secondary school. The study also investigated the effect of gender and retention onshifting misconceptions among SSIII biology students using conceptual assignments and conceptual change discussions instructional strategy.
3. The variables investigated by the researchers' work reviewed, the instructional strategies and the populations for the studies are not the same with the present study.The findings in the present study provide insight into the effects of these variables in shifting misconceptions thus improving learning among science students in general and biology in particular.

Nbina and Avwiri (2014) in their study examined the relative effectiveness of context-based teaching strategy on senior secondary school students' achievements in inorganic chemistry. The sample consists of 451 SSII chemistry students (224 males and 227 females) drawn from four out of 46 secondary schools in Port Harcourt Zone in Rivers State of Nigeria. Three research questions were answered and three null hypotheses were formulated and tested at the 0.05 level of significance. Stratified random sampling techniques were used in selection and classification of the sample into the experiment and control groups.

Inorganic Chemistry Achievement Test (ICAT) was employed in data collection. The instrument was validated and its reliability coefficient was 0.56. The ICAT instrument was administrated on both the pre-test and post- test. The data obtained from the administration of the instrument was analyzed using mean, standard deviation and analyses of covariance (ANCOVA). The study found out that context –based teaching strategy was significantly better than the expository method in enhancing students' transfer of learning in inorganic chemistry. The result also showed that there was no significant difference in the mean achievement scores of male and female students taught inorganic chemistry using the same method. In the same vein, the rural students performed significantly better than their urban counterparts taught using the context-based teaching strategy. Based on the findings, recommendations were made among which were that context-based teaching strategy be adopted in teaching and learning of inorganic chemistry in the secondary and tertiary levels of the educational systems.The result of the presents study also coincided with the findings ofthis study.

Madu and Orji (2015) investigated the efficacy of cognitive-conflict-based physics instruction over the traditionally designed physics instruction on students' conceptual change in heat and temperature. The subjects were 249 senior secondary II students from 2 schools purposively sampled from 12 secondary schools. The 2 schools sampled had well-equippedlaboratory, experienced physics teachers, and two intact classes. One of the intact classes in each school was assigned to control group. In one school, there were 70 subjects for experimental group and 60 for control group, while in the other school, there were 60 for experimental group and 59 for control group. Both groups were taught by the same teacher, and this lasted for 6 weeks of intensive treatment. The experimental group received cognitive-conflict-based instruction, while the control group received traditionally designed physics instruction. The instrument for obtaining the data was Thermal Concept Evaluation (TCE). Students in both groups were pretested using TCE to establish their level of initial understanding of heat and temperature. At the end of the treatment, the same test was administered as posttest. The data generated from the TCE were analyzed using frequency and chi-square statistics, indicating that the level of understanding of heat and temperature was significantly dependent on the treatment.The result of this present study showed thatthe experimental groups performed significantly better in genetics than the control group. That is, there is significant difference in the mean scores of students taught genetic concepts using conceptual assignments, conceptual discussions and enriched conceptual change discussions with conceptual assignments instructional strategies and those taught the same using the traditional instructional method.

Bello, (2011)investigated the outcomes of using group instructional strategy on learning of Physics in senior secondary schools in Nigeria and also determined whether group instructional strategy will improve the performance of below average ability students. By the use of purposive sampling, 365 senior secondary school year one Physics students were selected from a school of science, in Ile-Ife, Osun State, Nigeria for the study. The study design was pre-post-test control experimental. A validated Physics achievement test consisting of ten theory items was used for data collection, and the data collected were analyzed using t-test. The study revealed that those exposed to group instructional strategy performed better than those exposed to individual learning treatment; the below-average students exposed to group instruction have gain score over what they scored when not exposed to this method, which shows that there was improvement in their performance hence, more understanding of the Physics concept. Also, there is a significant difference in the collective work done by students exposed to group instruction and their performance individually revealing that the students gained better when they worked assignments together than when it is done individually. Furthermore, the individual who submitted class work in the group learning treatment did better than their counterparts in the individual learning treatment.

Khurshid and Ansari (2012) investigate the effects of innovative teaching strategies on the performance of students of grade 1. The experiment was done on the teaching of science subject to the students of grade 1.A sample of 50 students (boys and girls) was selected randomlyout of the population of 100 students in grade 1 from an English medium school of Islamabad. Two groups of 25 students each were made. Pre-test of General Science was given to both the groups and the results were recorded. One group was taken as a control group which was taught science by the teacher who used conventional method of teaching while the other i.e the experimental group was taught by the teacher who used innovative teaching techniques. After one month's time of teaching, a post-test was conducted. It wasfound that after one month the students (n=25) who were instructed using modern teaching techniques achieved significantly higher scores on science test than did the students (n=25) whose instructions were done on traditional/conventional method. In this study the conceptual assignments and conceptual change discussions and the traditional lecture method was used to teach genetic concepts to senior secondary school three biology students. Pre-test and post-test were used to assess students' performance and the results were compared to find the effectiveness of each instructional strategy.

2.9 Implications of Literature Reviewed for the Present Study

Evidences abound that there is a large body of research on misconceptions on the part of the teachers and students in respect to a variety of science subjects in general and biology in particular Eryilmaz 2002; Lakpini,2005; Goje 2007; Lawal 2009). All the researchers above agreed that misconceptions exist in science subjects and that teachers hold a number of conceptual errors which are prevalent among secondary school students. The studies also revealed the existence of a number of misconceptions in categories of learners, primary through to tertiary even among teachers and pre-service teachers (Asim, 2002; Kikas, 2004). The present study used the conceptual assignments and conceptual change discussion instruction strategies to remediate the misconceptions held by the students.

James (2000), Alausa (2001), Makanjuola (2002), Nzewi, Etokebe, Pati and Akpan (2003), Ruiyong (2004), Lakpini (2005), Nwaorgu (2005), Cirfat (2005), Okebukola (2005) and Ahmed (2007) Mahm (2008) Lakpini (2009) Lawal (2009) all worked on genetic concepts. Their work revealed that genetic concepts of biology are difficult for the biology teachers and students in secondary schools. These studies are related to the present study in that the present study is viewing the effect of conceptual assignments and conceptual change discussions on students' misconceptions, retention and academic performance in genetics in senior secondary schools.

An attempt has also been made in this review to discuss the stages of cognitive development with reference to the characteristics of each cognitive stage and their theoretical backgrounds. Besides, attempts have been made to discuss differential gender achievement in science. It is important to note that the performance of learners irrespective of gender differences in any content area, when critically examined is a function of the instructional strategy employed by the teacher in the classroom, students reasoning ability and the environmental factors.

The instructional strategy to a large extent could either positively or negatively influence the performance of the learner (Geary, 2005). Lawal (2009) confirmed lecture method to be an inappropriate method and which is mostly used in science teaching. Research findings of science educators like Okebukola (2002), Tsui and Treagust (2002), revealed that those teaching methods that are activity- oriented and that involved the learner taking active role in the teaching/learning process result in better learning and understanding of science concepts on the part of the learner. Moreso, researches in science education have shown the inadequacies of lecture method of teaching and learning of science concepts. Lawal (2009) opined that the overall picture resulting from the use of this approach in the teaching of students is that the students tend to come out with large number of misconceptions which result in poor performance and as such poor interest in science and science related courses.

Okebukola (2002) and Kikas (2004) suggested that for learners to overcome their misconceptions, they must first construct another potentially contradictory, better explanation, based on aspects of their knowledge structure which are familiar to them. Ajaja and Kpangban (2000) asserted that what the students know or do not know depend mainly on the teacher. Okoye and Okechukwu (2006) also worked on the effect of instructional strategies on achievement in genetics among Nigerian secondary school students.

Generally, the literature has also shown that traditional instruction, which does not take into account the existing beliefs of students, is largely ineffective in changing students' naïve scientific ideas (Baser, 2006;

Eryilmaz, 2002; Yeo & Zadnik, 2001; Madu and Orji, 2015). However, conceptual change research has led to the development of a variety of teaching methods and strategies which encourage students to actively reflect on, and evaluate,their existing knowledge (Yeo & Zadnik, 2001). Among others, one of such strategy is Conceptual Assignments and Conceptual Change Discussions instructional strategy.

From the literature reviewed, it was observed that several studies were carried out on misconception but the aspect of the use of survey design to ascertain the frequency and percentages of misconception was limited. Also,their studiesused only onetreatment such as Eryilmaz (2002); Baser (2006) and Lawal (2009).The aspect of using multiple treatments such as Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Change Discussions with Conceptual Assignments Instructional Strategieswas used in this study to fill the gap by:

i. investigating the misconceptions of genetic concepts that exist among the senior secondary school III students in Rigachikun Educational Zone of Kaduna State.
ii. determining the effects of conceptual assignments and conceptual change discussions on students' misconceptions, retention and academic performance in genetics in senior secondary schools in Kaduna State.
iii. determining the effect of conceptual assignments and conceptual change discussions on male and female students' retention ability of the genetic concepts at SS3 level.

The literature reviewed has brought to light the need to undertake further in depth researches on problems militating against proper understanding of scientific concepts and especially in this case the genetic concepts in biology and to establish whether or not misconceptions of genetic concepts in biology has relationship with academic performace of the students. It is hoped that the result of this study will bring about improvements in the performance of the students in biology at Senior Secondary School Certificate Examinations (SSSCE).

CHAPTER THREE

METHODOLOGY

3.1 Introduction

In this chapter, the research design and procedure for data collection were described. The study investigated the effects of conceptual change instructional strategies on secondary students' misconceptions, retention, and academic performance in genetics in Kaduna State, Nigeria. This chapter is presented in the following subheadings:

3.2 Research Design

3.3 Population of the study

3.4 Sample and Sampling Procedure

3.5 Instrumentation

3.5.1 Validation of the Instruments

3.5.2 Pilot Testing

3.5.3 Reliability of the Instruments

3.5.4 Item Analysis of the Instruments

3.6 Treatment Packages or Models

3.7 Administration of the Treatment

3.8 Data Collection Procedure

3.9 Procedure for Data Analysis

3.2 Research Design

The study was of two parts survey and experimental study. The first part was survey design in form of descriptive method to identify the misconceptions' students' hold about genetic concepts in Biology. The finding of the first part was used to develop and design the research instrument for the main study, which is the second part of the study. The second part of the study utilized a quasi-experimental pretest, post test and post post test, control group design. This design was used to investigate the effect of exposing the experimental groups to treatment conditions. Quasi-experimental design will approximate the conditions of true experiment in a setting which does not allow total control and manipulation of all relevant variables.

In the design, three experimental groups $EG_{I,}$ EG_2 and EG_3 were exposed to treatment conditions in terms of teaching strategies used. EG_1 was taught genetic concepts using conceptual assignments strategy while EG_2 was taught the same concepts using conceptual discussions and EG_3 was taught the same concepts using conceptual assignments and conceptual change discussions instuctional strategy. The treatment conditions given to $EG_{1,}$ EG_2 and EG_3 were denied to the control group (CG) who was taught the same genetic concepts using the traditional lecture method the four groups under study were pre and post-tested to determine the change that occured in terms of academic performance in genetic concepts following the treatment. The pre-test was used to find out if the three groups (EG_1, $EG_{2,}$ EG_3 and CG) are equivalent in the knowledge of genetic concepts before the instruction is given and also to investigate the existence of misconception in genetics among the senior secondary school students.

The post-test was used to determine the effect of treatment, if any, on the three experimental groups in relation to the control group.The post- test group mean scores and the standard deviations of male and female subjects were computed and subjected to ANOVA to find out if there is any significant difference in performance that could be attributed to gender.

The post, post-test was used to investigate the level of retention two weeks after instruction, as recommended by Broker (1974) and Haist et al (in Bichi, 2002). The research design for this study was presented in figure 3.1

The 4-group design was used in this study, viz: -

EG_1 ----------->O_1---------------->X_1------------->O_2--------------------->O_3

EG_2------------>O_1---------------->X_2------------->O_2--------------------->O_3

EG_3------------>O_1---------------->X_3------------->O_2--------------------->O_3

CG------------->O_1---------------->X_O------------->O_2--------------------->O_3

Figure 3.1

Where:

EG_I= Experimental Group1

EG_2 = Experimental Group 2

EG_3 = Experimental Group 3

CG = Control Group

X_1 = Conceptual Assignments

X_2 = Conceptual Change Discussions

X_3 = Enriched Conceptual Change Discussions with Conceptual Assignments

X_o = Traditional Method

O_1= Pre-test

O_2 = Post-test

O_3= Post, Post-test

3.3 Population of the Study

The population of this study was from the state Government owned Senior Secondary Schools SSS three offering Biology located within RigaChikun Educational zone, Kaduna State. The spatial extent of the study area; RigaChikun Education Zone encloses Kaduna North, Igabi, Chikun, Soba and Kauru Local Government Areas of Kaduna State and is bounded to the North by Zangon Aya, due to this spatial coverage, Rigachikun Educational Zone habitats schools that spread across Igabi, Kaduna North, Chikun, Soba and Kauru Local Government Areas of Kaduna State demarcated by the Kaduna State Ministry of Education for easier management. In essence, population for the study is from schools within the geographic entity of RigaChikun inspectorate division when the five Local Government Areas are juxtaposed.

The population of this study consisted of all the governmentSenior Secondary three (SS3) biology students in the Rigachikun Education zone of Kaduna state of Nigeria. The total SS3 students' population was

2854 which comprised of 1620 males and 1234 females distributed in nineteen secondary schools as shown in Table 3.1. These students are regarded as suitable for the study by the virtue of their age and academic experience. Their average age is 18 years.There are nineteen Kaduna State Government owned secondary schools in RigaChikun Education zone listed in Table 3.1.eighteen of these schools are co-educational while one is single sex (i.e. females only).The accessible population was all third-year Senior Secondary Schools biology students in Riga Chikun Educational zone of Kaduna state, Nigeria.The schools under study were homogenous with similar conditions in terms of staff, provision of equipment, instructional materials, students' enrolment, curriculum, academic calendar and supervised by the same educational sector. The detail of the population is presented in Table 3.1

Table 3.1 Population of the Study

S N	Name of school	Type	NO. of SS3 Male	Biology Female	Students Total
1	G.S.S Turunku	Co-Edu	25	5	30
2	G.S.S Gamagira	Co-Edu	55	7	62
3	G.S.S Rigachikun	Co-Edu	188	142	330
4	G.S.S Dandaura	Co-Edu	95	11	105
5	D.G.S.S Dalet Barracks Kawo Kaduna	All girls	-	280	280
6	G.S.S HayinBanki	Co-Edu	215	265	480
7	G.S.S.Sabon Afaka	Co-Edu	283	180	463
8	G.S.S Jaji	Co-Edu	57	47	104
9	G.S.S ZangonAya	Co-Edu	79	19	98
10	G.S.S BirniYero	Co-Edu	143	75	218
11	G.S.S RafinGuza	Co-Edu	140	112	252
12	G.S.S Tsohon Afaka	Co-Edu	40	13	53
13	G.S.S Wusono	Co-Edu	49	22	71
14	G.S.S Gurbabiya	Co-Edu	28	-	28
15	G.S.S Farakwai	Co-Edu	20	12	32
16	G.S.S Buruku	Co-Edu	30	18	48
17	G.S.S GadarGiyan	Co-Edu	73	4	77
18	G.S.S Sabon Birni	Co-Edu	16	3	19
19	G.S.S.Katabu Maraban Jos	Co-Edu	85	19	104
	Total		**1620**	**1234**	**2854**

Source: Kaduna State Ministry of Education: Education Inspectorate Unit, (2016)

Samples and Sampling Procedure

Simple random sampling technique was used to select the sample classes for this research, employing balloting method. Six schools were picked from the nineteen Government secondary schools in RigaChikun Education Division of Kaduna state. The nineteen Government secondary schools in Riga Chikun Education Division of Kaduna state are made up of one single sex school and nineteen co-educational schools. The study subjects were chosen because the genetic concepts are not new to the students. The senior secondary school three students have the average age of 18years. A class was chosen from each of the schools and a pretest was administered to the six schools for the purpose of comparability of ability level and the result was subjected to Analysis of Variance (ANOVA) and Scheffe's Test. Four schools that show no significant difference based on the result were selected.Simple random numbers were used in drawing the schools to experimental and control groups. If a school falls into the experimental or control group, all the students of that particular school were treated as such.

In each of the schools the science class (an intact class) was used for the study. This is because the schools have only one science class each in the SS3 offering science subjects. The study was guided by Central Limit Theory recommendation by Tuckman (1975), Dana (2000), Fraenkel & Wallen (2000), Sambo (2008) and John & James (2011) which proposed that thirty or more subjects are considered as large sample for experimental research of this nature. The sample size for the four groups were students in experimental groups and students in the control group.

Table 3.2 Sample for the Study

S/No	Group	Subject (N)		
		Boys	Girls	Total
1.	EG1	22	18	40
2.	EG2	23	24	47
3.	EG3	30	17	47
4.	CG	30	18	48
	Total	105	77	182

3.5 Instrumentation

The following instruments were developed by the researcher and used for data collection.

1. Genetic Misconception Test (GMT) which was used to collect data on students' misconceptions.
2. Genetic Performance Test (GPT) which wasused for pretest, posttestand post posttest.

3.5.1 Genetic Misconception Test (GMT)

Genetic Misconception Test (GMT) instruments were used to determine areas of misconception of genetic concepts among the students tested. The Genetic Misconception Test (GMT) was designed to identify the misconceptions students hold about genetic concepts at the SSS three level. The GMT was made up of total of twenty test items (short answer theory questions) which allowed the students to express themselves freely were used by the researcher. These questions were set to probe into the students' knowledge of the Transmission and expression of characters in organisms.Chromosomes: the basis of heredity Probability in genetics. Application of the principles of heredity in agriculture and in medicine.

3.5.2 Genetic Performance Test (GPT)

The Genetic Performance Test instrument (GPT) was used to determine students'performance and retention of genetic concepts.The GPT test items was developed by the research based on the findings from the Genetic Misconception Test (GMT), which was first administered to SSS three students from selected schools in the study area. The aim was to identify their misconceived ideas. These misconceived ideas were used as distracters in the construction of the GPT test items.The instruments and the marking schemes were constructed by the researcher and validated by experts in Department of Science Education. The Genetic Performance Test consists of forty (40) multiple choice questions which included the following topics. (i) Transmission and expression of characters in organisms (ii) chromosomes: the basis of heredity (iii) probability in genetics (iv) application of the principles of genetics in agriculture and medicine as shown in table 3.2 below.

Table 3.3 Items Specification in Genetic Performance Test

S/No	Topics	Number of GPT Items
1	Transmission and expression of characters in organisms	1,3,4,5,6,7,8,9,10,12,13,23,24,27&36
2	Chromosomes: the basis of heredity	11,14,15,16,17,18,19,20,21,22,25,26, 28,29,33&40
3	Probability in genetics	31, 32, 34, 35 &37
4	Application of the principles of heredity in agriculture and medicine	2, 30, 38 &39
	Total	40

Table 3.4: Specification for Item Based on Bloom's Taxonomy in the Cognitive Domain

S/N	Topic	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation	Total	Percentage
1	Transmission and expression of character in organisms	1, 3 &4	12	7, 8, 9, 24, 27 & 36	10 & 23	6	5 & 13	15	39.5
2	Chromosomes: the basis of heredity	14 & 20	11, 15, 18, 21, 22, 25, &28	29	16, 19 & 26	40	17 & 33	16	40
3	Probability in genetics			32		31	34, 35 & 37	5	12.5
4	Application of the principles of heredity in agriculture and medicine		38	2 & 39			30	4	10
	Total	**5**	**9**	**10**	**5**	**3**	**8**	**40**	**100**

3.5.1 Validity of the Instruments

The content validity of Genetic Performance Test and Genetic Misconception Test (GPT and GMT) and the marking schemes were assessed by a panel of experts that include the following:

a. three senior lecturers in the department of science education.

b. two biology teachers at the senior secondary school level that are NECO and WAEC examiners.

They were requested to critically examine and assess all the items of the instrument with reference to the following:

1. Whether or not the items conform with the subject matter they are supposed to test.
2. Whether or not the items are clear, readable and free from ambiguity for the level of students they are designed to test.
3. Whether or not the items satistify conditions for constructing multiple choice items.
4. To eliminate ambiquity and assess clarity of the test items
5. What general criticisms and suggestions could you give for the improvement of the instrument?

The face validity of the instrument was through the imputs from three Senior lecturers in Science Education and two biology teachers at the senior secondary school level that are NECO and WAEC examiners that were requested to examine the items of the instruments in relation to the following:

(a) whether or not the items test the basic ideas and concepts in genetics expected at the Senior Secondary School level.

(b) whether or not the ideas tested by the instruments are relevant to the pre-requisite to the introductory genetics at the University level.

(c) whether or not there are general criticisms and suggestions that could be used to improve the instruments.

The Secondary School Biology Teachers translate the biology curriculum at the classroom level. Their experience was sought to improve the items of the instruments. Specifically, they were requested to assess the items with reference to the following criteria. That is, whether the items:

1. relate to Genetic Concepts of the Senior Secondary School Biology syllabus.
2. are readable, appropriate and are neither too hardor too simple to Senior Secondary School Biology students.
3. attract criticism and suggestions that would be helpful in improving their quality.

The panel members examined the test items of Genetic Misconception Test (GMT) and Genetic Performance Test (GPT) in relation to the term of reference outlined above. Feedback from the panel members provided useful and constructive suggestions on the basis of which any of the items may be eliminated, reframed or modified in order to certify that the test items are of standard and free from ambiguity.During validation, the general information before section A (Biodata) was reframed. The biodata was also corrected. Question 13 was reframed. Question 33 was also corrected by transferring option D from page 148 where it was hanging to page 147. Difficulty and problem areas observed in the test were carefully noted from the result of the pilot test. Questions 6, 11, 13, 17, 23, 34 and 39 were reframed and accepted and questions 4, 8, 9, 14, 20, 27 and 34 were discarded.The corrections were made accordingly and the instruments were employed for the research work.

3.5.2 Pilot Testing

A pilot study was conducted using 30 students selected from Government Secondary School, Riga Chikun Kaduna. The study was intended to determine the reliability and feasibility of the test instruments. The choice of students was similar to the ones used for but not part of the one that used for the study. The pilot trial school was part of the study; this was to prevent the study subjects from having an idea of the instruments. The researcher personally administered the GMT test to the students to find out the misconceptions students hold in genetic concepts after which the GPT questions were constructed and administered to the students. The time to complete the exercises was 60minutes. The test– re–test method within two weeks (Tuckman, 1975; Sambo, 2008) was used and the data obtained were analyzed using

Pearson Product -Moment Correlation Coefficient (PPMCC) to establish the reliability of the instuments.The coefficient of GPT was calculated to be 0.82 and that of GMT was calculated to be 0.81. The students completed the test items in one hour (1hr). Data collected from the pilot study was used for item analysis.

3.5.3 Reliability of the Instruments

Reliability of a test is the degree of error or precision (in measuring an estimate) of a test (Odama, 1982). A test is said to be reliable if repeated measurements using the test gives more or less the same results. The reliability coefficient of the Genetic Achievement Test was determined by subjecting the scores obtained from the pilot study to Pearson Product Moment Correlation Coefficient to calculate the reliability coefficient. Before the administration of pretest and post test items, it is necessary to establish the reliability of the instrument. A study was conducted to establish the reliability of the instrument. Test retest reliability was used employing Pearson Product Moment Correlation Co-efficient statistics. A class was selected from the schools within the target population for reliability test. The test was administered at first and second occasion under the same condition as the first one.To test for reliability of the instruments Genetic Performance Test and Genetic Misconception Test, test-retest method within the interval of two (2) weeks in line with Tuckman, (1975) was employed and Pearson Product Moment Correlation Coefficient was used to determine the reliability of the instruments.

The reliability of instruments Genetic Misconception Test and Genetic Performance Test ,using PPMC test re test was found to be r = 0.81 and 0.82 respectively which indicate high correlation between the tests. The results obtained therefore showed the suitability of the test items for the study.This shows that the instruments are reliable for the main study. This was a confirmation of test of reliability by Spiegel (1992), Stevens (1996) and Olayiwola (2010). According to them an instrument is considered reliable if it lies between 0 and 1, and that the closer the calculated reliability coefficient is to zero, the less reliable is the instrument, and the closer the calculated reliability co-efficient is to 1, the more reliable is the instrument. This therefore confirms the reliability of the data collection instrument used as fit for the main work.

3.5.4 Item Analysis of the Instruments

The procedure for item analysis was as follows:

The data collected from the pilot testing was analysed to determine the difficulty and discrimination indices of each item and the reliability coefficient of the instrument as a whole. During the pilot study, the instrument was used to collect data on trial basis. The data obtained were analysed to determine the indices of difficulty and discrimination of each of the forty items of the draft. Students' responses to each item were analysed with a view to determine the two indices.

3.5.4a The Facility Index (FI)

The Facility Index (FI) (Difficulty Index) gives the difficulty level or the ease of answering an item and is derived by the formula:

Facility Index = R/T

Where

R =The number of correct responses

T =The total number of students.

Using this formula, the difficulty indices of all the test items were calculated along with their corresponding discrimination indices and presented in tables. Items with Facility Index of between 0.3 and 0.8 were recommended and considered by Satterly (1986),Frust (1958), Oyebanji (1978), Lakpini (2006), as adequate for selecting good test items for achievement test. In this study,after the analysis all the items with difficult indices below 0.2 were discarded for being too difficult while those with indices of 0.20 to 0.35 were selected for the final GPT instrument with some modification or reframing. Items with indices of 0.25 to 0.75 were selected without any modification, while those with indices above 0.75 were modified and accepted. Details of the selection iscontained in Appendix I.

3.5.4b Discrimination Index

Discrimination index indicates the discriminating power of each of the test items, differentiating between high and low marking of the learners in the whole test. That is discriminating between good and not so good performers. The discrimination index for each of the items were computed by subtracting the number of students in the lower group from the number in the upper group who got the item correctly or wrongly. This calculation was done using scores of the top twenty seven percent (27%) and bottom twenty seven percent (27%) of the total respondents.The number was divided by the number of students in the upper group.The discrimination index of the GPT was calculated using the formula given by (Frust in Lawal 2009)

$$D.I \quad \frac{Ru \quad R_I}{{}^1/_2\, N}$$

Where	d	=	discrimination index
	Ru	=	number among upper 27% of respondents
	R_I	=	number anmong lower 27% of respondents
	N	=	total number of respondents

Using the above formula, the discrimination indices of all the forty items of the GPT were calculated and presented in a table. According to Frust, (1958) and Usman (2008), items in a test with discrimination indices between0.3 to 0.49 were considered moderately positive while those with discrimination indices of 0.49 are highly positive and if solely used, well informed subjects will get the test items right than the poor ones. According to Ebel (1965), items in a test with discrimination indices of 0.40 and above are very good, 0.25 to 0.75 reasonably good; 0.20 to 0.29 marginal items that need improvement and items below 0.19 as poor items to be discarded. Ebel's (1965), criteria of evaluating discrimination indices was used to select items for final GPT. On the basis of these criteria, items marked ** in the table were discarded while those marked RR were reframed and accepted. New items were drafted to replace the discarded items to make up forty items of the instrument. The discriminatory indices of a range between. 0.30 to

0.70 is regarded as moderately positive and was accepted for the present study. This was used in selecting the final items of the test (GPT). See Appendix I

3.6.0 Administration of the Treatments

The teaching of the genetic concepts was done by trained research assistants. This is to ensure effective utilization of the model and also to ensure that teaching procedure is in accordance with the direction of the model. A letter seeking for permission was taken to the principals of the selected schools to administer the research instruments. The first lesson in the classes was used for revision and familiarization of the research assistants with the students and at the same time, revising the previous related work. In addition, the pretest was administered to ensure that the students were of the same ability level.The teaching lasted for a period of six weeks of 80 minutes (2 periods), twice a week. All teaching for the experimental group 3 (E_3) took place in the laboratory because of the activity nature of the teaching strategy. In addition, laboratory equipment like hand lens, camel hair brush, breeding bottles, microscope etc were used.

Before the commencement of the teaching, the genetic misconception test was administered to the students in the experimental and control groups and their responses were collected. The Genetic Performance Test was also administered before the commencement of the teaching as pretest. The students in the experimental groups were provided with the instructional package containing the instructions that was used in order to prevent any bias that might arise from socio-economic background of the subjects.

The treatments were administered in this study using the following models or packages.

3.6.1 Conceptual Assignments

3.6.2 Conceptual Change Discussions

3.6.3 Enriched Conceptual Change Discussions with Conceptual Assignments

3.6.0 Experimental Groups:

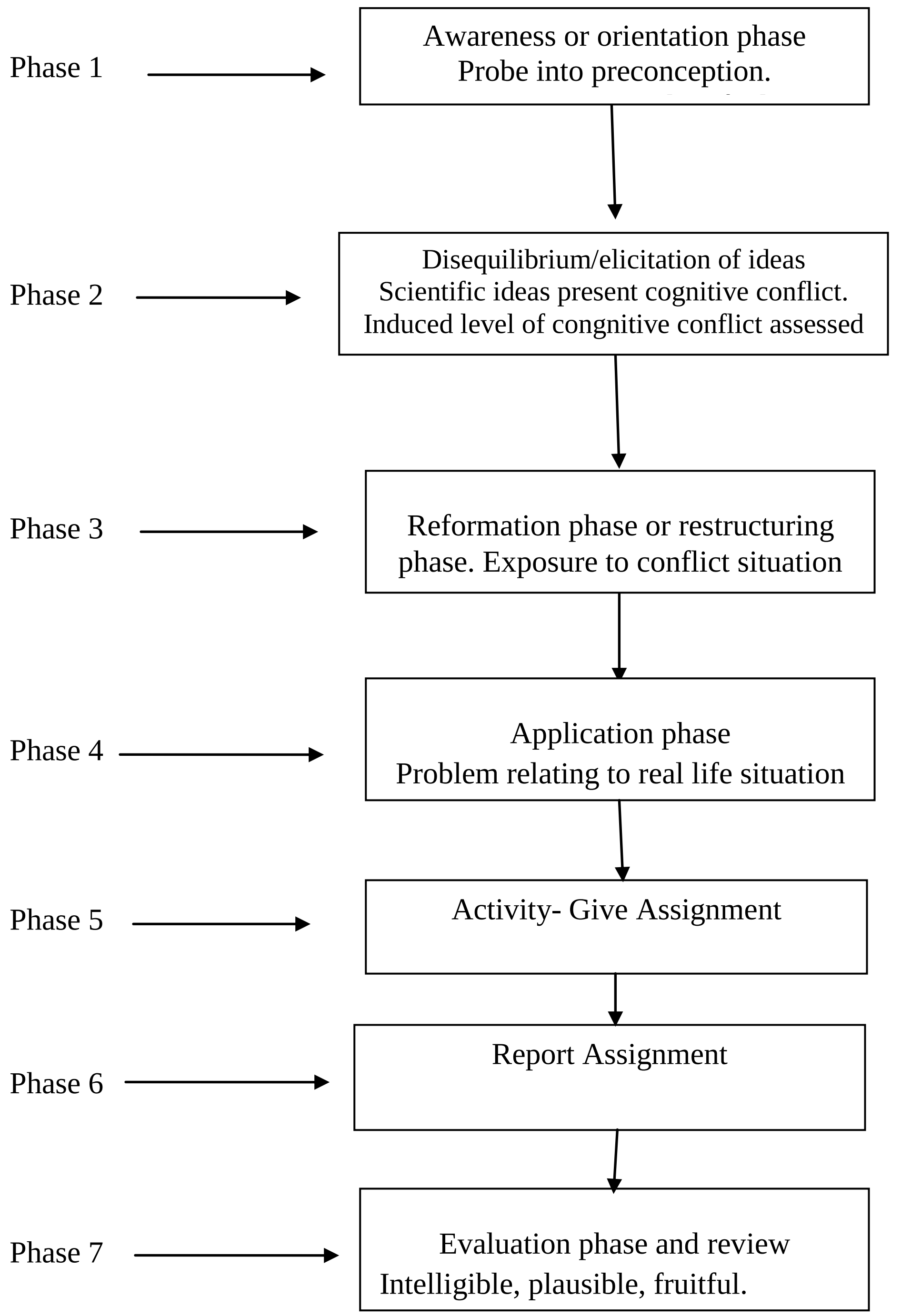
The subjects in the experimental group 1 (EG_1) were given assignments while the experimental group 2 (EG_2) and experimental group 3 (EG_3) were divided into sub groups made up of five members in each subgroup. The assignments of members to these subgroups were done using the result of the pretest as a guide each group included members that scored high, average and low marks in the pretest. This is to ensure an even distribution in terms of their level of performance. The researcher used one lesson to acquaint the subjects in the experimental groups with objectives of the conceptual change instructional strategy.

The experimental groups were then exposed to the teaching using the conceptual assignments and conceptual change instructional strategy. This comprised of laboratory work, assignments and discussions. Each session started with brainstorming questions aiming at eliciting and highlighting the existence and nature of competing viewpoints. The subjects were allowed to learn the concepts in question through practical activities and small group discussions. In exploration session, they were asked focusing questions meant to lead them to observe and discuss their experiences. Illustrations of conceptions were providedto counter experiences from their naïve conceptions. Discrepant ideas stimulated the students to articulate inconsistencies and discrepancies between the phenomenon under consideration and their own previously held ideas. The students were allowed to discuss their results as well as present and answer questions on their final decisions. Important decisions were written out by the leaders of the groups on the cardboard papers in each group. Correct theoretical explanations resulting from the discussions of the results were written out by selected subjects on separate part of the chalkboard and emphasized. The aim was to re-enforce appropriate scientific conceptions and possibly change students' misconceptions. The students were then asked to compare their previously held views with the correct views, critiquing it thoroughly as written out on the chalkboard. They were also allowed to suggest alternative explanations and compare them with their previous ideas. The new ideas were tested against scientifically accepted ideas and their thinking nurtured towards scientific descriptions to help bring about re-conceptualization. Students were given a number of exercises to help determine the status of their newly constructed scientific conceptions.

Assignments were given to the students on the next topic after each lesson in preparation for the next lesson.

3.6.1 Experimental Group I: Conceptual Assignments Instructional Strategy

This involves the use of Conceptual Assignments Instructional Strategy in which the teacher gives conceptual and thought provoking questions and activities to the students twice a week for a period of six weeks. The students in the Experimental Group 1 were also provided with the instructional package containing the instructions that was used in order to prevent any bias that might arise from socio-economic background of the subjects. Instructional aids were also provided to carry out all the activities related to each topic. The students answered the various questions and carried out the activities individually and submitted the assignments to the teacher for marking every week. The detail of the lesson note is presented in Appendix E.

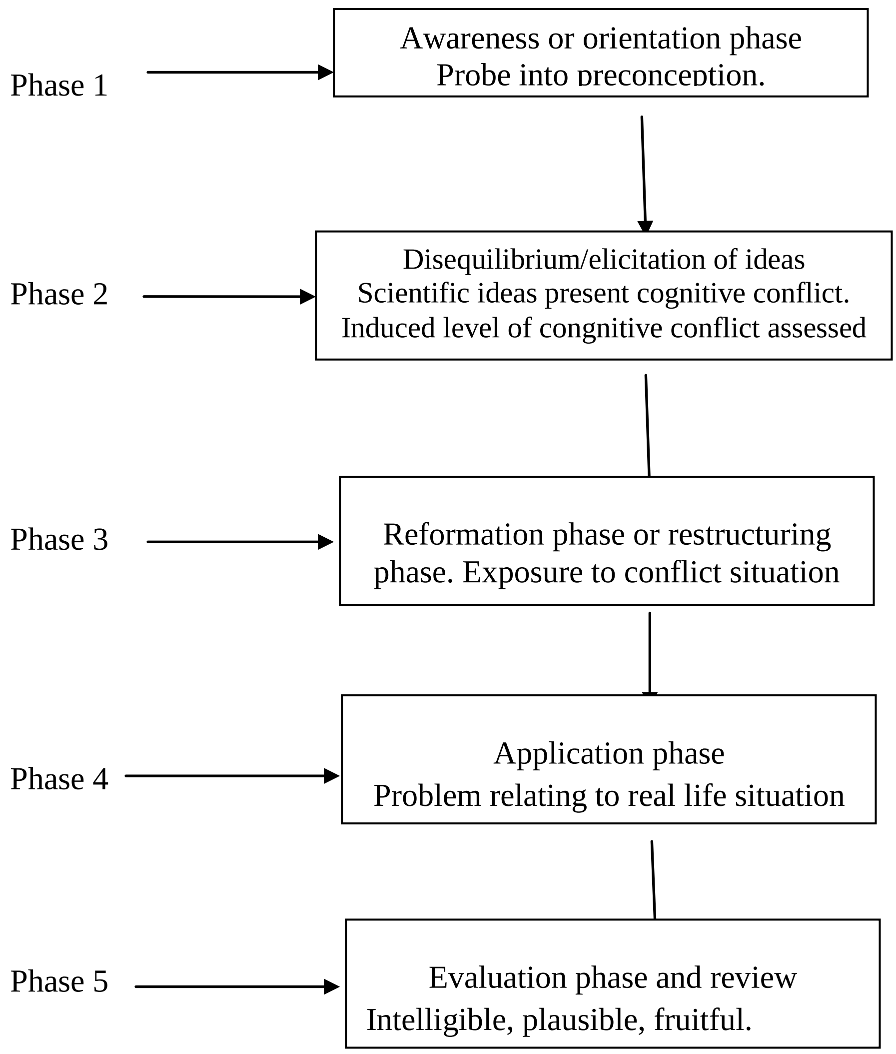


Source: Adapted from Posner et. al (1982) and Eryilmaz (2002)

Figure 3.2: A Flow Chart of Conceptual Assignments Instructional Strategy used forthe Study

3.6.2 Experimental Group 2: Conceptual Discussions Instructional Strategy

Conceptual Discussions Instructional Strategy was used to teach the experimental group 2. This involves the use of conceptual discussion strategy in which the teacher gives conceptual and thought provoking questions and activities to the students in a group of 5 - 6students per group. The subjects in the experimental group 2 were provided with the instructional package containing the instructions that were used in order to prevent any bias that might arise from socio-economic background of the subjects. Instructional aids were also provided to carry out all the activities related to each topic. The teacher acted as a moderator and went round to see that the students were carrying out the activities in their various groups correctly. The students discussed the answers to the various questions and carry out the activities in their various groups after which each group leader presents their answers to the class. The details of the lesson note are presented in Appendix F.



Source: Adapted from Posner et. al (1982)

Figure3.3:A Flow Chart of Conceptual Discussions Instructional Strategy used for theStudy.

3.6.3 Experimental Group 3: Enriched ConceptualChange Discussions withConceptual Assignments Instructional Strategy

The Enriched Conceptual Discussions with Conceptual Assignments Instructional Strategy was used to teach the experimental group 3. It is an adaptation of the model of Posner et. al (1982). The major theme in their model is that learning is a rational activity. Also, they argued that for a student to abandon one framework for another, four conditions are necessary. These are:

5. The learner must be dissatisfied with existing conceptions. He must have lost confidence in the ability of the existing conception to solve new problems.
6. The new conception must be intelligible.
7. It must be plausible and;
8. It must be fruitful.

The Posner et. al. model is preferred to other conceptual models discussed in this study because the model is logical and comprehensive. Above all, it puts into consideration the prior knowledge of the learner, which the constructivist believes is the best way to make sense of what is seen, heard and therefore learnt. The new concept studied is therefore studied in relation to the already known one. This is the fundamental issue in constructivist approach to learning.

Posner et al (1982) model comprised the following steps:

a. Students'preconceptions.
b. Increasing inconsistencies of preconceptions.
c. Dissatisfaction with preconceptions.
d. Turning to new scientific conceptions which must be:

    Intelligible

    Plausible and

    Fruitful to allow for:

e. a shift from preconception to new scientific conception which will lead to:
f. Accommodation of new scientifically validated conception.

In adapting the Posner et. al strategy for this study, all the four conditions proposed by Posner et. al (1982) were used as a guide. The strategy was organized into a six – phase teaching sequence as proposed by Posner et al, but in this study, the first two steps were merged as one and assignment phase was included. The present study used phases as follows:

Step 1: Awareness or orientation phase.

Step 2: Disequilibrium/ Elicitation of ideas.

Step 3: Reformation phase

Step 4: Application phase.

Step 5: Evaluation and review phase.

Step 6: Assignment phase

Lesson plans based on the model was written. Below is a description of each of these stages:

a). **Awareness and Orientation Phase**

This phase involves experiments and clarification which aim at making the learner to recognize the existence of conflict. At this stage, the following steps were taken;

i). Questions from the pretest were asked and students in their groups were allowed to give responses of their own to the questions. They were allowed to explore the phenomenon in question through small group discussion. The students were then asked to make their conceptions clear as brainstorming questions were asked.

ii). During the process of exploration, focusing questions were asked. These questions guidedthe students to observe and discuss their conceptions which may sometimes be contrary to what they already believed; this can lead to "cognitive conflict".

b). **Disequilibrium Phase.**

It is expected here that through the process of exploration, the students encountered new information which could lead to disequilibrium (dissatisfaction). Students were then allowed to test the validity of their existing ideas either through experimentation or using worksheets. After this more brainstorming questions were asked and some theoretical explanation offered.

c).**Reformation Phase**

The teacher then leads the students to reduce their conflict situation by reinforcing the appropriate scientific conceptions. All along results were discussed, new conceptions were discussed and the previous conception written out and copied on the board i.e with the aim of generating dissatisfaction with the pre-existing conceptions and making the scientific one plausible. More discussions and practical work were done where there is need to bring up major re-conceptualization extending or modifying students' ideas. The teacher acted as a facilitator providing relevant information and questions needed to lead students'thinking towards the scientific description.

d). **Application Phase.**

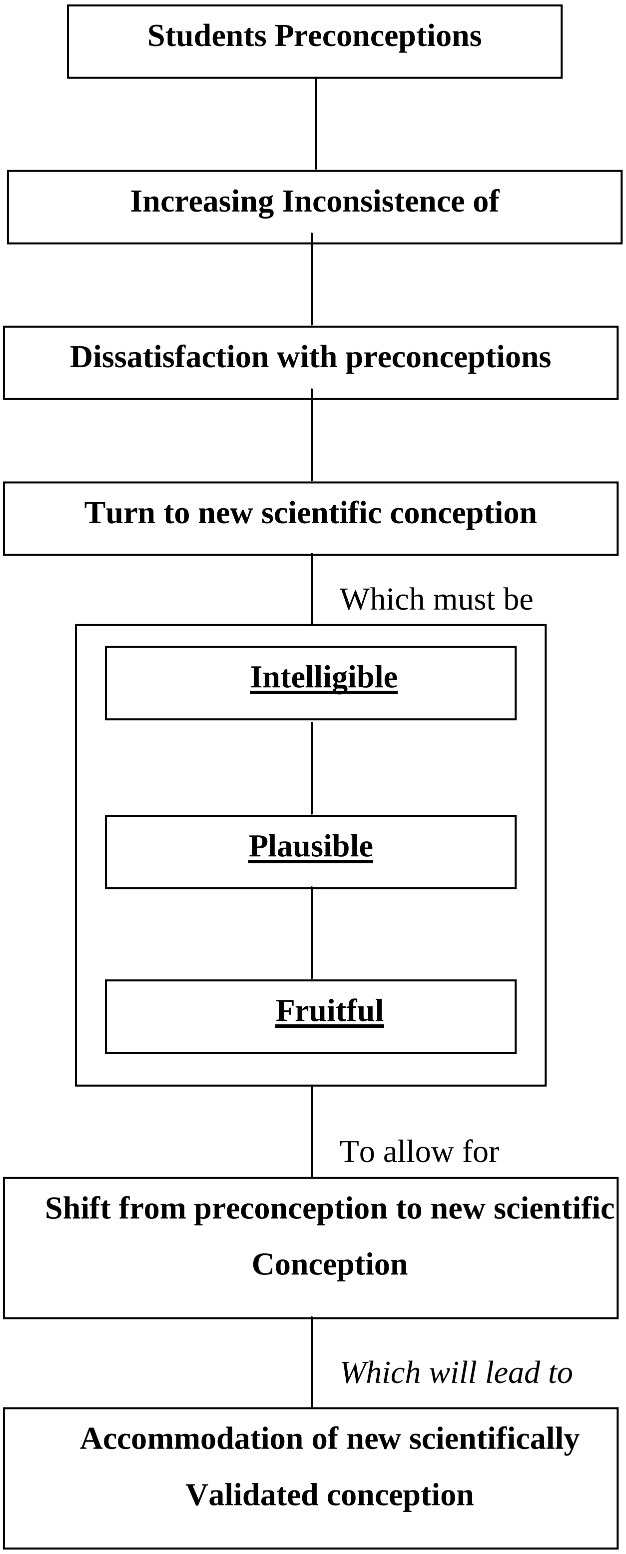
During this phase, opportunities were given to the students to explain novel phenomenon using new conceptions, solve some problems or give examples of phenomena in their real- life situation.

e).**Evaluation Phase**

Students were allowed to compare initial ideas with those currently held. Also, questions were asked to determine their status of the new constructed ideas. The reformation phase was repeated at times to make ideas clearer. It is important here to note that these stages are not stereotype. Sometimes, the misconceptions may be elicited at the reformative stage while some disequilibrium may even occur during the awareness as the students respond to questions.

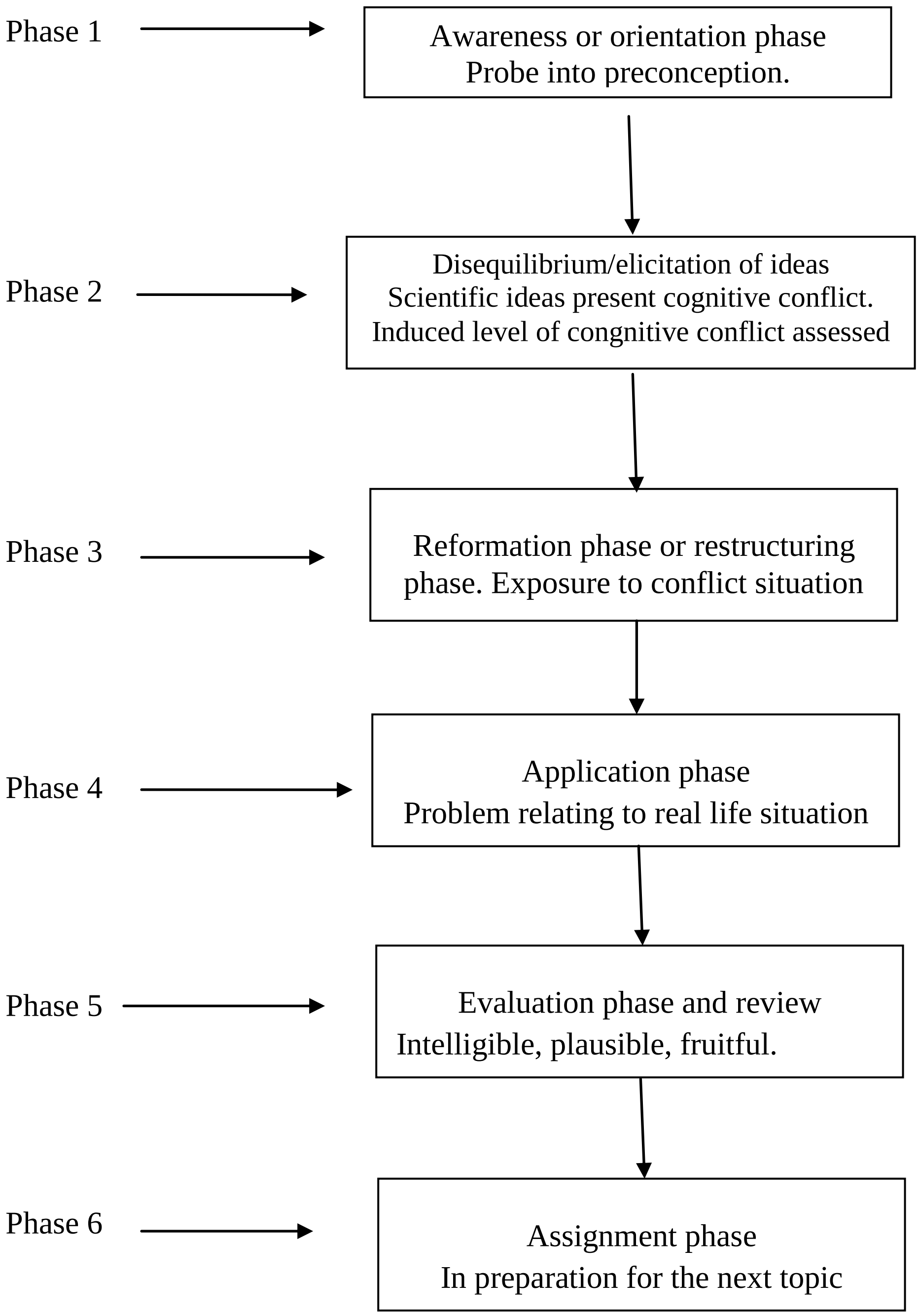
f). **Assignment Phase:** Students were given questions in preparation for the next lesson.

The details of the lesson note are presented in Appendix (G). Figure 3.3 is a flow chart of the Posner et al (1982) model which was adapted and used for the present study.



Source: Posner et al (1982)

Figure 3.4: A flowchart of the Posner et al (1982) conceptual change instructional model



Source: Modified from Posner et. al (1982)

Figure 3.5: A Flow Chart of Enriched Conceptual Change Discussions with Conceptual Assignments Instructional Strategy used for the Study.

3.6.4 Control Group: Traditional Instructional Strategy (TIS)

Traditional Instructional Strategy (TIS) was used to teach the contol group.

This involves the use of lecture method, which basically calls for verbal presentation of ideas about the selected topics. In this method, the students listen and take down notes as the teaching proceeds. The teacher stops from time to time to ask questions and the students also ask questions where they have doubts or where they find difficult to understand. During the teaching process, the teacher stopped to display, draw or show any necessary materials on the topic being taught as instructional aids where the need arose. The details of the lesson note are presented in Appendix (H).

3.6.5 Instructional Procedures

Four instructional strategies were used for this study. They are;

a) Traditional Instructional Strategy (TIS) used to teach the same concepts as in Conceptual Assignment Change Discussion Instructional Strategy, to the control group.
b) Conceptual Assignment Instructional Strategy, used for the treatment of experimental group 1.
c) Conceptual Discussion Instructional Strategy, used for the treatment of experimental group 2.
d) Conceptual Assignment and Conceptual Change Discussion Instructional Strategy, used for the treatment of experimental group 3.

Lesson notes were prepared to teach the selected topics. These are:

1. Transmission and expression of characters in organisms
2. Chromosomes: the basis of heredity
3. Probability in genetics
4. Application of the principles of heredity in agriculture and medicine.

The experimental groups were taught using the Conceptual Assignment Instructional Strategy for the treatment of experimental group 1, Conceptual Change Discussion Instructional Strategy for the treatment of experimental group 2, Conceptual Assignment and Conceptual Change Discussion Instructional Strategy for the treatment of experimental group 3 while the control group was taught using the Traditional Instructional Strategy (TIS).

The aims of this study among others was to find out if there are significant difference in the misconceptions expressed among the senior secondary school male and female students in genetic concepts. The second aim is to find out if there are significant differences in the academic performance of students taught genetic concepts using conceptual assignments and conceptual change discussions instructional strategies and those taught the same using the traditional instructional method. The third is to find out if there are significant differences in academic achievement of male and female students taught genetic concepts using conceptual assignments and conceptual change discussions instructional strategies. The fourth aim is to find out if there are significant differences in the retention ability of students taught genetic concepts using conceptual assignments and conceptual change discussions instructional strategies and those taught the same concepts using the traditional method of instruction. The fifth aim is to find out if there are significant differences in the retention ability of male and female students taught genetic concepts using conceptual assignments and conceptual change discussions instructional strategies. The sixth aim is to find out if there are significant differences in academic achievement between students taught genetic concepts using conceptual assignments and conceptual change discussions instructional strategies and those taught the same concepts using the conceptual discussions instructional strategy.

The study was conducted during the first eight weeks of the first term. Before the commencement of the treatment, the subjects in the experimental and control groups were given the performance tests as pretest. The study lasted for eight weeks.

3.7 Data Collection Procedure

The procedures for administration of research instruments and data collection are described as follows. The teaching of the concepts was done by the research assistants. The aim is to ensure effective utilization of the model and also to ensure that the teaching procedure is in accordance with the direction of the model. The instruments used for the study were Genetic Performance Test and Genetic Misconception Test, which wasused to determine whether there is any relationship between students' understanding of the genetic concepts and academic performance at Senior Secondary three level biology. The scores after the marking were collated and recorded based on the misconceptions made and also experimental and control groups as well as on males versus females.

3.8 Procedure for Data Analysis

The data collected were used to answer the research questions and test the hypotheses formulated. The responses of students on the two instruments were scored based on the marking schemes. Correct answer attracted one mark totaling 40marks. The maximum possible score was 40marks for the Genetic Performance Test and 100marks for Genetic Misconception Test. The results of the test items were collated using SPSS computer package analysis to answer the research questions and test the hypotheses. These were analyzed at $P \leq 0.05$.

3.8.1 Answering the Research Questions

Descriptive statistics of means and standard deviation were used to answer the research questions.

3.8.2 Hypotheses Testing

The hypotheses stated were tested using inferential statistics. The data were analysed to test the significant difference among variables of the study using percentages, Analysis of variance (ANOVA) and Scheffes test at probability level of $P \leq 0.05$ for retaining or rejecting the stated hypotheses. Each of the hypotheses was tested along with the description of the statistical tool that was used for testing it.

Null Hypothesis One

There is no significant difference in the posttest mean scores of students taught genetic concepts using conceptual assignments, conceptual discussions and enriched conceptual change discussions with conceptual assignments instructional strategies and those taught the same using the traditional instructional method. Analysis of Variance (ANOVA) statistical technique was used to find the significant difference (if any) between the mean scores of the four groups.

Null Hypothesis Two

There is no significant difference in the posttest mean scores of students taught genetic concepts using conceptual assignments, conceptual change discussions and enriched conceptual change discussions with conceptual assignments instructional strategies. Analysis of Variance (ANOVA) statistical technique was used to find the significant difference (if any) between the mean scores of the four groups.

Null Hypothesis Three

There is no significant difference in the posttest mean scores of male and female students taught genetic concepts using conceptual assignments, conceptual discussions and enriched conceptual change discussions with conceptual assignments instructional strategies and those taught the same concepts using the traditional method of instruction. ANOVA statistics was used to test this hypothesis.

Null Hypothesis Four

There is no significant difference in the post- posttest mean scores of students taught genetic concepts using conceptual assignments, conceptual discussions and enriched conceptual change discussions with conceptual assignments instructional strategies and those taught the same concepts using the traditional method of instruction. ANOVA statistics was used to test this hypothesis.

Null Hypothesis Five

There is no significant difference in the post- posttest mean scores of male and female students taught genetic concepts using conceptual assignments, conceptual discussions and enriched conceptual change discussions with conceptual assignments instructional strategies and those taught the same concepts using the traditional method of instruction. Analysis of Variance (ANOVA) statistical technique was used to find the significant difference (if any) between the mean scores of the four groups.

Null Hypothesis Six

There is no is no significant difference in the post- posttest mean scores of students taught genetic concepts using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments instructional strategies. Analysis of variance (ANOVA) statistical technique was used to find the significant difference (if any) between the mean scores of the three groups.

CHAPTER FOUR

DATA ANALYSIS, RESULTS AND DISCUSSION

4.1: Introduction

The study investigated Effects of Conceptual Change Instructional Strategies on Secondary School Students Misconceptions, Retention and Performance in Genetics in Kaduna State, Nigeria.This chapter contains data analysis, results and discussions. The results are presented according to the research questions and hypotheses which guided the study. The level of significance adopted for retaining or rejecting each null hypothesis is $P \leq 0.05$ level of significance. The data analysis was done with statistical package of version IBM 23. Means and standard deviations of the data obtained were used for answering the research questions while hypotheses were tested using Two-way Analysis of Variance (Two-way ANOVA) at $p \leq 0.05$ level of significance. The analysis is presented in three main sections and presented in the following sub-headings:

4.2 Data Analysis and Results Presentation

4.3 Summary of Findings

4.4 Discussions

4.2 Data Analysis and Results Presentation

4.2.1. Presentation of Results

4.2.1 Answering the Research Questions

Research Question One: What are the common misconceptions held among Senior Secondary School three (SS3) students in genetic concepts?

To answer this question the Genetic Misconception Test (GMT) was administered to all the students in the four groups before they were exposed to the treatments to identify the misconceptions held by the students.

Table 4.1: Frequency and Percentage of Common Misconceptions in Genetic Concepts (Experimental and Control Groups)

Groups	Gene	Allele	Hybrid	Sex Linkage	Rhesus Factor	Mutation	Total	%
EGI	20	25	20	35	38	38	176	73.33
EG2	24	25	23	43	44	45	205	72.69
EG3	24	25	24	43	45	45	206	73.04
CG	24	26	25	44	45	45	209	72.56
Total	92	101	92	175	172	173		
Percentage	50.54	55.49	50.54	96.15	94.50	95.05		
Remark	Low	Low	Low	High	High	High		

The results in Table 4.1 revealed that the computed Genetic Misconception Test pretest mean scores for Conceptual Assignments, Conceptual Discussions, Enriched Conceptual Discussions with Conceptual Assignments instructional strategies groups and control group were 73.33, 72.69, 73.04 and 72.56 respectively.Table 4.1 also revealed that Gene, Allele, Hybrid, Sex Linkage, Rhesus Factor and Mutation are the common misconceived genetic concepts among SS3 students. Gene and Hybrid have 50.54% each that is the least followed by Allele with 55.49%, Rhesus Factor with 94.50% and Mutation with 95.05% while Sex Linkage has the highest percentage of 96.15%.

Table 4.2: Percentages of Common Misconceptions in Genetic Concepts Before and After The Treatment (Experimental and Control Groups)

Group		Gene	Allele	Hybrid	SexLinkage	Rhesus Factor	Mutation	Total	Percentage
EGI	**Pre**	20	25	20	35	38	38	176	100
	Post	5	6	4	6	5	6	32	18.19
	Diff	15	19	16	29	33	32	144	81.81
	% Diff	**75**	**76**	**80**	**82.85**	**86.84**	**84.21**	**81.81**	
EG2	**Pre**	24	25	23	43	44	45	205	100
	Post	2	4	3	3	6	6	25	12.20
	Diff	22	21	20	40	38	39	180	87.80
	% Diff	**91.60**	**84**	**86.95**	**93.02**	**86.36**	**86.66**	**87.80**	
EG3	**Pre**	24	25	24	43	45	45	206	100
	Post	2	2	1	3	6	5	19	9.23
	Diff	22	23	23	40	39	40	187	90.77
	% Diff	**91.66**	**92**	**95.83**	**93.02**	**86.66**	**88.88**	**90.77**	
CG	**Pre**	24	26	25	44	45	45	209	100
	Post	8	11	10	20	25	23	97	46.42
	Diff	16	15	15	24	20	22	112	53.58
	% Diff	**66.66**	**57.69**	**60**	**54.54**	**44.44**	**48.88**	**53.58**	

Key

Pre - Pretest

Post - Posttest

Diff- Difference between Pretest and Posttest for Individual Concept

EGI - Conceptual Assignments

EG2 - Conceptual Discussions

EG3 - Enriched Conceptual Discussions with Conceptual Assignments

CG - Control Group

The results in Table 4.2 revealed that there is a great increase in the number of students that got items in the Genetic Misconception Test correctly in the posttest in each of the identified misconceived concepts.The differences between pretest and posttest for individual concept is shown in Table 4.2. Conceptual Assignments 81.81%, Conceptual Discussions 87.80%, Enriched Conceptual Discussions with Conceptual Assignments 90.77% instructional strategies groups and control group 53.58% got the misconceived genetic concepts correctly after the treatments respectively.

Table 4.3: Types of Misconceptions in Genetic Concepts (Experimental and Control Groups)

Group	Type of Misconception	Gene	Allele	Hybrid	Sex Linkage	Rhesus Factor	Mutation	Total	Percent
EGI	**PN**	2	2	2	2	2	1	11	6.25
	NB	-	-	-	-	-	1	10	0.56
	CM	-	-	-	-	-	1	10	0.56
	VM	10	13	10	18	18	20	89	50.56
	FM	8	10	8	16	18	15	75	42.61
EG2	**PN**	2	-	1	3	4	4	14	6.86
	NB	-	-	-	-	-	-	-	-
	CM	-	-	-	-	-	-	-	-
	VM	12	15	10	20	20	21	98	48.03
	FM	10	10	12	20	20	20	92	45.09
EG3	**PN**	2	2	1	3	3	2	13	6.31
	NB	-	-	-	-	-	-	-	-
	CM	-	-	-	-	-	-	-	-
	VM	12	10	10	20	21	22	95	46.11
	FM	10	12	13	20	20	21	96	46.60
CG	**PN**	2	2	1	4	2	2	13	6.22
	NB	-	-	-	-	-	-	-	-
	CM	-	-	-	-	-	-	-	-
	VM	10	10	14	20	22	21	97	46.41
	FM	12	14	10	20	21	22	99	47.37

PN Preconceived Notions

NB Nonscientific Beliefs

CM Conceptual Misunderstanding

VM Vernacular Misconceptions

FM Factual Misconceptions

The results in Table 4.3 revealed that most of the subjects in the experimental and control groups harbor vernacular misconceptions and factual misconceptions of genetic concepts. Only a few of the subjects harbor preconceived notions of the genetic concepts. Conceptual Assignments has vernacular misconceptions 50.56%, factual misconceptions 42.61% and preconceived notions 6.25%, Conceptual Discussions has vernacular misconceptions 48.03%, factual misconceptions 45.09% and preconceived notions 6.86%, Enriched Conceptual Discussions with Conceptual Assignments has vernacular misconceptions 46.11%, factual misconceptions 46.60% and preconceived notions 6.31% and control group has vernacular misconceptions 46.46%, factual misconceptions 47.36% and preconceived notions 6.22% respectively.

Question Two: What are the effects of Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments instructional strategies in correcting the identified students' misconceptions in genetic concepts in Senior Secondary School three (SS3)?

To answer this question the Genetic Misconception Test (GMT) was re- administered to all the subjects in the four groups the Conceptual Assignments group, Conceptual Change Discussions group, Enriched Conceptual Change Discussions with Conceptual Assignments group and the Control group after they have been exposed to the treatments.

Table 4.4: Descriptive Statistics of Pretest and Posttest Scores of Experimental and Control Groups in Genetic Misconception Test.

	Group		**Pretest**		**Posttest**		
		N	**Mean**	**SD**	**Mean**	**SD**	**Mean Difference**
	EG1	40	12.47	4.23	55.05	6.41	42.58
Performance	EG2	47	12.95	2.98	68.4	12.23	55.45
	EG3	47	12.93	3.72	71.43	11.7	58.5
	CG	48	12.43	4.68	39.88	10.9	27.45

The results in Table 4.4 revealed that the computed pretest mean scores for Conceptual Assignments, Conceptual Discussions, Enriched Conceptual Discussions with Conceptual Assignments instructional strategies groups and control group are 12.47, 12.95,12.93 and 12.43 respectively while the posttest mean scores for Conceptual Assignments, Conceptual Discussions, Enriched Conceptual Discussions with Conceptual Assignments instructional strategies groups and control group are 55.05, 68.40, 71.43 and 39.88 respectively but the Enriched Conceptual Discussions with Conceptual Assignments group had the highest mean score of 71.43 and the control group had the least mean score of 39.88. This implied that each of the three experimental groups had an increased mean post test scores than the control group. This showed that Enriched Conceptual Discussions with Conceptual Assignments instructional strategies can be used to correct students' miconceptions of genetic concepts.

Question Three: What is the difference between the academic performance of students taught genetic concepts using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments Instructional Strategies and those taught the same using the traditional instructional method?

To answer this question the means and standard deviations of post- test of the four groups were computed and mean differences computed to determine the difference between each treatment in the mean academic performance of genetic concepts of the students.

Table 4.5: Descriptive Statistics of Posttest Mean Scores in GPT of Experimental and Control Groups.

	Group	Posttest			
		N	Mean	SD	Mean Difference
	EG1	40	26.82	3.99	12.01
Performance	EG2	47	27.76	5.09	12.95
	EG3	47	28.23	5.23	13.42
	CG	48	14.81	4.18	0.00

The results in Table 4.5 revealed that the computed Posttest scores for Conceptual Assignments, Conceptual Discussions, Enriched Conceptual Discussions with Conceptual Assignments instructional strategies groups and control group are 26.82, 27.76, 28.23 and 14.81 respectively but the Enriched Conceptual Discussions with Conceptual Assignments group had the highest mean score and the control group had the least mean score. This implied that each of the three experimental groups had an increased mean post test scores than the control group.

Question Four: What is the difference between the academic performance of students taught genetic concepts using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments Instructional Strategies?

To answer this question, the means and standard deviations of post test of the three experimental groups were computed and mean differences computed to determine the difference in the students mean scores.

Table 4.6: Descriptive Statistics of Posttest Scores of Experimental Groups.

	Group	**N**	**Post-test Mean**	**SD**	**Mean Difference**
	EG1	40	26.82	3.99	0.94
Performance	EG2	47	27.76	5.09	0.47
	EG3	47	28.23	5.23	0.00

The results in Table 4.6 showed that the experimental groups with mean of 26.82 for Conceptual Assignments, 27.76 for Conceptual Discussions and 28.23 for Enriched Conceptual Change Discussions with Conceptual Assignments group which is the highest. This implied that there is no difference in the mean scores of the experimental groups. This showed that all the three experimental groups each had high mean post test scores difference. These showed that there is a positive effect of the three experimental treatments alike.

Question Five: What is the difference between the academic performance of male and female students taught genetic concepts using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments Instructional Strategies?

Table 4.7: Descriptive Statistics of the Performance of Male and Female Students in the Experimental Groups

Group	Sex	N	Mean	Standard Deviation	Mean Difference
EG1	Male	22	20.38	9.13	1.63
	Female	18	18.75	7.16	
EG2	Male	23	20.06	7.9	-058
	Female	24	20.64	9.09	
EG3	Male	30	21.73	9.19	
	Female	17	19.55	8.14	2.18

From Table 4.7 the performance mean scores for male and female in the experimental groups are as follow for Conceptual Assignments is 20.38 and 18.75, Conceptual Discussionsis 20.06 and 20.64 and Enriched Conceptual Discussions with Conceptual Assignments is 21.73 and 19.55. The mean difference between male and female students are 1.63, -0.58 and 2.18 in Conceptual Assignments, Conceptual Discussions, Enriched Conceptual Discussions with Conceptual Assignments groups respectively.This showed that treatments do not affect the gender performance of students in genetic concepts. That is genetic concepts are gender friendly.

Question Six: What is the effect of Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments on students' retention ability of the genetic concepts at senior secondary school?

To answer question six, descriptive statistics of mean and standard deviation was used. The detail of the result is presented in Table 4.8.

Table 4.8: Descriptive Statistics of Students' Post Post Test Scores of Genetic Performance Test in Experimental and Control Groups

Group	N	Mean	S D	Mean Difference
EG1	40	26.77	3.78	11.92
EG2	47	27.65	4.70	13. 20
EG3	47	28.06	5.16	12. 80
CG	48	14.85	4.13	0.00

The results of the descriptive statistics in Table 4.8 showed that the experimental groups with mean of 26.77 for Conceptual Assignments, 27.65 for Conceptual discussions, 28.06 for Enriched Conceptual Discussions with Conceptual Assignments and 14.85 for the control group but the Enriched Conceptual Discussions with Conceptual Assignments group had the highest mean score and the control group had the least mean score. This implied that the mean scores of the three experimental groups are significantly higher than that of the control group.

Question Seven: What is the effect of Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments on retention ability of genetic concepts among male and female students?

Table 4.9: Descriptive Statistics of Mean and Standard Deviation of Post Post Test Scores of Male and Female Students of the Experimental Groups.

Group Retention	N	Sex	Mean	Standard Deviation	Mean Diffrence
EG1	22	Male	27.00	4.25	1.50
	18	Female	26.50	3.22	
	23	Male	28.17	4.32	0.22
EG2	24	Female	27.95	5.12	
EG3	30	Male	29.16	5.30	2.16
	17	Female	27.00	3.71	

From the results of the descriptive statistics in Table 4.9 it could be seen that among the males, their post post test mean scores were 27.00, 28.17 and 29.16 by students taught with Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments and Control groups respectively. Among the females, the computed post post test mean scores were 26.50, 27.95 and 27.00 by students taught with Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments groups respectively. The mean differences between male and female students were 1.50, 0.22 and 2.16 by students taught with Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments groups respectively. This result showed clearly that gender has no effect on the retention abilities of students in each of the three groups.

Question Eight: What is the difference in the retention ability among students taught genetic concepts using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments instructional strategies?

Table 4.10: Mean and Standard Deviation of Post Post Test Scores of Students in the Experimental Groups.

Groups	N	Mean	Standard. Deviation	Mean Difference
EGI	40	26.77	3.78	1.29
EG2	47	28.06	4.70	0.00
EG3	47	27.65	5.16	0.41

The results in Table 4.10 revealed that the descriptive statistics showed that the computed Post Post Test mean scores were 26.77, 28.06 and 27.65 by students taught genetic concepts using Conceptual Assignments, Conceptual discussions and Enriched Conceptual Discussions with Conceptual Assignments respectively. This implied that the retention abilities of each of the three experimental groups are high.

4.2.1 Hypotheses Testing

The data collected as described in 4.1- 4.10 above were used to test the stated hypotheses. The results are presented in Tables 4.11 – 4.16.

Comparison of the Academic Performance of Experimental and Control Groups

Null Hypothesis One

There is no significant difference in the mean score of students taught genetic concepts using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Change Discussions with Conceptual Assignments instructional strategies and those taught the same using the traditional instructional method. To test the hypothesis, the post test performance of students taught genetic concepts with Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Change Discussions with Conceptual

Assignments instructional strategies and those taught using traditional method were computed using Analysis of Variance (ANOVA) statistical technique was used to find the significant difference (if any) between the mean scores of the four groups.

Table 4.11a: Analysis of Variance (ANOVA) of Mean Scores of Experimental and Control Groups

Source	Type III Sum of Squares	Df	Mean Square	F	p-value	Remark
Corrected Model	1839.310[a]	3	613.103	66.620	.001	*S
Intercept	62546.844	1	62546.844	6796.327	.001	*S
Group	1839.310	3	613.103	66.620	.001	*S
Error	1638.140	178	9.203			
Total	65656.000	182				

Table 4.11a reveals a significant difference between the mean academic performance scores of students taught genetic concepts using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments instructional strategies and those taught using traditional method. This is because p-value of 0.001 obtained is less than the level of significance set at $p \leq 0.05$. The significant difference is in favour of students exposed to conceptual change instructional strategies. Therefore, the null hypothesis which states there is no significant difference in the posttest mean scores of students taught genetic concepts using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments instructional strategies and those taught the same using the traditional instructional method, is hereby rejected.

Table 4.11b: Post-Hoc Scheffe's Test Analysis of Variance Differences in the Mean Scores of Experimental and Control Groups Multiple Comparisons Dependent Variable: Performance

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	p-value	Remark
EG1	EG2	-.72	.656	.752	*NS
	EG3	-1.39	.653	.212	*NS
	Control	6.34*	.646	.001	*S
EG2	EG1	.72	.656	.752	*NS
	EG3	-.67	.629	.767	*NS
	Control	7.06*	.623	.001	*S
EG3	EG1	1.39	.653	.212	*NS
	EG2	.67	.629	.767	*NS
	Control	7.74*	.619	.001	*S
Control	EG1	-6.34*	.646	.001	*S
	EG2	-7.06*	.623	.001	*S
	EG3	-7.74*	.619	.001	*S

Key : *. The mean difference is significant at the 0.05 level.

*S = Significant at $P \leq 0.05$ level

*NS = Not Significant at $P \geq 0.05$ level

Post-hoc in Table 4.11b showed that there is significant difference between the posttest mean scores of students taught using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments instructional strategies and those taught using traditional method. The Conceptual Assignments (EG1) has p-value of 0.752, Conceptual Discussions has the p-value of 0.767 and Enriched Conceptual Discussions with Conceptual Assignments (EG3) has the p-value of 0.212 and those taught using traditional method with p-value of 0.001. These indicate that the use of conceptual change instructional strategies is capable of improving students' performance in genetic concepts.

Table 4.12 Comparison of Mean Performance Test Scores of the Post Test for Experimental Groups

Null Hypothesis Two: There is no significant difference among the posttest mean score of students taught genetic concepts using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Change Discussions with Conceptual Assignments instructional strategies.

To test the hypothesis, the post test mean scores of students taught genetic concepts with Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Change Discussions with Conceptual Assignments instructional strategies were computed using the Analysis of Variance (ANOVA) Statistics.

Table 4.12a: Two Way Analysis of Variance (ANOVA) of the Mean Scores of Experimental Groups

Source	Type III Sum of Squares	Df	Mean Square	F	p-value	Remark
Corrected Model	41.937[a]	2	20.968	6.285	.002	*S
Intercept	54819.415	1	54819.415	16430.697	.001	*S
Groups	41.937	2	20.968	6.285	.002	*S
Error	433.732	130	3.336			
Total	55776.000	133				

Key : *. The mean difference is significant at the 0.05 level.

*S = Significant at P $\leq$ 0.05 level

The result of the Analysis of Variance (ANOVA) in Table 4.12a showed that significant difference exists between the mean of those in experimental and control groups and vice versa. This is because p-value of .002 obtained is less than the level of significance set at p $\leq$ 0.05. The significant difference is in favour of the conceptual discussions experimental group two. Therefore, the null hypothesis which states that there is no significant difference between the mean scores of students taught genetic concepts using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments instructional strategies is hereby rejected.

Table 4.12b: Post-Hoc Scheffe's Test Analysis of Variance Differences in the Mean Scores of Experimental Groups
Multiple Comparisons Dependent Variable: Performance

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	p-value	Remark
EG1	EG2	-.72	.395	.194	*NS
	EG3	-1.39*	.393	.002	*S
EG2	EG1	.72	.395	.194	*NS
	EG3	-.67	.379	.210	*NS
EG3	EG1	1.39*	.393	.002	*S
	EG2	.67	.379	.210	*NS

Post-hoc in Table 4.12b showed that there is significant difference between the posttest mean scores of students taught using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments instructional strategies. The Conceptual Assignments (EG1) has p-value of .194, Conceptual Discussions has the p-value of .210 and Enriched Conceptual Discussions with Conceptual Assignments (EG3) has the p-value of .002. These indicate that there is significant difference between the posttest mean scores of students taught using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments instructional strategies in favour of experimental group one and experimental group two.

Table 4.13: Test Gender- related difference in the mean scores of Males and Females in the Experimental Groups and Control Group

Null Hypothesis Three

There is no significant difference in the mean score of male and female students exposed to Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments instructional strategies and those taught using traditional method. To test this hypothesis, the post test scores of students taught genetic concepts with Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments instructional strategies and those taught using traditional method were computed using the Analysis of Variance statistics.

Table 4.13a: Analysis of Variance (ANOVA) statistics on Gender- related difference in the Mean Scores of Male and Female Students in the Experimental and Control Groups

Source	Type III Sum of Squares	Df	Mean Square	F	p-value	Remark
Intercept	60141.213	1	60141.213	6774.907	.001	*S
Group	1607.613	3	535.871	60.366	.001	*S
Gender	5.769	1	5.769	.650	.421	*NS
Group * Gender	89.835	3	29.945	3.373	.020	*NS
Error	1544.607	174	8.877			
Total	65656.000	182				

*S = Significant at $P \leq 0.05$ level

*NS = Not Significant at $P \leq 0.05$ level

Two Way Analysis of Variance (ANOVA) at $p \leq 0.05$ level of significance results in Table 4.13a revealed no significant difference between the posttest mean scores of male and female students when taught using conceptual change instructional strategies. This is because p-value of 0.20 obtained is greater than the level of significance set at $p \leq 0.05$. That is there is no significant difference in the academic performance of students in genetic concepts on the basis of gender for Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments and control groups. Reason being that the calculated p- value of groups versus gender value of 0.20 is higher than the 0.05 alpha level of significance. This showed that among each of the four groups, the academic performance of male and female is very close, without significance. This shows that gender of students does not significantly affect the performance of students in genetic concepts. Therefore, the null hypothesis which states that there is no significant difference in the academic performance of male and female students exposed to Conceptual Assignments, Conceptual Discussions and Conceptual Discussions with Conceptual Assignments instructional strategies and those taught using traditional method is hereby accepted and retained.

Table 4.13b: Post-Hoc Scheffe's Test Analysis of Variance Differences Analysis of Variance (ANOVA) statistics on Gender- related difference in the Mean Scores of Male and Female Students in the Experimental and Control Groups Multiple Comparisons Dependent Variable: Performance

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	p-value	Remark
EG1	EG2	-.72	.644	.742	*NS
	EG3	-1.39	.641	.198	*NS
	Control	6.34*	.635	.001	*S
EG2	EG1	.72	.644	.742	*NS
	EG3	-.67	.618	.756	*NS
	Control	7.06*	.612	.001	*S
EG3	EG1	1.39	.641	.198	*NS
	EG2	.67	.618	.756	*NS
	Control	7.74*	.608	.001	*S
Control	EG1	-6.34*	.635	.001	*S
	EG2	-7.06*	.612	.001	*S
	EG3	-7.74*	.608	.001	*S

Significance at $p \leq 0.05$

Not significant at $p \geq 0.05$

Null Hypothesis Four

There is no significant difference in the post post test mean scores of students taught genetic concepts using conceptual assignments, conceptual discussions and enriched conceptual discussions with conceptual assignments instructional strategies and those taught the same concepts using the traditional method of instruction.

To test this hypothesis, the post posttest mean scores of students taught genetic concepts with Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual

Assignments instructional strategies and those taught using traditional method were computed using the Analysis of Variance and Scheffe's Test statistics.

Table 4.14a: Analysis of Variance (ANOVA) Results on Students' Retention Ability in the Experimental Groups and Control Group

Retention

	Sumof Squares	**Df**	**Mean Square**	**F**	**P-value**	**Remark**
Between Groups	5721.953	3	1907.318	94.089	.001	*S
Within Groups	3608.316	178	20.271			
Total	9330.269	181				

*S = Significant at P $\leq$ 0.05 level

The Analysis of Variance statistics in Table 4.14a showed that significant difference exist in the mean post post test mean scores of senior secondary students taught genetic concepts with Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments and those taught with lecture method. Reasons being that the calculated p value of 0.001 is lower than the level of significance set at p $\leq$ 0.05.

Table 4.14b: Post Hoc Scheffe's Test of Analysis of Variance Differences in the Post Post Test Mean Scores of Experimental and Control Groups

Multiple Comparisons

Dependent Variable: Retention

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	P-value	Remark
EGI	EG2	-1.28883	.96855	.622	*NS
	EG3	-.88457	.96855	.841	*NS
	Control	11.92083*	.96390	.001	*S
EG2	EG1	1.28883	.96855	.622	*NS
	EG3	.40426	.92877	.979	*NS
	Control	13.20966*	.92392	.001	*S
EG3	EG1	.88457	.96855	.841	*NS
	EG2	-.40426	.92877	.979	*NS
	Control	12.80541*	.92392	.001	*S
Control	EG1	-11.92083*	.96390	.001	*S
	EG2	-13.20966*	.92392	.001	*S
	EG3	-12.80541*	.92392	.001	*S

*. The mean difference is significant at the 0.05 level.

*S = Significant at $P \leq 0.05$ level

*NS = Not Significant at $P \leq 0.05$ level

Post-hoc in Table 4.14b showed that there is significant difference between the post post test mean scores of students taught using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments instructional strategies and the control group. The Conceptual Assignments (EG1) has p-value of .622, Conceptual Discussions has the p-value of .979 and Enriched Conceptual Discussions with Conceptual Assignments (EG3) has the p-value of .841. These indicate that there is significant difference between the post post test mean scores of students taught using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments instructional strategies in and the control group in favour of experimental group groups. This implies that the means of the three experimental groups is significantly higher than that of the control group. Therefore, the null hypothesis which states that there is no significant difference in the post post test mean scores of the students taught genetic concepts using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Assignments and Conceptual Discussions instructional strategies and those taught the same concepts using the traditional method of instruction is hereby rejected.

Null Hypothesis Five

The null hypothesis states that there is no significant difference in the post post test mean scores of male and female students taught genetic concepts using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments instructional strategies and those taught the same concepts using the traditional method of instruction. To test this hypothesis, the post post test mean scores of male and female students taught genetic concepts with Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments instructional strategies and those taught using traditional method were computed using the Analysis of Variance statistics.

4.15: Effects of Instructional strategies on Male and Female Students'Retention of Genetic Concepts.

Table 4.15a: Analysis of Variance (ANOVA) Statistics on Male and Female Students' Post Post Test in the Experimental Groups and Control Group

Source	Type III Sum of Squares	df	Mean Square	F	p-value	Remark
Intercept	104542.25	1	104542.25	10152.62	0.00	*S
Group	5400.98	3	1800.33	174.84	0.00	*S
Gender	43.33	1	43.33	4.21	0.04	*S
Group*Gender	19.42	3	6.47	.63	0.59	*NS
Error	1791.69	174	10.29			
Total	115476.00	182				

*. The mean difference is significant at the 0.05 level.

*S = Significant at $P \leq 0.05$ level

*NS = Not Significant at $P \leq 0.05$ level

Results of the Analysis of Variance statistics in Table 4.15a showed that there was no significant gender difference in the post post test of students taught with Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Assignments and Conceptual Discussions. This is because the gender versus group calculated p value of 0.59 is higher than the 0.05 alpha level of significance. This shows that in each group the scores of male and female students are not significantly different, implying that gender has no effect on the retention abilities of students in the groups.Therefore, the null hypothesis which states that there is no significant difference in the retention ability of male and female students taught genetic concepts using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Assignments and Conceptual Discussions instructional strategies and those taught the same concepts using the traditional method of instruction is hereby accepted and retained.

Table 4.14b: Post Hoc Scheffe's Test of Analysis of Variance Differences in the Post Post Test Mean Scores of on Male and Female Students' in the Experimental Groups and Control Groups

Multiple Comparisons

Dependent Variable: Retention

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	p-value	Remark
EG1	EG2	-1.18	0.69	0.41	*NS
	EG3	-1.61	0.69	0.15	*NS
	Control	11.57*	0.68	0.00	*S
EG2	EG1	1.18	0.69	0.41	*NS
	EG3	-.43	0.67	0.94	*NS
	Control	12.75*	0.66	0.01	*S
EG3	EG1	1.61	0.69	0.15	*NS
	EG2	.43	0.67	0.94	*NS
	Control	13.18*	0.66	0.01	*S
Control	EG1	-11.57*	0.68	0.01	*S
	EG2	-12.75*	0.66	0.01	*S
	EG3	-13.18*	0.66	0.01	*S

**S = Significant at $P \leq 0.05$ level
*NS = Not Significant at $P \leq 0.05$ level

Post-hoc in Table 4.15b showed that there was significant difference between the post post test mean scores of male and female students taught using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments instructional strategies and the control group. The Conceptual Assignments (EG1) has p-value of 0.15, Conceptual Discussions has the p-value of 0.41 and Enriched Conceptual Discussions with Conceptual Assignments (EG3) has the p-value of 0.94 while the Control Group (CG) has the p-value of 0.01. These indicate that there is significant difference between the post post test mean scores of male and female students taught using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments instructional strategies and the control group in favour of experimental groups. This implies that the postpost test mean scores of the male and female students in the three experimental groups is significantly higher than that of the control group.

Null Hypothesis Six:

The null hypothesis states that there is no significant difference in the between the post post test mean scores of students taught genetic concepts using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Change Discussions with Conceptual Assignments instructional strategies.

To test this hypothesis, the post post test performance of students taught genetic concepts with Conceptual Assignments, Conceptual discussions and Conceptual Assignments and Conceptual Change Discussions instructional strategies were computed using the Analysis of Variance statistics.

Table 4.16: Analysis of Variance (ANOVA) Statistics on Students' Retention Ability of the Experimental Groups.

Retention

	Sum of Squares	**Df**	**Mean Square**	**F**	**P-value**	**Remark**
Between Groups	36.977	2	18.488	.864	.424	*NS
Within Groups	2804.337	131	21.407			
Total	2841.313	133				

*NS = Not Significant at $P \leq 0.05$ level

Analysis of Variance (ANOVA) statistics Table 4.16 b showed that there was no significant difference in the post posttest mean scores among students taught genetic concepts using Conceptual Assignments, Conceptual Discussions and Conceptual Assignments and Conceptual Discussions instructional strategies. Reasons being that the ANOVA calculated p value of 0.424 was greater than 0.05 alpha level of significance and the computed F value of 0.864 is less than the F critical value of 2.50. This implied that the retention ability of each of the three experimental groups is the same. Conclusively, the null hypothesis which state that there is no significant difference in the retention ability among students taught genetic concepts using Conceptual Assignments, Conceptual discussions and Enriched Conceptual Assignments and Conceptual Discussions, is hereby accepted and retained.

Table 4.14b: Post Hoc Scheffe's Test of Analysis of Variance Differences in the Post Post Test Mean Scores of Experimental and Control Groups

Multiple Comparisons

Dependent Variable: Retention

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	p-value	Remark
EG1	EG2	-1.18	0.66	0.20	*NS
	EG3	-1.61	0.65	0.05	*NS
EG2	EG1	1.18	0.66	0.20	*NS
	EG3	-0.43	0.63	0.79	*NS
EG3	EG1	1.61	0.65	0.05	*NS
	EG2	0.43	0.63	0.79	*NS

Post-hoc in Table 4.12b showed that there is significant difference between the mean academic performance scores of students taught using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Discussions with Conceptual Assignments instructional strategies and those taught using traditional method. The Conceptual Assignments (EG1) has p-value of 0.20, Conceptual Discussions has the p-value of 0.79 and Enriched Conceptual Discussions with Conceptual Assignments (EG3) has the p-value of 0.05. These indicate that the use of conceptual change instructional strategies is capable of enhacing students' retention in genetic concepts.

4.3 Summary of Findings

The summary of the findings from the results are as follows:

1. Misconceptions held by the subjects were identified. It was also discovered that most of the subjects were not able to attempt most of the questions in the Genetic Misconceptions Test correctly.
2. The analysis of the pretest and posttest mean scores of the Genetic Misconception Test indicates that the experimental groups performed better than the control group.
3. There was no significant difference among the academic performance of the male and the female students who were taught using Conceptual Assignments, Conceptual Discussions andEnriched Conceptual Change Discussions with Conceptual Assignments instructional strategies.

4.2 Discussion of the Results

The study investigated the effects of conceptual assignments and conceptual change discussions instructional strategies on secondary school students' misconceptions, retention and performance in genetics in Kaduna State, Nigeria. The data collected from posttest administered were analyzed employing Analysis of Covariance and Scheffes test statistics at $P \leq 0.05$ level of significance.

The main objective of this study was to identify the common misconceptions held among Senior Secondary School three (SS3) students in genetic concepts and to investigate whether conceptual assignments and conceptual change discussions instructional strategies can correct the identified students' misconceptions in genetic concepts at Senior Secondary School level. This study was also aimed at determining the effect of conceptual assignments and conceptual change discussions instructional strategies on the academic performance of senior secondary school students in genetic concepts.Wherethe instructional strategy positively affects the subjects, an improvement in the performance of the subjects would be observed as meaningful learning would be achieved (Tsui and Treagust, 2002; Kikas 2004; Lawal 2009).

Research question one was stated to identify misconceptions biology students hold about genetic concepts using Genetic Misconception Test (GMT) see appendix A. The result of the test questions administered revealed a number of misconceptions in appendix. The misconceptions biology students hold about the genetic topics: Transmission and expression of characters in organisms, Chromosomes: the basis of heredity, Probability in genetics and Application of the principles of heredity in agriculture and medicine were used as distracters in the Genetic Performance Test (GPT). The result of this study is thus, evident that students harbour misconceptions on the genetic concepts. This is in support of Lawal (2009) assertions that learners harbour misconceptions, and that such misconceptions affect learning. In fact, Rea-Ramirez et al (2002) confirmed that alternative conceptions do constitute a major interference to subsequent learning as they constitute major block to conceptual understanding.

The result of testing hypothesis one showed a significant difference in the posttest means performance scores of the experimental and control groups. The experimental group achieved significantly higher than the control group in the posttest scores (Table 4.9). The significant difference in favour of the experimental groups suggests a greater effectiveness of the conceptual assignments, conceptual discussions and enriched conceptual assignments and conceptual change discussions instructional strategies used to teach the experimental groups over the traditional instructional strategy used to teach the control group. The conceptual change instructional strategies thus tended to have helped in shifting the subjects' misconceptions thus influencing their performance positively. This finding is in agreement with the finding of Davis (2001), Lawal (2009) who separately reported that conceptual change instructional strategy can displace or shift misconceptions, enhance understanding of concepts and consequently lead to improved performance compared to the traditional instructional strategy.

The effectiveness of conceptual change instructional strategy over the traditional instructional strategy was also reported by Lakpini (2006) and Lawal (2009). These researchers individually found in their studies that using conceptual change instructional strategy helped in improving the quality of instruction thus leading to better performance of the subjects. Samba (1998), also reported in her study the effectiveness of the conceptual change instruction strategy in displacing misconceptions as well as improving performance.

With the above assertion, Biology teachers therefore have the challenge to present relevant classroom activities that can facilitate conceptual change, allow understanding, and recognize individual differences amongst students. Kyle and Abell (2008) maintained that Generative Learning Model (GLM) which is constructivist based will substantially provide this opportunity. The main tenet of the constructivist's theory is that children use their prior knowledge to construct new learning. Conceptual change model is a teaching learning model that substantially provides students opportunity for active participation in the learning process rather then empty cup to be filled. Ezeliora (2010) also maintained that if learners are active in the class, they will learn more effectively and exhibit greater performance.Conceptual change modelhas the capacity of enabling the students to construct meaning through interaction. It has phases which give the students chance and potential to modifying misconceptions thus enabling students explain elaborately or defend their positions to others.This result also supports the observation by Anderson and Krathwohl (2001), that subjects' cognitive process and academic achievement can be enhanced through effective instructions. The relatively poor performance of the subjects in the control group is an indication that the lecture method adopted in teaching science by the science teacher is not effective in promoting cognitive proceeses in students in senior secondary schools as observed by Lawson (2002).

Hypothesis Two states that there is no significant difference in the academic performance of students taught genetic concepts using conceptual assignments and conceptual change discussions instructional strategies. This was stated to find out if there is any significant difference in the mean performance of the subjects after teaching, using conceptual assignments, conceptual change discussions and enriched conceptual assignments and conceptual change discussions instructional strategies. Findings from the study indicate that the experimental groups taught using conceptual assignments and conceptual change discussions instructional strategies showed significant difference in the performance scores of subjects in the experimental groups. Thus, the null hypothesis is retained and this therefore means that Conceptual Assignments, Conceptual Change Discussions and Conceptual Assignments and Conceptual Change Discussions instructional strategies are better at improving students' performance in the genetic concepts taught. The effectiveness of conceptual change instructional strategy over the traditional instructional strategy was also reported by Eryilmaz (2002) Lakpini (2006) and Lawal (2009).

Hypothesis Three states that there is no significant difference in the mean performance scores of male and female subjects after teaching using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Change Discussions with Conceptual Assignments instructional strategies.The results from the data analysis showed that there is no significant difference in the mean scores of both male and female students exposed to the teaching using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Change Discussions with Conceptual Assignments instructional strategies. The findings of this study showed that both boys and girls who were taught using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Change Discussions with Conceptual Assignments instructional strategieslearnt equally well. This therefore means that the Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Change Discussions with Conceptual Assignments instructional strategiesused for teaching the experimental groups are gender- friendly. However, there is no significant difference between the male and female students in the control group taught using traditional instructional strategy. Thus, the null hypothesis is accepted and retained. The importance of deeper learning as a means of developing learners' capacity to apply knowledge gained during the learning process to problem solving was reflected in this study since the students taught through the Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Change Discussions with Conceptual Assignments instructional strategies demonstrated their understanding of the concepts during the evaluation phase. Students' active participation, their interaction in groups and the teacher's role as provider of thought provoking questions might have enhanced students' performance in the Genetic Performance Test as established by Moyer et al (2007). The result of this study showed that there is no significant difference in performance between male and female students in the experimental groups taught selected topics in genetic concepts using the Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Change Discussions with Conceptual Assignments instructional strategies.

As for the influence of gender on students' academic performance, science educators differ in their findings.Specifically, some studies have been carried out to find out the influence of gender (Anidu, 2007) on students' achievement in science generally and on the students' achievement in chemistry in particular. For example, Ogbu (2005) revealed that there was no significant different in the achievement of male and female students in chemistry while Egbo (2005) observed significant difference in achievement due to gender. Moreso, Nnadi (2002) reported that female students performed better than their male counterparts and Okafor (2004) reported that male students are better than female students. This finding of no significant difference in performance of male and female students taught using conceptual change instructional strategy is also supported by the findings of Bichi (2002), Adedayo (2004), Atadoga (2005), Aluko (2005),Nwaiwu and Audu, (2005), Lorchugh, (2006),Lakpini (2006), Ceylan (2008), Anaso (2008), Bitrus (2012), Bunkure (2012), Yusuf and Adigun (2010), Oludipe (2012), Dahiru (2013), Nbina and Avwiri (2014) and Muhammad (2014) and Okonkwo (2015) in separate studies, reported that gender has no effect on students' achievement in science. This similarity could be attributed to the use of student-centered strategy while teaching. Lawal (2009) found that female subjects were significantly better than their male counterparts and that there was a significant difference between the male and female subjects in their ability to evaluate science concepts. Also, Omwirhiren (2013), Daluba (2013) Ndirika, (2013), Udo and Udofia (2014) and Aniodoh & Eze, (2014) noted that the male performed significantly better than their female counterparts in evaluating science concepts. Moreso, Musa (2000), Usman (2008), Ibrahim (2012), Olorukooba, Lawal and Jiya (2012) and Umar (2013) reported a significant difference in the experimental group favouring male of the experimental group. Also, Akinnubi, Oketayo, Akinwande and Ifedayo (2012) reported that the gender of the students does influence their performance in genetics with the female having a better inclination to learn and higher performance score. This non-conformity could be as a result of teaching strategy employed, location and subject matter that were taught. The consensus among science educators is that some instructional strategies are gender bias while some are gender friendly. However, the degree of gender related differences in learning vary from one method of instruction to the other as well as the concept being learnt.

Hypothesis Four states that there is no significant difference in the retention ability of the students taught using conceptual assignments and conceptual discussions instructional strategies and those taught using traditional instructional strategy. With regards to students' retention ability, significant difference exists in the mean retention ability levels of senior secondary school students taught genetic concepts using conceptual assignments and conceptual discussions instructional strategies and those taught using traditional instructional strategies. This result is in agreement with the findings of Lakpini (2006), Anaso (2008) and Bunkure (2012) who found that students in the experimental group of varied abilities had higher retention than the control group of varied abilities. The analysis of the hypothesis showed that the use of conceptual assignments and conceptual change discussions instructional strategies led to higher retention than the traditional method. The mean scores of the subjects in the experimental groups maintain higher retention level than the subjects in the control group. From Table 4.2 there is no significant difference in the retention abilities of male and female subjects taught using conceptual assignments and conceptual discussions instructional strategies. This also buttresses the study of Lakpini (2006) and Bunkure (2012).

Working in small groups where each one is free to express oneself freely, enable the members of such groups to verbalize and organize their thoughts. Such act, help them to resolve conflicts in the ideas they have as well as constructing knowledge based on shared mentoring. The conceptual change instructional strategies aid the restructuring of cognitive structure as well as restructuring of information and gives opportunity for deeper reflective thinking. These aid' memory' retention of what was learnt, thus resulting in higher performance of the students. Research Findings of Crow et al (1997) on aiding retention of information in students using activities that require drawing upon existing knowledge and integrating previous learnt material with new ideas is in support of the present findings.

The research findings of Mba (2001) and Lawal (2009) showed that people remember 95% of what is taught to someone else and 70% of what is discussed by others. Mba’s finding is in support of the findings of this study. However, for the control group in this study, who were taught using traditional instructional strategy, research findings showed that retention level of what is taught using lecture method is short, as people tend to remember only 10% of what is heard, (Mba 2001). This means more of what is heard verbally through lecture method is easily forgotten, thus remembering is very little. The findings of this study isalso supported with those of earlier investigators that teaching chemical concepts with activity-oriented strategies can impact significantly on students’ retention, achievement and understanding (Eze,2002; Egbo,2005 and Omwirhiren,2005).

Hypothesis Five states that, there is no significant difference in the retention ability of male and female subjects taught genetic concepts using conceptual assignments and conceptual change discussions instructional strategies. The results of the post-posttest scores of the subject revealed no significant difference in the retention levels of the male and female students in the experimental groups. This means that the retention level of the subjects when taught genetic concepts in biology using conceptual assignments and conceptual change discussions instructional strategies is not significantly affected by gender. This finding is in agreement with the findings of Lakpini (2006) who individually reported no observed differences between boys and girls in their retention abilities.

Hypothesis Six states that, there is no significant difference in the retention level of male and female students exposed to the teaching of genetic concepts using Conceptual Assignments, Conceptual Discussions and Enriched Conceptual Assignments and Conceptual Discussions instructional strategies. The results of the post-posttest scores of the subjects revealed no significant difference in the retention levels of the boys and girls in the experimental groups.This means that the retention level of the students taught genetic concepts using conceptual assignments and conceptual discussions instructional strategies is not significantly affected by gender. This finding is in agreement with the findings of Lakpini (2006) who individually reported no observed differences between male and female students in their retention abilities.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This study examined the Effects of Conceptual Change Instructional Strategies on Secondary Students' Misconceptions, Retention and Performance in Genetics in Kaduna, Nigeria. Six hypotheses were outlined to guide the investigation. This chapter summarises the entire study and is presented in the following subheadings:

5.2 Summary

5.3 Summary of Major Findings

5.4 Conclusion

5.5 Contributions to Knowledge

5.6 Recommendations

5.7 Limitations of the Study

5.8 Suggestions for Further Studies

5.2 Summary

The purpose of this study was to examine the Effects of Conceptual Change Instructional Strategies on Secondary Students' Misconceptions, Retention and Performance in Genetics in Kaduna, Nigeria.. In chapter one, the study was introduced in which the variables were defined and the psychological theory underlying the study was stated.The problem that prompted the study was spelt out, six objectives, eight research questions and six null hypotheses were stated. Thereafter, significance of the study, scope of the study and basic assumptions were the final aspects of the chapter.

Chapter two reviewed literature that were relevant to the study. Researches that were similar to the study were also reviewed and critiqued in the overview of similar studies. The chapter ended with the implication of the study in which it was concluded with the uniqueness of the study.

Chapter three dealt with the research methodology used in the study. The research design that was adopted for this study was quasi-experimental control groups design, involving pre-test and post-test. Four schools were purposively selected for the study. The Government Senior Secondary Schools used for the study were G.S.S. RafinGusa as the Experimental Group one, G.S.S. Jaji as the Experimental Group two, G.S.S. Sabon Afaka as the Experimental Group three and G.S.S. HayanBanki as the Control Group. Each of the four schools were taught the genetic concepts using the different strategies. The total number of students in the four schools was one hundred and eight two (182). The study also used two instruments namely; Genetics Misconception Test ((GMT) and Genetics Performance Test (GPT) A total of 6 weeks was used for the treatment, after which the instruments were administered to the students.

In chapter four, data collected from the pretest and posttest scores were analyzed based on the research questions and hypotheses. Research questions were analyzed using mean, standard deviation and while research hypotheses were analyzed using two -way ANOVA and Scheffe's Test at 0.05 level of significance and each of the tables were interpreted. Summary of findings were made and the results from the data analysis were discussed and critiqued afterwards.

Finally, chapter five is the summary, conclusion and recommendations aspect of the study. The study was summarized from chapters one through five in this section and summary of major findings were clearly stated. The study was concluded and the contributions the study made to knowledge were outlined. Recommendations were made, limitation of the study and suggestion for further studies were given.

5.3 Conclusion

This study was carried out to examine the Effects of Conceptual Change Instructional Strategies on Secondary Students' Misconceptions, Retention and Performance in Genetics in Kaduna, Nigeria. From the findings the following conclusions are drawn:

1. Senior secondary school student of biology hold misconceptions about genetic concepts in Biology.
2. The study also found that Conceptual Change Instructional Strategies are capable of remediating students' misconceptions in genetic concepts.

3. Conceptual Change Instructional Strategies enhanced better performance than conventional lecture method.
4. Conceptual Change Instructional Strategies increased the students' retention ability in the learning of genetics.
5. Conceptual Change model is gender friend**ly**

5.5 Contributions to Knowledge

This study has made the following contributions to knowledge.

i. Conceptual Change Instructional Strategies model is efficient in improving academic performance of students.

ii. This study established that Conceptual Change Instructional model increases Students' retention of genetic concepts.

iii. Conceptual Change Instructional Strategies can be used in teaching Biology at the secondary school level irrespective of the gender of students.

iv. The lesson plan used in this study has never been employed for research on Conceptual Change Instructional model based on the knowledge of the researcher because of the inclusion of discussion, evaluation and assignment to the model.

v. The instruments used in this study were developed by the researcher and could be adopted or adapted by other researchers in a similar study.

vi. . Conceptual Assignments, Conceptual Discussions and Conceptual Discussions with Conceptual Assignments are viable in reducing students' misconceptions in genetics.

vii. The findings of this study have also added new information to the existing literature on the teaching of genetic concepts and classroom practices as it affects biology teachers and students.

5.6 Recommendations

Based on the findings of this study the following recommendations are made.

1. Teachers of Biology should be encouraged by the Ministry of Education, National Teachers Institute, National Commission for Colleges of Education among others to use Conceptual Change Instructional Strategies to improve academic performance of their students.
2. Training and retraining of science teachers through seminars and workshops should be organized by the Ministry of Education for Biology teachers in secondary schools to employ Conceptual Change Instructional model in the classrooms.
3. Since Conceptual Change Instructional model is not gender bias in co-educational institutions, it could appropriately be useful in educational setting in both Federal and State government schools where males and females come together to learn.
4. The conceptual change instructional strategies be used by teachers of biology in teaching as it helps to shift misconceptions students harbour. Consequently, it creates a suitable conceptual framework necessary for subsequent meaningful learning. Academic performance is also enhanced in the subjects taught genetic concepts using conceptual change instructional strategies compared to using traditional instructional method. Conceptual change instructional strategies help and encourage verbalization and reorganization of science facts in the learners' cognitve structure. It should therefore be encouraged for teaching in the science classroom.
5. The strategy also helped in enhancing retention ability in students better than traditional method. It is therefore recommended that conceptual change instructional strategies be used by teachers of biology, as the use of it will aid students to retain much of what is learnt. This is very important in education, as the teacher assesses the learners to determine how much they have retained of what has been taught. The learners also rely very much on how much their cognitive structure can retain long after the learning process. Retention is thus very important to education and every method of teaching that can help students retain much of the information learnt should be encouraged in biology classroom.
6. This study revealed that the use of conceptual change instructional strategies in the teaching of students showed no gender difference in academic performance. It is recommended that the

strategies be used to teach in order to minimize the effect of gender on learning in the science classroom.

7. Professional associations such as the Science Teachers' Association (STAN),Mathematics Association of Nigeria (MAN), and research centers like Nigerian Educational and Research Development Council (NERDC) should incorporate conceptual change instructional strategy in their science curricular at the junior and senior secondary school levels to encourage the use of the strategy among teachers. When this method is used by teachers it will go a long way to improve teaching and learning at these foundation levels of learning science and technology.
8. It is recommended that teacher trainers like the colleges of education and universities should incorporate conceptual change instructional strategies, into their methodology curricular at all levels. This will ensure the development of its knowledge in the teachers on training.
9. Teachers should be encouraged to attend workshops and seminars on the use of Conceptual Assignments, Conceptual discussions and Conceptual Assignments and ConceptualChange Discussions.

5.7 Limitation of the Study

The restriction of the study to only four co-educational Senior Secondary Schools in Rigachukun Education Zone of Kaduna State made the scope of the generalizations from the study fairly narrow.

1. The study was restricted to only four secondary schools in Kaduna State, Nigeria.The samples used in this study were limited to only Senior Secondary Schools three (SSSIII) students and secondary schools owned by Kaduna State Government in Riga Chikun Education Division. Privately owned secondary schools either owned by organizations or individuals were not used.An extension of the study to other classes, and other senior secondary schools in other local government areas of Kaduna State would be necessary in order to be able to generalize the findings.

2. A sample size of only 182 Senior Secondary Schools three (SSSIII) Biology students were used for the study. It is possible that when larger sample size is used the result may not be the same.

3. The concepts taught were limited to Transmission and expression of characters in organisms, Chromosomes: the basis of heredity, Probability in genetics and Application of the principles of heredity in agriculture and medicine.

4. The conclusion about the effectiveness of Conceptual Assignments, Conceptual Discussions and Conceptual Assignments and Conceptual Change Discussions instruction strategies in this study is limited to genetic concepts.

5.8 Suggestions for Further Studies

The researcher suggests that further studies be carried out on related and similar studies to cover other concepts in biology as well as:

1. The use of conceptual change instructional strategies in correcting misconceptions in other difficult concepts in Biology and other science subjects and compare the effects on rural and urban students.
2. The Factors hindering the effective use of Conceptual Assignments, Conceptual Discussions and Conceptual Assignments and Conceptual Change Discussions in secondary schools in Kaduna state.
3. Effects of conceptual change instructional strategies on other topics attainment in biology among secondary school students.
4. In order to increase the scope of generalization, this study should be replicated in other secondary schools in other local government areas in Kaduna State, many other states of Nigeria and many other countries in the world.
5. There is need to conduct similar studies to investigate the effects of other activity based teaching methods such as problem solving method, project mehod, etc. in teaching the genetic concepts to Senior Secondary Schools Biology students.

6. This study can be extended to NCE students, undergraduate students, to investigate if these levels of education have an effect on the variables that this study dealt with.
7. Other difficult areas of Biology or any other science subject should be investigated using the same approach.
8. A similar study on Conceptual Change Instructional model can be conducted in similar senior secondary schools and higher institutions in other parts of the country to investigate if a similar result would be obtained.
9. Researchers can use other concepts in Biology in order to find out the effectiveness of Conceptual Change Instructional model.
10. Similar study can be extended to other disciplines to find out if Conceptual Change Instructional model has any influence on students' choice of career.
11. Researchers are encouraged to conduct studies on effectiveness of Conceptual Change Instructional model on other attitudinal measures such as interest, anxiety, self-efficacy among others.

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APPENDIX A

GENETIC MISCONCEPTION TEST (GMT)

Dear student,

The test questions are not intended to rate your school performance but to gather information that will be used to improve students' understanding of genetic concepts of biology for better results at the West African Examinations Council Senior Secondary School Certificate (WASSCE) and National Examination Council (NECO).

The result will be treated most confidentially.

SECTION A

BIODATA

School   Time Allowed   1hr 30Minutes

Name

Class

Gender   Male [ ]   Female [ ]

Age   12-14 [ ]   15-17 [ ]   18-20 [ ]   21-23 [ ]

SECTION B

GENETIC MISCONCEPTION TEST (GMT)

INSTRUCTIONS: Answer all the questions on the answer sheet provided. You can express yourself as freely as possible

1. Explain the following terms;
    a. Genetics   b. variation   c. heredity
2. Differentiate between hereditary variations and environmental variations.
3. List ten (10) characteristics that can be transmitted from parents to offspring in man.
4. List five characteristics that can be inherited in plants.

5. How are characteristics transmitted from parents to offspring in living organisms?

6. State Mendel's first and second laws of inheritance.

7. Briefly explain Mendel's experimental method.

8. What do you understand by the following terms;

   a. Gene b. Dominant characters c. recessive characters.

9. What is sex linkage?

10. List two examples of sex linked traits.

11. Write short notes on the following;

    i. Sickle cell trait

    ii. Blood types

    iii. Albinism

    iv. Rhesus factor

12. How is the sex of a child determined in man?

13. Explain the term chromosomes, giving examples.

14. What are the roles of chromosomes in the transmission of hereditary characteristics?

15. What is mutation?

16. Explain the molecular structure of DNA.

17. Explain the following terms;

    a (i) Alleles (ii) Genotype (iii) Phenotype

    b (i) Homozygous organism (ii) Heterozygous organism (iii) Hybrid

    c (i) Zygote (ii) Haploid (iii) Diploid.

18. In a plant with genotype Tt, what is the probability that a gamete will contain gene t?

19. List four ways in which the knowledge of genetics is useful to man.

20. State three applications of the knowledge of genetics to agriculture.

APPENDIX B

GENETIC MISCONCEPTION TEST MARKING SCHEME

1a. Genetics is the scientific study of heredity and variation. 2marks

b. Variation is the differences between individuals of the same species. 2marks

c. Heredity is the transmission of characteristics from parents to offspring. 2marks

2. Hereditary variations are variations that can be transmitted from parents to offspring 1mark

Environmental variation is the variation that cannot be transmitted from parent to their offspring (acquired variation) 1mark

3. Ten (10) characteristics that can be transmitted from parents to offspring in man

- Body stature and posture
- Shape of the body, head, forehead, nose, jaw etc.
- Size of the head, nose, and jaw;
- Color of the eyes, skin, and hair etc.
- Length of hands, legs, neck, feet, toes, fingers;
- Characteristics of voice, speech;
- Intelligence
- Rhesus factor
- sickle cell trait
- color blindness
- blood types
- baldness Any 10 correct points 5marks

4. Five characteristics that can be inherited in plant

- Size of plant
- Size and weight of fruits

- Color of leaves, flowers, fruits and seeds
- Taste of fruits. Any 5correct points 2½ marks

5. How are characteristics transmitted from parent to offspring?

The characteristics of parents are transmitted to the offspring through the gametes 2marks

6. State Mendel's first and second laws of inheritance

- First law of inheritance - The law of segregation. The law of segregation of germinal units states that of a pair of contrasting characteristics, only one can be represented in a gamete by its germinal units. 2marks

- Second law of inheritance. The law of independent assortment. The law of independent assortment of germinal units which states that the factors (or alleles) for two pairs of contrasting characteristics are inherited independently of each other. 2marks

7. Briefly explain Mendel's experimental method of inheritance

- Monohybrid inheritance: Mendel artificially crossed two types of plants at a time, which differed in one pair of contrasting characters (e.g. tall and short plants) 2marks.

- Dihybrid inheritance. Mendel also carried out experiments in which he crossed plants which differed in two pairs of contrasting characteristics, such as seed shape (round and wrinkled seeds) and seed color (yellow and green seeds). 2marks

8a. Gene is any segment of DNA which, by itself or in association with other genes, expresses a traits in an organisms. 2marks

b. Dominant character is the physical trait that expresses itself both in homozygous and heterozygous states. Of a pair of contrasting characteristics; one overshadows the other. For example, if red color is dominant over white, the red color would be expressed, whether the genotype is RR or Rr. 2marks

c. Recessive character is the trait that is not expressed in heterozygous state. E.g r in Rr, t in Tt. 2marks

9. What is sex linkage?

_ Genes on the same chromosomes are said to be linked because they tend to be inherited together. A sex linked gene is a gene located on the X chromosome. Such genes are inherited along with such X chromosome.

Sex-linked traits occur more in males than in females because if the gene for the trait is located on the only X chromosome of the male, it would express the trait in the X chromosome of the male, it would express the traits in the male. For a female to show the traits, the gene must be located on the two X chromosomes of the female.

Sex linked genes on X chromosomes are transmitted from mothers to their sons, because the only X chromosomes of the son is inherited from the mother. But they are transmitted from father and mother to their daughters if such genes are located on both X chromosomes inherited by their daughter. Any 3 correct points= 3marks.

10. List two examples of sex linked traits

- colour blindness
- Haemophilia
- Baldness Any 3correct points = 3marks

11. Write short note on the following

i. Sickle cell trait ii. Blood types iii. Albinism iv. Rhesus factor

i. Sickle cell trait

- This condition is controlled by a recessive gene S which causes some of the red blood cells of some people to be sickle shaped. The haemoglobin of the affected red blood cells is abnormally shaped and is inefficient in transporting oxygen. In conditions of low oxygen concentration, the haemoglobin breaks down causing the cells to become sickle shaped. Such red blood cells block the cavities of small blood vessels in the body, thereby hindering the free flow of blood in them. Any part of the body affected, receives insufficient blood, oxygen and nutrients. At such periods, the victim goes into a crisis which is characterized by pains in the bones and joints, decrease in the level of haemoglobin, low oxygen concentration and drastic fall in the level of blood fluid. This condition is called sickle cell anaemia. Such sufferers are called sicklers and their genotype is SS. Sicklers are not resistant to malaria. They are always sick and may also suffer heart and kidney failure. For this reason, they have little chance of surviving without good medical care. The disease is hereditary. Those who are heterozygous for the trait i.e, AS are said to have sickle cell trait. Such persons are normal but carriers of the trait and they have a high resistance to malaria. The normal red blood cells are spherical and biconcave disc shaped, this normal condition is controlled by a dominant gene often denoted by A. Those that are homozygous for this normal gene i.e, AA do not have the sickling trait in them but have low resistance to malaria. A person who is heterozygous for this gene is described as carrier because, while the individual is not a sufferer, he can transmit the gene for the disease. If two carrier of the sickle cell trait marry, their offspring will have the genotypes shown in the following. Any 5 correct Points 5marks

11ii. Blood types

There are four blood types namely A, B, AB and O in humans. These are controlled by three alleles which are denoted by A, B and O. This represent a case of multiple alleles; but only two can be represented in an individual. The ability of the two alleles in a heterozygous individual to express themselves fully is called co-dominance.

Antigen A and B are co-dominant i.e. none is dominant over the other. Individually, they are dominant over O. The nature of these multiple alleles have given rise to the following genotypes

Blood group	Genotype
A	AA, AO
B	BB, BO

AB	AB
O	OO

Any 5 correct Points = 5 marks

iii. Albinism

This is the condition in which the skin of an animal is non-pigmented because of lack of the pigment melanin. The expression of this trait is controlled by a recessive gene, which is usually represented by 'a'. Any 3 Points 3 marks

iv. Rhesus Factor

Rhesus factor is an inherited characteristic of the blood Human beings are either rhesus position (Rh^+) or rhesus negative (Rh^-). A rhesus positive individual has the rhesus antigen in the red blood corpuscles while a rhesus negative person has none.

If a father is rhesus positive (Rh^+) the zygote will be rhesus positive. If the mother is rhesus negative, the blood of the mother will produce antibodies which will cause the red blood corpuses' in the foetus to dump together. If the foetus is born, it may be of very poor health. Any 4 correct points = 4marks

12. Sex Determination (How is sex of a child determined in man?)

In the body cell of a human being there are 23 pairs of homologous chromosomes. One pair are called the sex chromosomes because they bear the genes that determine the sex of a child. All the other 22 homologous pairs of chromosomes are called autosomes.

In the females, the two sex chromosomes are alike and are called XX chromosomes but in the males, they are not alike. One member of the pair is similar to the X chromosomes of the females and is called X chromosomes. The other member which is different is called Y chromosomes. Therefore, a female being has XX sex chromosomes while a male has XY sex chromosomes. Any child that inherits a Y chromosome turns out to be a male. Any 6 correct points = 3marks

13. Explain the term chromosomes giving examples

- Chromosomes are seen with a microscope only during cell-division (mitosis or meiosis). They appear at the beginning of cell division as long slender threads. As cell division progresses they shorten (condense) and thicken. After some time, each chromosome is observed to be made up of two threads called chromatids, held together at the centromere. All organisms of the same species have the same number of chromosomes in each body cell. The number of chromosomes in a body cell, known as the diploid number, is double the number of chromosomes in a gamete, known as haploid number. The diploid number is represented by 2n, while the haploid number is represented by n.

Examples Maize has 20 chromosomes

Man has 46 chromosomes

Dog has 78 chromosomes

Sunflower has 34 chromosomes. Any 10 correct points = 5marks

14. What are the roles of chromosomes in the transmission of hereditary characteristics?

- The chromosomes, carrying the genes, pass into the gametes during meiosis.
- At fertilization, nuclei of the gametes fuse. The zygote receives two genes for the same character, one from the egg from the female parent and the other from one chromosome in the sperm from the male parent.
- A gene directs the formation of a protein, usually an enzyme, which affects the formation of cell products that bring about the expression of a character e.g. eye cooler. Any 4 correct points 2marks.

15. What is mutation?

Mutation is a permanent change in DNA structure that may alter or destroy a give character or give use to new character. Only germinal mutations are inevitable. Generally, mutations are harmful. For example, sickle cell anaemia and haemophilia are due to mutation. Occasionally, however, advantageous mutations occur, providing the raw materials for evolution. Any 5 correct points 5marks

16. Write note on the molecular structure of DNA

_ the chromosome is made up of Deoxyribose Nucleic Acid (DNA) and protein

_ the dexyribose nucleic acid is a very large molecule made up of repeating units called nucleotides

_ Each nucleotide is made up of:

I deoxyribose, a sugar molecule

ii phosphate

iii an organic nitrogen compound which may be Adenine, Guanine, Thymine or Cytosine

- The repeating units are arranged in the form of a double helix.
- The sides of the helix are formed by sugar and phosphate
- The steps in the ladder are formed by the organic nitrogen compounds in a definite way: Adenine is always joined to thymine, and guanine is always joined to cytosine, by hydrogen bonds. Any 5 correct points is 5marks

17. Explain the following terms:

A (i) Alleles (ii) Genotype (iii) Phenotype

B (i) Homozygous organism (ii) Heterozygous organism (iii) Hybrid

C (i) Zygote (ii) Haploid (iii) Diploid

A (i) Alleles:

- These are the different forms of a gene, e.g a plant species that has

- varieties that bread true for red flowers and other that breed true for white
- colour, the gene for the expression of flower colour has two alleles.
- Alternative gene for the same character is called alleles. In pea plants, for instance, the genes for tallness and the genes for shortness are alleles.
- These occupy corresponding loci (positions) on homologous chromosomes.

Any 2 correct points = 2marks

A (ii) Genotype:

- The sum total of the genes inherited by an organism. The genetic materials carried in the gametes constitute the genotype.
- It is the gene present in the somatic cell of an organism.

  It maybe used to describe the genes for one characteristic alone. For example, TT or tt are genotypes for pea plant height. Any 2 correct points = 2marks

A (iii) Phenotype

- Visible physical characteristics of an organism.
- It is the external appearance of an organism.
- Physical expression of the genes.

  The interaction of the genes and the environment modify the phenotype of an organism e.g. tall, short, white etc. Any 2 correct points = 2marks.

B (i) Homozygous organism

- An organism that possesses the same form of a geneson corresponding loci of homologous chromosomes e.g. TT, RR, tt, rr.
- When an organism has two similar genes for the same characteristic, the organism is said to be homozygous for hat particular characteristic.

  For instance, a true breeding tall pea plant, or a true breeding short pea plant is homozygous for plant height. Any 2 correct points = 2marks

B(ii) Heterozygous organism

- When an organism has two unlike genes for the same character, the organism is said to be heterozygous.
- For instance, a hybrid tall pea plant which carries the gene for tallness and also the gene for shortness is said to be heterozygous.

- An organism that possesses contrasting forms of a gene on corresponding loci of homologous chromosomes. Any 2 correct points = 2marks

B(iii) Hybrid

- Organism produced from a cross between parents that are different in genotype particularly between unlike parents e.g. of two different stains ortwo distinct species.
- Offspring of a cross between organism having contrasting traits.

Any 2 correct points = 2marks

C (i) Zygote

- It is product of fertilization i.e. it is form as a result of the fusion of the nuclei of the male and the male gametes.
- It is one cell
- It may be in plant or animal. Any 2correct points is 2marks

C(ii) Haploid

- The number of chromosomes in the gamete of an organism.
- It is represented by n. Any 2correct points is 2marks

C(iii) Diploid

- The number chromosomes in the body cell of an organism.
- This is double the haploid number of chromosomes.
- It is represented by 2n. Any 2correct points is 2marks

18. In a plant of genotype Tt, what is the probability that a gamete will contain gene t. Any 1 correct point 1mark

19. List four ways in which the knowledge of genetics is useful to man.

- Diagnosis of diseases
- Hereditary diseases and genetic counseling
- Rhesus factor and health of unborn babies
- Blood transfusion

- Cases of disputed parentage. Any 4 correct points is 4marks

20. State three applications of the knowledge of genetics to agriculture

- Development of high-yielding varieties of plants (e.g. maize, rice) and animals (e.g. cattle, domestic fowl)
- Development of early maturing varieties (e.g. cassava, citrus)
- Improvement in quality of crops e.g. avocado pear
- Development of disease resistant varieties e.g. cassava, maize.

Any 3 correct points 3 marks.

APPENDIX C

GENETIC PERFORMANCE TEST (GPT)

Dear student,

The test questions are not intended to rate your school performance but to gather information that will be used to improve students' understanding of genetic concepts of biology for better results at the West African Examinations Council Senior Secondary School Certificate (WASSCE) and National Examination Council (NECO).

The result will be treated most confidentially.

SECTION A

BIODATA

School   Time Allowed   1hr

Name

Class

Gender   Male [ ]   Female [ ]

Age   12-14   [ ]   15-17   [ ]   18 – 20 [ ] 21-23   [ ]

SECTION B

GENETIC PERFORMANCE TEST

INSTRUCTIONS: Answer all the questions on the answer sheet provided.

Each question is followed by four options A-D of which only one is correct. Select the right response for each item and shade the corresponding letter on theanswer sheet.

An example is given below

The number of chromosomes in a body cell is known as

A. The haploid number (n)

B. The diploid number (2n)

C. The triploid (3n)

D. The tetraploid (4n)

The correct answer is B .

1. The branch of biology concerned with the scientific study of heredity and variation is known as

A. Evolution

B. Genetics

C. Variation

D. Adaptation

2. The believe of some people that the unborn human babies resembles those people the woman sees during pregnancy is known as

A. Morphological variation

B. Functional variation

C. Superstitions

D. Structural adaptation

3. Hereditary variation is best described as

A. characters transmitted from generation to generation

B. traits acquired from diseases

C. character that show up due to social conditions

D. traits acquired from habits and environmental conditions

4. Which of the following is a definition of heredity? It is the….

A. non resemblance of closely related organisms

B. total absence of parental traits in offspring

C. absence of variation in organisms

D. transfer of characters from parents to offspring

5. Which of the following is not a reason why an offspring looks different from its parents?

A. Random reorganization of chromosomes during gamete formation

B. Existence of multiple alleles in organisms

C. Formation of chiasmata in chromatids during meiosis

D. Mutation which gives rise to new combination of gene

6. Which of these is not a hereditary variation?

A. Infant paralysis

B. Blood group

C. Sickle cell

D. Shape of face and nose

7. One of Mendel's experiments was repeated by crossing a red variety of pepper with that of a yellow variety which produced all red offspring. The red offspring were then self pollinated and these produced both red and yellow pepper. The yellow colour can be said to be

A. dominant to red

B. recessive to red

C. homozygous to red\

D. heterozygous to red

E. locked up to red

8. If the cross of a red flowered plant with a white flowered plant produces a pink flowered plant, it is an example of

A. co dominance

B. mutation

C. incomplete dominance

D. linkage

9. Hereditary characteristics include the following except

A. big muscle of a boxer

B. characteristics of voice and speech

C. intelligence and certain aptitudes

D. baldness in a family

10. The tendency for two or more genes to segregate together in a cross is known as

A. incomplete dominance

B. co dominance

C. polygenic

D. sex linkage

11. __________ are responsible for the transmission of hereditary characteristics

A. Nucleus

B. Chromatids

C. Genes

D. Somatic cells

12. Observable expression of transmitted traits is referred to as the

A. Genotype

B. Variation

C. Resemblance

D. Phenotype

13. What will be chance of two parents homozygous for albino traits producing albinos

A. 20%

B. 25%

C. 50%

D. 100%

14. The genotype of an individual can be summed up as the

A. Totality of expressed traits

B. Individuals physical appearance

C. Individual's entire genetic make up

D. Physiological traits of the individual

15. The correct increasing order of size for the cell components responsible for heredity is

A. chromosome → DNA → Nucleus → gene

B. DNA → gene → chromosome → nucleus

C. Chromosome → nucleus → DNA → gene

D. DNA → gene → nucleus → chromosome

16. The DNA structure consists of nitrogenous bases which does not include

A. Guanine

B. Thymine

C. Adenine

D. Uracil

17. How many chromosomes will be present in a gamete if the somatic cell has eight (8) chromosomes?

A. 4

B. 6

C. 8

D. 10

18. When two carriers of sickle cell gene marry, what percentage of their F1 generation will be carriers?

A. 50%

B. 35%

C. 60%

D. 75%

19. Which of the following is found in Meiosis and not Mitosis?

A. Chromatids

B. Prophase

C. Crossing over

D. Spindle fibers

20. Which of these statements is correct?

A. Recombination at fertilization does not occur between two homologous chromosomes

B. In homologous chromosomes two genes very close to each other are more likely to form recombinants at Meiotic prophase I

C. A dominant gene masks the presence of a recessive gene

D. Meiosis leads to the formation of daughter cells with diploid chromosomes number

21. Which of the following statements is not true about chromosomes?

A. Each chromosome is made up of two chromatids

B. Body cells have diploid numbers of chromosomes

C. Homologous chromosomes do not occur in pair naturally

D. The sex cells have haploid number of chromosomes

22. The pair of genes expressed in a heterozygous individual is described as

A. Allele

B. Chromatid

C. Dominant gene

D. Centrosome

23. Identical twins inherit their genes from?

A. The same ovum and different spermatozoa

B. The same sperm and different ova\

C. Different spermatozoa and many ova

D. The same ovum and the same sperm

24. The offspring produced when pure strains interbreed is described as

A. Dominance D. Hybrid

B. Phenotype

C. Allele

25. Which of the following is a function of the chromosome?

A. Transmission of hereditary traits

B. Protein synthesis

C. Excretion

D. Energy production

26. The inheritable characters that are determined by a gene located only on the X-chromosome is

A. Recessive

B. Sex-linked

C. Homologous

D. Dominant

27. The crossing of individuals of the same species with different genetic characteristics is?

A. Cross breeding

B. Polygenic inheritance

C. Non-disjunction

D. Inbreeding

28. When two genes of the same characters (allele) are contained in the same individual, the character that shows is known as the?

A. Important character

B. Dominant character

C. Controlling character

D. Superior character

29. A cross test is carried out to determine an organism's

A. Phenotype

B. Genotype

C. Dominant gene

D. Sex

30. The number of alleles controlling human blood groups is?

A. 3

B. 4

C. 5

D. 2

31. If a red gene is represented by (R) and a white gene by (r) , a cross between a heterozygous red flowered plant (Rr) and a white flowered plant (rr) will produce offspring in the ratio of

A. 1 red : 3 white

B. 3 white : 1 red

C. 4 red : 0 white

D. 2 red : 2 white

32. In a monohybrid cross when two heterozygous individuals are crossed, what will be expected inheritance of the offspring in F1 generation?

A. All offspring will be homozygous

B. All offspring will be phenotypically the same

C. Genotypic ratio will be 2 : 2

D. Genotypic ratio will be 1 : 2 : 1

33. The number of chromosomes in a somatic cell of man is

A. 13.

B. 48.

C. 46.

D. 23.

The table below indicates the result of an experiment during which grains of different colours in to maize cobs were counted

Maize cobs	Colours of maize grains		
	White	pink	Red
I	30	60	30
II	50	99	49

34. Which of the following ratios agrees with the result?

A. 9 : 3 : 3

B. 1 : 2 : 1

C. 1 : 3 : 1

D. 2 : 1 : 1

Use the following information to answer Questions 35 and 36

Pure breeding tall peas were crossed with pure breeding dwarf ones and offspring were all tall. These tall peas were then self-fertilized

35. The proportion of tall to dwarf peas that will be obtained in the F2 generation would be in the ratio of?

A. 3 : 1

B. 1: 1

C. 2 : 1

D. 3 : 2

36. The trait for the dwarf pea is said to be

A. Segregated

B. Recessive

C. Independent

D. Dominant

37. In a plant of genotype Tt, what is the probability that a gamete will contain gene t ?

A. ¾

B. 1/8

C. ½

D. ¼

38. In which of the following is the knowledge of genetics not applicable?

A. Development of high yielding varieties

B. Preservation of seeds

C. Development of early maturing varieties

D. Development in quality of yield

39. An individual with blood group AB can receive blood from those in blood group(s)

A. A, B, AB and O

B. AB only

C. AB and O onlyB only

40. The members of the pair of chromosomes that differ in the sexes are known as

A. Autosomes C. Homozygote

B. Sex chromosomes D. Heterozygote

APPENDIX D

GENETIC PERFORMANCE TEST

MARKING SCHEME

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

Total = lmark x 40 = 40 marks

APPENDIX E
EXPERIMENTAL GROUP 1
CONCEPTUAL ASSIGNMENTS INSTRUCTIONAL STRATEGY
TOPIC ONE

SCHOOL: Government Secondary School RafinGuza
DATE
SUBJECT Biology
CLASS: SS3
TIME
DURATION 80minutes
TITLE OF UNIT Continuity of Life
TOPIC: Transmission and expression of characters in organisms.
BEHAVIOURAL OBJECTIVES: By the end of the lesson, the students should be able to;

1. define the term genetics.
2. define heredity.
3. define variations.
4. state the types of variations.
5. list at least five examples of hereditary variations in humans.
6. state the characteristics that can be transmitted in man.
7. list the characteristics that can be transmitted in plants.
8. explain how characteristics are transmitted from parents to offspring.
9. explain how characteristics behave from generation to generation.

References :

1. Ndu, F. O. C; Asun, and P. Aina J. O. (2001) Senior Secondary Biology book 3 New Edition Longman Nigeria Plc.
3. Ndu, F. O. C; Edward, A. W. A., Danquah, K. and Ezenkwe, M. U. (2001) Round Up Biology for WestAfrican Senior Secondary School Certificate Examination. A complete guide. Longman Nigeria Plc.

Previous knowledge: Students are familiar with variation and genetics.
Introduction: The teacher introduces the lesson by asking the students the following questions
What is variation?
What is genetics?
Presentation or Development
Step I The teacher leads the students on to the definitions of variation and genetics.
Step II The teacher gives the types of variations to the students and lists the examples of hereditary variations in humans.
Step III The teacher explains the characteristics that can be transmitted in Plants and in man to the students.
Step IV The teacher further explains to the students how characteristics are transmitted from parents to offspring and how characteristics manifest from generation to generation.
Students Activities: The students answer the teacher's questions and asksquestions when necessary. They also copy note in their exercise books. They also submit the assignment given to them.
Summary: The teacher briefly goes over the lesson and lays more emphasis

on important points.

Evaluation: The teacher asks questions on the topic to assess the success of the lesson.

1. Define the term genetics.
2. Define heredity.
3. Define variation.
4. State the types of variation.
5. List the types of hereditary variation in humans.
6. State the characteristics that can be transmitted in man.
7. List the characteristics that can be transmitted in plants.
8. Explain how characteristics are transmitted from parents to the offspring.
9. Explain how characteristics are transmitted from generation to generation.

Assignment: The teacher gives the following questions to the students in preparation for the next topic.

1. Why did Mendel choose pea plant for his experiments?
2. List Mendel's traits.
3. Explain Mendel's experimental methods.
4. Explain Mendel's experimental factors i.e. germinal units.
5. Explain dominant and recessive traits.
6. State the law of segregation of germinal units.
7. State the law of independent assortment of germinal units.

Conclusion: The teacher gives more explanation to the students on what to do.

TOPIC TWO

SCHOOL: Government Secondary School RafinGuza
DATE
SUBJECT Biology
CLASS: SS3
TIME
DURATION 80minutes
TITLE OF UNIT Continuity of Life
TOPIC: Mendel's work in genetics
BEHAVIOURAL OBJECTIVES: By the end of the lesson, the students should be able to:

1. explain why Mendel chose pea plant for his experiments.
2. list Mendel's traits correctly.
3. explain Mendel's experimental methods correctly.
4. explain Mendel's experimental factors i.e. germinal units.
5. explain dominant and recessive traits.
6. state the law of segregation of germinal units.
7. state the law of independent assortment of germinal units.

References :

1. Ndu, F. O. C; Asun, and P. Aina J. O. (2001) Senior Secondary Biology book 3 New Edition Longman Nigeria Plc.
2. Ndu, F. O. C; Edward, A. W. A., Danquah, K. and Ezenkwe, M. U. (2001) Round Up Biology for West African Senior Secondary School Certificate Examination. A complete guide. Longman Nigeria Plc.

Previous knowledge: Students have been taught transmission and expression of characters in organisms.
Introduction: The teacher introduces the lesson by asking the students the following questions.
Presentation or Development
Step I The teacher explains the Mendel's experimental methods and Mendel's traits to the students.
Step II The teacher gives the reasons why Mendel chose pea plants for his experiments to the students.
Step IV The teacher further explains to the studentsthe following terms:germinal units, dominantand recessive traits and gives the two Mendelian laws to the students.
Students Activities: The students answer the teacher's questions and ask questions.They also copy note in their exercise books and submit their assignment to the teacher for marking.
Summary: The teacher briefly goes over the lesson laying more emphasis on important points.
Evaluation: The teacher asks questions on the topic to assess the success of thelesson.

1. Explain why Mendel chose pea for plant for his experiments.
2. List Mendel's traits correctly.
3. Explain Mendel's experimental methods correctly.
4. Explain Mendel's experimental factors i.e. germinal units.
5. Explain dominant and recessive traits.
6. State the law of segregation of germinal units.
7. State the law of independent assortment of germinal units.

Assignment:
Teacher gives the students the following questions to answer in their exercise books:

1. Explain Mendel's result of crossing pea plants.
2. List and explain the traits that are inherited in Mendel's pattern.
3. Explain the meaning of some genetic terms:

a. Genes b. Alleles c. Homozygous d. Heterozygous e. Locus f. Haploid
g. Diploid h. Genotype i. Phenotype

4. How is the sex of a child determined in man?
5. What is sex linkage?
6. List the sex linked traits in man.

Conclusion: The teacher gives more explanation to the students on what to do.

TOPIC THREE

SCHOOL: Government Secondary School RafinGuza

DATE

SUBJECT Biology

CLASS: SS3

TIME

DURATION 80minutes

TITLE OF UNIT Continuity of Life

TOPIC: Mendel's work in genetics.

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

1. explain Mendel's result of crossing pea plants.
2. list and explain the traits that are inherited in Mendel's pattern.
3. explain the meaning of some genetic terms.
4. explain sex determination in man.
5. explain sex linkage.
6. list sex linked traits in man.

References :

1. Ndu, F. O. C; Asun, and P. Aina J. O. (2001) Senior Secondary Biology book 3 New Edition Longman Nigeria Plc.
2. Ndu, F. O. C; Edward, A. W. A., Danquah, K. and Ezenkwe, M. U. (2001) Round Up Biology for West African Senior Secondary School Certificate Examination. A complete guide. Longman Nigeria Plc.

Previous knowledge: Students are familiar with reproduction in plants and animals.

Introduction: The teacher introduces the lesson by asking the students some questions.

Presentation or Development

Step I The teacher explains to the students the Mendel's result of crossing pea plants and lists the traits that are inherited in Mendel's pattern..

Step II The teacher gives the meaning of some genetic terms.

Step III The teacher explains sex determination in man.

Step IV The teacher further explains to the students the meaning of sex linkage and lists the sex linked traits in man.

Students Activities: The students answer the teacher's questions and ask questions. They also copy note in their exercise books

Summary: The teacher briefly goes over the lesson laying more emphasis on important points.

Evaluation: The teacher asks questions on the topic to assess the success of thelesson.

1. Explain Mendel's result of crossing pea plants.
2. List and explain the traits that are inherited in Mendel's pattern.
3. Explain the meaning of some genetic terms.
4. Explain sex determination in man.
5. Explain sex linkage.
6. List sex linked traits in man.

Assignment: The students are given the following assignment on the concept of chromosome: the basis of heredity

1. What are chromosomes?

2.Where are chromosomes located in the cell?

3.Describe the structure of chromosome.
4.What are the roles chromosomes play in the transmission of hereditary characters from parents to offspring?
5.Explain the process of the transmission of hereditary characters from parents to offspring.
6.Explain the molecular structure of DNA.

Conclusion: The teacher gives more explanation to the students on what to do and collects students' assignments for marking.

TOPIC FOUR

SCHOOL: Government Secondary School RafinGuza

DATE

SUBJECT Biology

CLASS: SS3

TIME

DURATION 80minutes

TITLE OF UNIT Continuity of Life

TOPIC: Chromosomes: the basis of heredity.

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

1. identify chromosomes in permanently prepared slides of cells.
2. recall that chromatin granules, the precussors of chromosomes are present in the nucleus.
3. infer that chromosomes carry genes
4. infer that genes are responsible for inherited characters.
5. describe the structure of chromosomes.
6. list the number of chromosomes present in the somatic cells of at least three plants and five animals.
7. describe the molecular structure of DNA.
8. list the components of the nucleotide.
9. explain the role of chromosome in the transmission of hereditary characters.
10. explain the process of transmission of hereditary characteristics.

References :

1. Ndu, F. O. C; Asun, and P. Aina J. O. (2001)Senior Secondary Biology book 3 New Edition Longman Nigeria Plc.
2. Ndu, F. O. C; Edward, A. W. A., Danquah, K. and Ezenkwe,M. U. (2001) Round Up Biology for West African Senior Secondary School Certificate Examination. A complete guide. Longman Nigeria Plc.

Previous knowledge: Students have been taught Mendel's work in genetics.

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

1. What is a germinal unit?
2. State the first and second Mendel's laws.

Presentation or Development

Step I The teacher explains the chromatin granules, the precussors of chromosomes are located in the nucleus to the students.

Step II The teacher describes the structure of chromosomes and gives thenumber of chromosomes present in the somatic cells of some plants and animals.

Step III The teacher also explains the roles of chromosomes in thetransmission of hereditary characters to the students.

Step IV The teacher further explains to the students the molecular structure of DNA.

Students Activities: The students answer the teacher's questions and ask questionswhen necessary.They also copy note in their exercise books and submit their assignment to the teacher for marking.

Summary: The teacher briefly goes over the lesson and lays more emphasis on important points.

Evaluation: The teacher asks questions on the topic to assess the success of thelesson.

1. The precussors of chromosomes present in the nucleus are called_______
2. Chromosomes carry____________
3. __________ are responsible for inherited characters.
4. Describe the structure of chromosomes.
5. List the number of chromosomes present in the somatic cells of at least three plants and five animals.
6. Describe the molecular structure of DNA.
7. List the components of the nucleotide.
8. Explain the role of chromosome in the transmission of hereditary characters.
9. Explain mthe process of transmission of hereditary characteristics.

Assignment: The teacher asks the following questions in preparation for the next lesson.

1a. Define the term probability.

b. How will you apply the knowledge of probability to the formation of gametes?

c. How will you use the knowledge of probability to explain sex determination in man?

d. How will you use the knowledge of probability to explain sex linked traits in man?

2. Toss an unbiased coin upwards, what is the probability that

a. the coin may fall with head side up?

b. the coin may fall with tail side up?

3. When a ludo die is rolled out of its cup, what is the probability that the die will finally come to rest with the side containing

a. 1 facing upwards?

b. 2 facing upwards?

c. 3 facing upwards?

d. 4 facing upwards?

e. 5 facing upwards?

f. 6 facing upwards?

4. Mrs Audu is pregnant, what is the probability that the expected baby will be

a. a boy?

b. a girl? d. either a boy or girl?

c. a goat?

Conclusion: The teacher gives more explanation to the students on what to do and collects students assignments for marking.

TOPIC FIVE

SCHOOL: Government Secondary School RafinGuza
DATE
SUBJECT Biology
CLASS: SS3
TIME
DURATION 80minutes
TITLE OF UNIT Continuity of Life
TOPIC: Probability in genetics
BEHAVIOURAL OBJECTIVES: By the end of the lesson, the students should be able to:

1. define probability.
2. apply the knowledge of probability to the formation of gametes.
3. apply the knowledge of probability to the formation of offspring.
4. apply the knowledge of probability to the determination of sex of a child in man.
5. apply the knowledge of probability to the transmission of sex linked traits in man.

Previous knowledge: Students are familiar with ludo and playing cards.
References:
1.Ndu, F. O. C; Asun, and P. Aina J. O. (2001) Senior Secondary Biology book 3 New Edition Longman Nigeria Plc.
2. Ndu, F. O. C; Edward, A. W. A., Danquah, K. and Ezenkwe, M. U. (2001) Round Up Biology for WestAfrican Senior Secondary School Certificate Examination.AComplete guide.Longman Nigeria Plc.
Introduction: The teacher introduces the lesson by asking the students the following questions
What is probability?
What is genetics?
Presentation or Development
Step I The teacher leads the students on to the definition of probability ingenetics.
Step II The teacher explains the application of the knowledge of probability in the formation of gametes and offspring to the students.
Step III The teacher further explains to the students the application of theknowledge of probability to the determination of sex of a child in manand to the transmission of sex linked traits in man.
.
Students Activities: The students answer the teacher's questions and ask questions. They also copy note in their exercise books and submit their assignment to the teacher for marking..
Summary: The teacher briefly goes over the lesson and lays more emphasison important points.
Evaluation: The teacher asks questions on the topic to assess the success of thelesson.

1. Define probability.
2. How will youapply the knowledge of probability to the formation of gametes.
3. How will you apply the knowledge of probability to the formation ofoffspring.
4. How will you apply the knowledge of probability to the determination of sex of a child in man.
5. How will you apply the knowledge of probability to the transmission of sex linked traits in man.

Assignment: The teacher asks the following questions.
1a. Define the term probability.
c. How will you apply the knowledge of probability to the formation of gametes?
c. How will you use the knowledge of probability to explain sex determination in man?
d. How will you use the knowledge of probability to explain sex linked traits in man?

2. Toss an unbiased coin upwards, what is the probability that

c. the coin may fall with head side up?
d. the coin may fall with tail side up?

3.When a ludo die is rolled out of its cup, what is the probability that the die will finally come to rest with the side containing

g. 1 facing upwards?
h. 2 facing upwards?
i. 3 facing upwards?
j. 4 facing upwards?
k. 5 facing upwards?
l. 6 facing upwards?

4. Mrs Audu is pregnant, what is the probability that the expected baby will be

d. a boy?
e. a girl? d. either a boy or girl?
f. a goat?

5a. List the types of asexual reproduction.

b. List five organisms that can reproduce asexually.

c. List five organisms that can reproduce sexually.

d.What are the differences between self fertilization an cross fertilization?

6a. In a tabular form state the differences between inbreeding and out breeding.

List and explain the applications of the principles of genetics in

i. agriculture
ii. medicine

Conclusion: The teacher gives more explanation to the students on what to do.

TOPIC SIX

SCHOOL: Government Secondary School RafinGuza

DATE

SUBJECT Biology

CLASS: SS3

TIME

DURATION 80minutes

TITLE OF UNIT Continuity of Life

TOPIC: Application of the principles of heredity in agriculture and medicine

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

1. differentiate between sexual and asexual reproduction.
2. differentiate between self fertilization and cross fertilization.
3. differentiate between inbreeding and out breeding
4. list and explain the applications of the principles of genetics in agriculture.
5. list and explain the applications of the principles of genetics in medicine.

Previous knowledge: Students are familiar with variation and genetics.They arealso familiar with plant and animal breeding.

References:

1. Ndu, F. O. C; Asun, and P. Aina J. O. (2001) Senior Secondary Biology book 3 New Edition LongmanNigeria Plc.
2. Ndu, F. O. C; Edward, A. W. A., Danquah, K. and Ezenkwe, M. U. (2001) Round Up Biology for WestAfrican Senior Secondary School Certificate Examination. A complete guide. Longman Nigeria Plc.

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

What is heredity?

What is variation?

Presentation or Development

Step 1 The teacher leads the students on to the differences between sexual and asexual reproduction.

Step II The teacher gives the differences between self fertilization and cross fertilization and inbreeding and out breeding.

Step III The teacher further lists and explains to the students the applications of the principles of genetics inagriculture and in medicine.

Students Activities: The students answer the teacher's questions and ask questionswhere necessary. They also copy note in their exercise books and submit their assignment to the teacher for marking.

Summary: The teacher briefly goes over the lesson laying more emphasis on important points.

Evaluation: The teacher asks questions on the topic to assess the success of the lesson.

1. Differentiate between sexual and asexual reproduction.
2. Differentiate between self fertilization and cross fertilization.
3. Differentiate between inbreeding and out breeding
4. List and explain the applications of the principles of genetics in agriculture.
5. List and explain the applications of the principles of genetics in medicine.

Assignment:

The teacher gives the following questions to the students.

1a. List the types of asexual reproduction.

b. List five organisms that can reproduce asexually.

c. List five organisms that can reproduce sexually.

d.What are the differences between self fertilization and cross fertilization?

2. In a tabular form state the differences between inbreeding and out breeding.

3. List and explain the applications of the principles of genetics in

iii. agriculture

iv. medicine

Conclusion: The teacher gives more explanation to the students on what to do.

EXPERIMENTAL GROUP 2

APPENDIX F

CONCEPTUAL DISCUSSION INSTRUCTIONAL STRATEGY

TOPIC ONE

SCHOOL: Government Secondary School Jaji

DATE:

SUBJECT: Biology

CLASS: SS 3

TIME:

DURATION:80 minutes

TITLE OF UNIT: Continuity Life

TOPIC OF LESSON: Transmission and expression of characters in organisms.

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

1. define the term genetics.
2. Define heredity.
3. Define variations.
4. State the term of variations.
5. List at leats five examples of hereditary variations in humans.
6. State the characteristics that can be transmitted in man.
7. List the characteristics that can be transmitted in plants.
8. Explain how characteristics are transmitted from parents to offspring.
9. Edxplain how characteristics behave from generation to generation.

TEACHING MATERIALS: Different plants, flowers and leaves, fruits, paper, pencil, cardboard, eraser, students themselves.

References:

1. Ndu, F. O. C: Asun, and P. Aina J. O. (2001) Senior Secondary Biology book 3 New Edition Longman Nigeria Plc.

2. Ndu, F. O. C: Edward, A. W. A. Danquah. K. and Ezenkwe. M. U. (2001) Round Up Biology for West African Senior Secondary School Certificate Examination. A complete guide. Longman Nigeria Plc.

Previous knowledge: The students are familiar with different plants and animals.

Introduction: Students are divided into small groups of 4-5. The teacher gives the package prepared on genetics to individual students in their various groups. The teacher asks the following questions to arouse the interest of the students.

1. Are all the members of your family of the same sex?
2. Are all the members of your family of the same height?
3. Are you exactly like your parents?
4. If your answer is no why are you not exactly like your parents?

Presentation:

Step1: The teacher asks the students the following questions which are to be discussed in their variou s groups.

1. What is genetics?
2. What is heredity?
3. What is variation?
4. List the types of variations.
5. List five examples of hereditary variations in humans.
6. List five examples of hereditary variations in plants.
7. How are characteristic transmitted from parents to offspring?
8. How do characters behave from generation to generation?

Activities:

Look at the members of your group and answer the following questions;
What are the features you have in common?
Are you all of the same height? If your answer is no, compare your height.
Why are you not the same?

Step 2: Teacher continues to act as a facilitator and moderator of students' ideas. The teacher provides learning experiences and questions that on discussion leads to interactions with the students' prior
knowledge through:

i. Extending prior knowledge where ideas are needed.
ii. Helping students to refine their own ideas to scientifically validated ideas.

Step 3: The teacher at this stage re-emphasizes the scientifically correct ideas. The teacher asks questions on how the knowledgeof transmission and expansion of characters in organisms can help the students to

a. Explain why children of the same parents are not exactly the same?
b. Why are children not exactly like their parents?
a. Why do children resemble their grandparents?

Students Activities:

Students discuss and sought the answers to the questions in their small groups and arrive at concrete suggestions on how genes behave from generation to generation with the help of the package given to them after which the group leaders present the answers compiled by the group. Students in their small groups of 4-5 carry out the activities and discuss among themselves. The leader of each group explains the findings of the group
to the class. As the idea of each group is being presented by the group leader, alternative view points are identified and students are helped to recognize critically examine such alternative viewpoints.

Evaluation

The teacher assesses the success of the lesson by asking the following questions.

1a. What is genetics?
b. Define heredity.
c. What is variation?
2a. List the types of variations
b. List five examples of hereditary variations in humans.
c. List five examples of hereditary variations in plants.

3a. List five characteristics that can be transmitted in humans.

b. List five characteristics that can be transmitted in plants

4. How are characters transmitted from parents to offspring?
5. Explain how characters behave from generation to generation.

Conclusion: The teacher makes a brief summary of the topic of the lesson from the beginning to the end of the discussion.

TOPIC TWO

SCHOOL: Government Secondary School Jaji
DATE
SUBJECT: Biology
CLASS: SS3
TIME
DURATION: 80minutes
TITLE OF UNIT: Continuity of Life
TOPIC OF LESSON: Mendel's work in genetics
BEHAVIOURAL OBJECTIVES: By the end of the lesson, the students should be able to:

1. determine why Mendel chose pea plant for his experiments.
2. list Mendel's traits correctly.
3. state Mendel's experimental methods correctly.
4. explain Mendel's experimental factors i.e. germinal units.
5. identify dominant and recessive traits.
6. state the law of segregation of germinal units.
7. state the law of independent assortment of germinal units.
8. compare their results (i.e. the ratios they obtain) with that of Mendel.

TEACHING MATERIALS: Yellow maize, white maize, Drosophila flies, breeding bottles, culture medium (food for flies), camel hair brush, ether and a white sheet of paper, muslin, twine, drawing book, cardboard sheets, pencil, eraser.

References :

1. Ndu, F. O. C; Asun, and P. Aina J. O. (2001) Senior Secondary Biology book 3 New Edition Longman Nigeria Plc.
2. Ndu, F. O. C; Edward, A. W. A., Danquah, K. and Ezenkwe, M. U. (2001) Round Up Biology forWest African Senior Secondary School Certificate Examination. A complete guide. Longman Nigeria Plc.

Previous knowledge: The students are familiar with different plants and animals and they have been taught the transmission and expression of characters in organisms.

Introduction: Students in their small groups of 4-5 answer the following questions asked by the teacher to arouse their interest.

1a. What is genetics?
b. Define heredity.
c. What is variation?
2a. List the types of variations
b. List five examples of hereditary variations in humans.
c. List five examples of hereditary variations in plants.
3a. List five characteristics that can be transmitted in humans.
b. List five characteristics that can be transmitted in plants
4. How are characters transmitted from parents to offspring?
5. Explain how characters behave from generation to generation.

Presentation:

Step1: The teacher gives the following questions to the students which they are to discuss in their v groups after which each of the group leaders presents the answers to the questions given to them:

1. Why did Mendel choose pea plant for his experiments ?
2. List the Mendelian traits.

3. Explain Mendel's experimental methods.
4. Explain Mendel's experimental factors i.e germinal units.
5. What do you understand by recessive and dominant traits and how are they controlled?
6. State the law of segregation of genes.
7. State the law of independent assortment of genes.

Teacher guides the students on what to do and moderate their ideas.

Step 2:

Teacher continues to act as a facilitator and moderator of students' ideas. The teacher provides learning experiences and questions that on discussions lead to interactions with the students prior knowledge through:

i. Extending prior knowledge where ideas are needed.
ii. Helping students to refine their own ideas to scientifically validated ideas.

Students activities: Students discuss and sought the answers to the questions in their small groups and arrive at concrete suggestions on how genes behave from generation to generation with the help of the package given to them after which the group leaders present the answers compiled by the group. Students in their small groups of 4-5 observe breeding bottles containing drosophila flies and discuss among themselves. The leader of each group explains the findings of the group to the class. As the idea of each group is being presented by the group leader, alternative view points are identified and students are helped to recognize critically examine such alternative viewpoints.

Evaluation

The teacher assesses the lesson by asking the following questions:

1. Why did Mendel choose pea plant for his experiments?
2. List the Mendelian traits.
3. Explain Mendel's experimental methods.
4. Explain Mendel's experimental factors i.e. germinal units.
5. What do you understand by recessive and dominant traits and how are they controlled?
6. State the law of segregation of genes.
7. State the law of independent assortment of genes.

Conclusion: The teacher makes a brief summary of the topic of the lesson from the beginning to the end of the discussion.

TOPIC THREE

SCHOOL: Government Secondary School Jaji

DATE

SUBJECT: Biology

CLASS: SS3

TIME

DURATION: 80minutes

TITLE OF UNIT Continuity of Life

TOPIC OF LESSON: Mendel's work in genetics

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

1. explain Mendel's result of crossing pea plants.
2. list and explain the traits that are inherited in Mendel's pattern.
3. state the meaning of some genetic terms.
4. explain sex determination in man.
5. explain sex linkage.
6. list sex linked traits in man.

TEACHING MATERIALS: Yellow maize, white maize, Drosphila flies, breeding bottles, culture medium (food for flies), camel hair.

References :

1. Ndu, F. O. C; Asun, and P. Aina J. O. (2001) Senior Secondary Biology book 3 New Edition Longman Nigeria Plc.
2. Ndu, F. O. C; Edward, A. W. A., Danquah, K. and Ezenkwe, M. U. (2001) Round Up Biology for West African Senior Secondary School Certificate Examination. A complete guide. Longman Nigeria Plc.

Previous knowledge: The students are familiar with different plants and animals and they have been taught Mendel's work in genetics.

Introduction: Students maintain their small groups of 4-5. The teacher introduces the lesson by asking the following questions to arouse their interest.

1. Why did Mendel choose pea plant for his experiments ?
2. List the Mendelian traits.
3. Explain Mendel's experimental methods.
4. Explain Mendel's experimental factors i.e. germinal units.
5. What do you understand by recessive and dominant traits and how are they controlled?
6. State the law of segregation of genes.
7. State the law of independent assortment of genes.

Presentation:

Step1:

The teacher gives the following questions to the students which they are to discuss in their various groups after which each of the group leaders presents the answers to the questions given to them to the class.

1. What do you know about Mendel's results of crossing pea plants?
2. List and explain the inherited traits in Mendel's pattern.
3. Explain the meaning of the following:

a. Genes
b. Alleles
c. Homozygous

d. Heterozygous
e. Locus
f. Haploid
g. Diploid
h. Genotype
i. Phenotype
4. How is the sex of a child determined in man?
5. What is sex linkage?
6. List the sex linked traits in man.

Teacher guides the students on what to do and moderate their ideas.

Step 2:

Teacher continues to act as a facilitator and moderator of students' ideas. The teacher provides learning experiences and questions that on discussions leads to interactions with the students prior knowledge through:

a. Extending prior knowledge where ideas are needed.
b. Helping students to refine their own ideas to scientifically validated ideas.
c. The teacher reemphasizes the scientifically correct ideas
d. The scientifically correct ideas are written on the chalk board beside the students ideas

Step 3:

Teacher asks questions on how the knowledge of Mendel's work can help the students to explain how the sex of a child is determined in man and sex linkage and how sex linked traits in man are inherited.

Students' Activities:

Students discuss and sought the answers to the questions in their small groups and arrive at concrete suggestions on Mendel's work in genetics with the help of the package given to them after which the group leaders present the answers compiled by the group. Students in their small groups of 4-5 observe breeding bottles containing drosophila flies and discuss among themselves. Students observe and make representation of what they observe in their various groups. The students discuss among themselves and make the representation of their conclusions diagrammatically on Mendel's work in genetics" The leader of each group explains the findings of the group to the class. As the idea of each group is being presented by the group leader, alternative view points are identified and students are helped to recognize critically examine such alternative viewpoints.Students also discuss the answers to the questions in their small groups and arrive at concrete suggestions on how the sex of a child is determined in man, sex linkage and how sex linked traits are inherited in man.

. **Evaluation:**

The teacher asks the following questions to summarize the topic:

1. Explain Mendel's result of crossing pea plants.
2. List and explain the traits that were inherited in Mendelian pattern.
3. Explain the following genetic terms:

a. Gene
b. Alleles
c. Homozygous
d. Heterozygous
e. Locus
f. Haploid
g. Diploid

i. Genotype

j. phenotype.

4. How is the sex of a child determined in man?
5. What is sex linkage?
6. How are the sex linked traits inherited?
7. Mention examples of sex linked traits in man.

Conclusion: The teacher makes a brief summary of the topic of the lesson from the beginning to the end of the discussion.

TOPIC FOUR

SCHOOL: Government Secondary School Jaji

DATE

SUBJECT: Biology

CLASS: **SS3**

TIME

DURATION: 80minutes

TITLE OF UNIT Continuity of Life

TOPIC OF LESSON: Chromosomes: The Basis of Heredity.

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

1. identify chromosomes in permanently prepared slides of cells.
2. recall that chromatin granules, the precussors of chromosomes are present in the nucleus.
3. infer that chromosomes carry genes
4. infer that genes are responsible for inherited characters.
5. describe the structure of chromosomes.
6. list the number of chromosomes present in the somatic cells of at least three plants and five animals.
7. describe the molecular structure of DNA.
8. list the components of the nucleotide.
9. explain the role of chromosome in the transmission of hereditary characters.
10. explain the process of transmission of hereditary characteristics.

TEACHING MATERIALS: Prepared slides of roots tips of onion or lily showing mitosis, permanently prepared slides of testis of locust or grasshopper, drawing books, pencil, eraser, cardboard sheets.

References:

7. Ndu, F. O. C; Asun, and P. Aina J. O. (2001) Senior Secondary Biology book 3 New Edition Longman Nigeria Plc.
8. Ndu, F. O. C; Edward, A. W. A., Danquah, K. and Ezenkwe, M. U. (2001) Round Up Biology for West African Senior Secondary School Certificate Examination. A complete guide. Longman Nigeria Plc.

Previous knowledge: The students are familiar with different plants and animals and they have been taught Mendel's work in genetics.

Introduction: Students maintain their small groups of 4-5. The teacher introduces the lesson by asking the following questions:

1. Explain Mendel's result of crossing pea plants.
2. List and explain the traits that were inherited in Mendelian pattern.
3. Explain the following genetic terms:

i. Gene
ii. Alleles
iii. Homozygous
iv. Heterozygous
v. Locus
vi. Haploid
vii. Diploid
viii. Genotype
ix. Phenotype.

4. How is the sex of a child determined in man?
5. What is sex linkage?
6. How are the sex-linked traits inherited?
7. Mention examples of sex linked traits in man.

Presentation:

Step1:

The teachergives the following questions to the students which they are to discuss in their various groups after which each of the group leaders presents the answers to the questions given to them:

1a. What are chromosomes?
  b. Where are chromosomes located in the cell?

2a. Describe the structure of chromosome.
  b. What are the roles chromosomes play in the transmission of hereditary characters from parents tooffspring?

3. Explain the processes of transmission of hereditary characters from parents to offspring
4. Describe the molecular structure of DNA.
5. What are the roles of chromosomes in the transmission of hereditary characters from parents to offspring?
6. How are inherited characters transmitted from parents to offspring?
7. What percentage the offspring genetic makeup is inherited from each of the parents?

The teacher writes out activities for students to carry out:

Activities

Examine the slides mounted on the microscope to identify chromosomes.

Draw a highpower magnification of the cell.

Step2:

Teacher continues to act as a facilitator and guide. The teacher identifies alternative view-points students have and leads them to scientifically validated ideas about chromosomes. The teacher re-emphasizes the scientifically validated ideas by looking at the students' ideas and refining such scientifically valid ideas.

Students activities:

In each of the working groups, students observe and make drawing of what they observe.

They discuss among themselves and draw conclusions. These are represented diagrammatically and are presented on chromosomes. The report from each group is presented by the leader of the group. As the explanations are given alternative view-points identified are understood by students critically examining the alternative view points. Students then use the scientifically correct ideas to arrange the mitotic cell division diagrams they made accordingly. The students discuss the answers in their small groups and arrive at correct suggestions on the roles of chromosome in the transmission of hereditary characters from parents to offspring.

Evaluation

The teacher asks the following questions to summarize the topic:

1. What are chromosomes?
2. Where are chromosomes located in the cell?
3. What are the roles of chromosomes in the transmission of hereditary characters from parents to offspring?
4. Describe the structure of chromosome.
5. Describe the molecular structure of DNA.
6. Explain the process of transmission of hereditary characters from parent to offspring.

Conclusion: The teacher makes a brief summary of the topic of the lesson from the beginning to the end ofthe discussion.

TOPIC FIVE

SCHOOL: Government Secondary School Jaji

DATE

SUBJECT: Biology

CLASS: **SS3**

TIME

DURATION: 80minutes

TITLE OF UNIT: Continuity of Life

TOPIC OF LESSON: Probability in genetics

BEHAVIOURAL OBJECTIVES: by the end of the lesson, the students should be able to:

1. define probability.
2. apply the knowledge of probability to the formation of gametes.
3. apply the knowledge of probability to the formation of offspring.
4. apply the knowledge of probability to the determination of sex of a child in man.
5. apply the knowledge of probability to the transmission of sex linked traits in man.

TEACHING MATERIALS: cardboard sheets, dice, coins, ball of different colours, Pencils, drawing books and eraser.

References:

1. Ndu, F. O. C; Asun, and P. Aina J. O. (2001) Senior SecondaryBiologybook 3 New Edition Longman Nigeria Plc.
2. Ndu, F. O. C; Edward, A. W. A., Danquah, K. and Ezenkwe, M. U. (2001) Round Up Biology for West African Senior Secondary School Certificate Examination. A complete guide.Longman Nigeria Plc.

Previous knowledge: The students are familiar with different plants and animals. The students have been taught Chromosomes: The Basis of Heredity.

Introduction: Students maintain their small groups of 4-5. The teacher introduces the lesson by asking the following questions:

1. What are chromosomes?
2. Where are chromosomes located in the cell?
3. What are the roles of chromosomes in the transmission of hereditary characters from parents to offspring?
4. Describe the structure of chromosome.
5. Describe the molecular structure of DNA.
6. Explain the process of transmission of hereditary characters from parent to offspring.

Presentation:

Step1:

The teacher gives the following questions to the students which they are to discuss in their various groups after which each of the group leaders presents the answers to the questions given to them:

1a. define the term probability.

b. how will you apply knowledge of probability to the formation of gametes?

c. how will you apply knowledge of probability to the formation of offspring?

d. how will you use the knowledge of probability to the determination of sex of a child in man?

e. how will you use the knowledge of probability to the transmission of sex linked traits in man?

'2. the teacher write out the following activities for the students to carry out.

1. Toss an unbiased coin upwards, what is the probability that
   a. the coin may fall with head side up?
   b. the coin may fall with tail side up?

3.When a ludo die is rolled out of its cup, what is the probability that the die will finally come to rest with the side containing

a. facing upwards?
b. facing upwards?
c. facing upwards?
d. facing upwards?
e. facing upwards?
f. facing upwards?

Step 2:

The teacher acts as a guide and facilitator providing guiding questions that lead the students to the formulation of scientifically accepted responses. Correct responses given by the students will re-empahasized by the teacher. As these discussions go on misconceived ideas written on the cardboard are being thtashed one after the other. The teacher finally gives the summary of the ideas arrived at and places more emphasis on those that constitute a common source of misconceptions.

Students activities:

In each of the working groups. Students dcarry out the activities and record what they observe They discuss among themselves and draw conclusions. The report from each group is presented by the leader of the group. As the explanations given alternative view-points identified are understood by students critically examining the alternative view points. The students discuss the answers in their small groups and arrive at correct suggestions on probability in genetics.

Evaluation:

Teacher acts as a guide and facilitator and asks the following guiding and leading questions.

1. What is the probability in genetics?
2. What is the probability that two consecutive children of the same parents will be males?
3. How will you apply the he teacher asks the following leading questions.
4. Mrs. Audu is pregnant, what is the probability that the expected baby will be

a. a boy? b. a girl?
b. either a boy or a girl?
c. a goat?

Conclusion: The teacher makes a brief summary of the topic of the lesson from the beginning to the end of the discussion.

TOPIC SIX

SCHOOL: Government Secondary School Jaji
DATE
SUBJECT: Biology
CLASS: **SS3**
TIME:
DURATION: 80minutes
TITLE OF UNIT: Continuity of Life
TOPIC OF LESSON: Application of the principles of heredity in agriculture and medicine
BEHAVIOURAL OBJECTIVES: by the end of the lesson, the students should beable to:

differentiate between sexual and asexual reproduction.
differentiate between self fertilization and cross fertilization.
differentiate between inbreeding and out breeding
list and explain the applications of the principles of genetics in agriculture.
list and explain the applications of the principles of genetics in medicine.

TEACHING MATERIALS: cardboard sheets, drawing books, maize, sorghum
References :

1. Ndu, F. O. C; Asun, and P. Aina J. O. (2001) Senior Secondary Biology book 3 New Edition Longman Nigeria Plc.
2. Ndu, F. O. C; Edward, A. W. A., Danquah, K. and Ezenkwe, M. U. (2001) Round Up Biology for West African Senior Secondary School Certificate Examination. A complete guide. Longman Nigeria Plc.

Previous knowledge: The students are familiar with different plants and animals and the students have been taught probability in genetics.

Introduction: Students maintain their small groups of 4-5. The teacher introduces the lesson by asking the following questions:

1. Define probability.
2. How will youapply the knowledge of probability to the formation of gametes?
3. How will you apply the knowledge of probability to the formation ofoffspring?
4. How ill you apply the knowledge of probability to the determination of sex of a child in man?
5. How will you apply the knowledge of probability to the transmission of sex linked traits in man?

Presentation:

Step1:

The teacher gives the following questions to the students which they are to discuss in their various groups after which each of the group leaders presents the answers to the questions given to them:

1. List the types of asexual reproduction.
2. List five organisms that can reproduce asexually.
3. List five organisms that can reproduce sexually.
4. What are the differences between self fertilization and cross fertilization?
5. In a tabular form state the differences between inbreeding and out breeding.
6. List and explain the applications of the principles of genetics in
   a. agriculture
   b. medicine.

Step 2:

The teacher acts as a guide and facilitator providing guiding questions that lead the students to the formulation of scientifically accepted responses. Correct responses given by the students will be reemphasized by the teacher. The teacher finally gives the summary of the ideas arrived at and lays more emphasis on those that constitute a common source of misconceptions.

Students activities:

Students discuss and sought the answers to the questions in their small groups and arrive at concrete suggestions the application of the principles of heredity in agriculture and medicine with the help of the package given to them after which the group leaders present the answers compiled by the group. The leader of each group explains the findings of the group to the class. As the idea of each group is being presented by the group leader, alternative view points are identified and students are helped to recognize critically examine such alternative viewpoints.

Evaluation:

The teacher acts as a guide and facilitator. The teacher asks the following questions.

1. Differentiate between inbreeding and out-breeding.
2. Explain the various ways in which the knowledge of genetics can be applied in
   a. medicine
   b. agriculture
3. State the advantages of the application of heredity to agriculture and medicine

APPENDIX G

EXPERIMENTAL GROUP 3

ENRICHED CONCEPTUAL CHANGE DISCUSSIONS WITH CONCEPTUAL ASSIGNMENTS INSRUCTIONAL STRATEGY

TOPIC ONE

SCHOOL: Government Secondary School Sabon Afaka

DATE

SUBJECT

CLASS: SS3

TIME

DURATION: 80minutes

TITLE OF UNIT: Continuity of Life

TOPIC: Transmission and expression of characters in organisms.

BEHAVIOURAL OBJECTIVES: the end of the lesson, the students should be able to;

1. define the term genetics.
2. define heredity.
3. define variations.
4. state the types of variations.
5. list at least five examples of hereditary variations in humans.
6. state the characteristics that can be transmitted in man.
7. list the characteristics that can be transmitted in plants.
8. explain how characteristics are transmitted from parents to offspring.
9. explain how characteristics behave from generation to generation.

References :

1. Ndu, F. O. C; Asun, and P. Aina J. O. (2001) Senior Secondary Biology book 3 New Edition Longman Nigeria Plc.

4. Ndu, F. O. C; Edward, A. W. A., Danquah, K. and Ezenkwe, M. U. (2001) Round Up Biology for West African Senior Secondary School Certificate Examination. A complete guide. Longman Nigeria Plc.

Previous knowledge: Students are familiar with variation and genetics.

Introduction: The teacher introduces the lesson by asking the students the following questions to arouse theirinterest.

1. Are all the members of your family of the same sex?
2. Are all the members of your family of the same height?
3. Are you exactly like your parents?
4. If your answer is no why are you not exactly like your parents?

Presentation

Steps	Teacher's activities	Students activities
1. Orientation/ Awareness phase	The teacher introduces the lesson by asking the following questions. - What is genetics? - What is heredity? - What is variation? - List the types of variations. - List five examples of hereditary variations in humans. - List five examples of hereditary variations in plants. - How are characteristiics transmitted from parents to offspring? - How do characters behave from generation to generation? **Activities** Look at the members of your group and answer the following questions; 1.What are the features you have in common? 2.Are you all of the same height? If your answer is no, compare your height. 3.Why are you not the same?	Students discuss among themselves and sought out answers to the questions raised.
2. Elicitation of idea or Disequilibrium phase.	The teacher guides the students and moderates their ideas.	
3. Reformative	The teacher continues to act as a facilitator. The teacher provides learning experiences and questions that on discussions leads to interactions with students' prior to knowledge through; 1. Extending students prior knowledge where ideas are needed. 2. Helping students to refine their own ideas to scientifically validated ideas.	
4. Application phase	The teacher at this stage will reemphasize on scientifically correct ideas. Teacher asks questions on how the knowledge of transmission and expansion of characters in organisms can	Students discuss the answers to the questions in small groups and arrive at concrete conclusions.

	help the students. a. Explain why children of the same parents are not exactly the same. b. Why are children not exactly like their parents? c.Why do children resemble their grandparents?	
5. Evaluation phase	The teacher assesses the success of the lesson by asking the following questions. 1a.What is genetics? b. Define heredity. c. What is variation? 2a. List the types of variations. b. List five examples of hereditary variations in humans c. List five examples of hereditary variations in plants 3a. List five characteristics that can be transmitted in humans. b. List five characteristics that can be transmitted in plants. 4. How are characters transmitted from parents to offspring? 5. Explain how characters behave from generation to generation. The teacher makes a brief summary from the beginning to the end of the discussion.	The students will respond to the question in each case.
6. Assignment	The teacher gives the following questions to the students in preparation for the next topic; 1. Why did Mendel choose pea plant for his experiment? 2. List the Mendelian traits. 3. Explain the factors for Mendel's experiment. 4. Explain Mendel's experimental method. 5. Explain dormant and recessive traits. 6. State the law of segregation of germinal units. 7. State the law of independent assortment.	

TOPIC TWO

SCHOOL: Government Secondary School Sabon Afaka
DATE
SUBJECT
CLASS: SS3
TIME
DURATION: 80minutes
TITLE OF UNIT: Continuity of Life
TOPIC: Mendel's work in genetics
TEACHING MATERIALS: Yellow maize, white maize, Drosophila flies, breeding bottles, culture medium (food for flies), camel hair brush, ether and a white sheet of paper, muslin, twine, drawing book, cardboard sheets, pencil and cleaner.
BEHAVIOURAL OBJECTIVES: By the end of the lesson, the students should be able to:

i. Explain why Mendel chose pea plant for his experiments.
ii. List Mendel's traits correctly.
iii. Explain Mendel's experimental methods correctly.
iv. Explain Mendel's experimental factors i.e. germinal units.
v. Explain dominant and recessive traits.
vi. State the law of segregation of germinal units.
vii. State the law of independent assortment of germinal units.
viii. Compare their results (i.e. the ratios they obtain) with that of Mendel.

Presentation

Steps	**Teachers activities**	**Students activities**
1. Orientation/ Awareness.	Teacher introduces the lesson by asking the students the following questions: 1.Why did Mendel choose pea plant for his experiment? 2. List the Mendelian traits. 3. Explain Mendel's experimental factors i.e. germinal units. 4. Explain Mendel's experimental factors. 5.What do you understand by recessive and dominant traits and how are they controlled? 6. State the law of segregation of genes. 7.State the law of independent assortment of genes. 8. Explain Mendel's experimental methods.	- Students discuss and sought answers to the questions raised. - Students give responses to the questions raised by the teacher, giving explanations in each case.
2. Elicitation of ideas/	Teacher guides the students on what to	-Students form small groups of

Disequilibrium phase.	do and moderate their ideas.	4-5. -Students observe breeding bottles containing drosophila flies and discuss among themselves. -Conclusions of the discussions will be written on cardboard paper tagged "students ideas on Mendel's work on genetics". -These are displayed on the chalk board. -The leader of each group explains the findings of the group to the class.
3. Reformative **4. Application phase**	Teacher asks questions that on discussions lead to interactions with students' prior knowledge. This is done by: a. Extending prior knowledge where ideas are limited. b. Helping students to refine their ideas and re-emphasizes scientifically valid ideas. Teacher asks questions on how the knowledge of Mendel's work on genetics can help them to understand how genes behave from generation to generation.	As the idea of each group is being presented by group leader, alternative viewpoints are identified and students are helped to recognize and critically examine such alternative viewpoints. Students discuss the answers to the questions in their small groups and arrive at concrete suggestions on how genes behave from generation to generation.
5. Evaluation phase	Teacher asks the following questions: 1. Why did Mendel choose pea plant for his experiments? 2. List the Mendelian traits. 3. What are the factors of Mendel' experiments? 4. Explain Mendel's experimental methods. 5. What do you understand by recessive and dominant traits and how are they controlled? 6. State the law of segregation of genes.	Students give responses to the questions raised by the teacher giving explanations in each case.

	7. State the law of independent assortment of genes.	
6. **Assignments**	1. Explain Mendel's result of crossing pea plants. 2. List and explain the traits that are inherited in Mendelian pattern. 3. Explain the meaning of the following terms: a. Gene. b. Alleles. c. Homozygous. d. Heterozygous. e. Locus. f. Haploid. g. Diploid. h. Genotype. i. Phenotype. 4. Explain sex determination in man. 5. What is sex linkage? 6. List the sex-linked traits in man.	

TOPIC THREE

SCHOOL: Government Secondary School Sabon Afaka

DATE

SUBJECT

CLASS: SS3

TIME

DURATION: 80minutes

TITLE OF UNIT: Continuity of Life

TOPIC: Mendel's work in genetics.

TEACHING MATERIALS: Yellow maize, white maize, Drosphila flies, breeding bottles, culture medium (food for flies), camel hair.

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

1. explain Mendel's result of crossing pea plants.
2. list and explain the traits that are inherited in Mendel's pattern.
3. explain the meaning of some genetic terms.
4. explain sex determination in man.
5. explain sex linkage.
6. list sex linked traits in man.

Presentation

Steps	Teacher's activities	Students activities
1.Orientation/ Awareness	Teacher asks the following questions: 1. What do you know about Mendel's results of crossing pea plants? 2. List and explain the inherited traits in Mendelian pattern. 3. Explain the meaning of the following: i. Genes ii. Alleles iii. Homozygous iv. Heterozygous v. Locus vi. Haploid vii. Diploid viii. Genotype ix. Phenotype 4. How is sex of a child determined in man? 5. What is sex linkage? 6. List the sex-linked traits in man. Activities The students continue with the practical in lesson 2.	1. Students discuss the answers to the questions raised by the teacher in the various groups They write the final answers on the cardboard sheet in each group which is tagged "students ideas about Mendel's work in genetics". 2.Students carry out the activities in lesson 2 in their various groups, recording the information into their cardboard sheet already tagged "students ideas on Mendel's work in genetics".
2. Elicitation of ideas or Disequilibrium phase.	Teacher acts as facilitatorguides and moderates students' ideas.	- Students observe and make representation of what they observe in their various groups. - The students discuss among themselves and make the representation of their conclusions diagrammatically and captioned "student's ideas about Mendel's work in genetics".
3. Reformative	• Teacher continues to act as facilitator and moderator of students' ideas. • Teacher asks questions that on discussions leads to interactions with the students prior knowledge through: a. Extending prior knowledge where ideas are limited.	• Report of each of the groups is displayed by the team leader on the chalkboard. • Each team leader gives full explanations of the ideas of the group. As

	b. Helping students to refine their own ideas to scientifically validated ideas. c. The teacher re-emphasizes the scientifically correct ideas d. The scientifically correct ideas are written on the chalk board beside the students ideas.	these explanations and points are identified, students are then helped to recognize critique and examine such alternative point.
4. Application phase	Teacher asks questions on how the knowledge of Mendel's wok can help the students to explain how the sex of a child is determined in man and sex linkage and how sex linked traits in man are inherited.	Students are to discuss the answers to the questions in their small groups and arrive at concrete suggestions on how the sex of a child is determined in man, sex linkage and how sex linked traits are inherited in man.
5. Evaluation phase.	The teacher asks the following questions to summarize the topic: 1. Explain Mendel's result of crossing pea plants. 2. List and explain the traits that were inherited in Mendelian pattern. 3. Explain the following genetic terms: gene, alleles, homozygous, heterozygous, locus, haploid, diploid, genotype, phenotype. 4. How is the sex of a child determined in man? 5. What is sex linkage? 6. How are thesex- linked traits inherited? 7. Mention examples of sex linked traits in man.	- Students give responses to the questions raised by the teacher, giving explanation in each case. - Answers will be scientifically accepted ideas.
6.Assignment	The students are given the following assignment on the concept of chromosome: the basis of heredity 1. What are chromosomes? 2. Where are chromosomes located in the cell? 3. Describe the structure of chromosome. 4. What are the roles chromosomes	Students go through the questions in preparation for the next lesson.

	play in the transmission of hereditary characters from parents to offspring? 5. Explain the process of the transmission of hereditary characters from parents to offspring. 6. Explain the molecular structure of DNA.	

TOPIC FOUR

SCHOOL: Government Secondary School Sabon Afaka
DATE
SUBJECT
CLASS: SS3
TIME
DURATION: 80minutes
TITLE OF UNIT: Continuity of Life
TOPIC: Chromosomes: the basis of heredity.
TEACHING MATERIALS: Prepared slides of roots tips of onion or lily showing mitosis, permanently prepared slides of testis of locust or grasshopper, drawing books, pencil, eraser, cardboard sheets.
BEHAVIOURAL OBJECTIVES: By the end of the lesson, the students should be able to:

1. identify chromosomes in permanently prepared slides of cells.
2. recall that chromatin granules, the precussors of chromosomes are present in the nucleus.
3. infer that chromosomes carry genes
4. infer that genes are responsible for inherited characters.
5. describe the structure of chromosomes.
6. list the number of chromosomes present in the somatic cells of at least three plants and five animals.
7. describe the molecular structure of DNA.
8. list the components of the nucleotide.
9. explain the role of chromosome in the transmission of hereditary characters.
10. explain the process of transmission of hereditary characteristics.

Presentation

Steps	Teachers activities	Students' Activities
1. Orientation / Awareness	1. The teacher introduces the lesson by asking the following questions: 1a. What are chromosomes? b. Where are chromosomes located in the cell? 2a. Describe the structure of chromosome. c. What are the roles chromosomes play in the transmission of hereditary characters from parents to offspring? 3. Explain the processes of transmission of hereditary characters from parents to offspring 4. Describe the molecular structure of DNA.	1.Students discuss answers to the questions raised by the teacher in their various groups. The answers to the questions are written on the cardboard sheets tagged "students ideas about chromosomes". 2.Students carry out the activities, draw and record their observationsas they go along.

	c. The teacher writes out activities for students to carry out: **Activities** - Examine the slides mounted on the microscope to identify chromosomes. - Draw a highpower magnification of the cell.	
2. Elicitation of ideas or disequilibrium	Teacher continues to act as a guide and as facilitator.	In each of the working groups, students observe and make drawing of what they observe. They discuss among themselves and draw conclusions. These are represented diagrammatically and are captioned "students ideas about chromosomes".
3. Reformative	1. Teacher continues to act as a facilitator and guide. - The teacher identifies alternative view-points students have and leads them to scientifically validated ideas about chromosomes. 2.The teacher re-emphasizes the scientifically validated ideas by looking at the students' ideas and refining such scientifically valid ideas. i. These are written out on the chalkboard beside the students' ideas.	1. The report from each group is the displayed by the leader of the group. 2. As the explanations are given alternative view-points identified are understood by students critically examining the alternative view points. 3. Students then use the scientifically correct ideas to arrange the mitotic cell division diagrams they made accordingly.
4. Application phase	The teacher asks the following leading questions. 1. What are the roles of chromosomes in the transmission of hereditary characters from parents to offspring? 2. Through chromosomes	The students discuss the answers in their small groups and arrive at correct suggestions on the roles of chromosome in the transmission of hereditary characters from parents to offspring.

	inherited characters are transmitted from parents to offspring. 3. Offspring can only get 50% of the genetic makeup each of the parents.	
5. Evaluation phase	The teacher asks the following summarizing questions. a. What are chromosomes? b. Where are chromosomes located in the cell? c. What are the roles of chromosomes in the transmission of hereditary characters from parents to offspring? d. Describe the structure of chromosome. e. Describe themolecularstructure of DNA. f. Explain the process of transmission of hereditary characters from parent to offspring.	Students then give responses to the questions raised by the teacher giving explanation in each case. Answers will now be scientifically accepted ideas as indication that learning has taken place.
6. **Assignment**	1. What is probability? 2. How will you apply probability to the formation of gametes? 3. How will you apply probability to the formation of offspring? 4. How will you apply knowledge of probability to the determination of sex of a child in man? 5. How will you apply the knowledge of probability to the transmission of sex linked traits in man?	

TOPIC FIVE

SCHOOL: Government Secondary School Sabon Afaka
DATE
SUBJECT
CLASS: SS3
TIME
DURATION: 80minutes
TITLE OF UNIT: Continuity of Life
TOPIC: Probability in genetics
BEHAVIOURAL OBJECTIVES: by the end of the lesson, the students should be able to:

1. define probability.
2. apply the knowledge of probability to the formation of gametes.
3. apply the knowledge of probability to the formation of offspring.
4. apply the knowledge of probability to the determination of sex of a child in man.
5. apply the knowledge of probability to the transmission of sex linked traits in man.

TEACHING MATERIALS: cardboard sheets, dice, coins, ball of different colours, Pencils, drawing books and eraser.

Presentation

Steps	**Teacher's Activities**	**Students' Activities**
1. Orientation/ Awareness	1. The teacher introduces the lesson by asking the following questions. i. Define the term probability. ii. How will you apply the knowledge of probability to the formation of gametes? i. How will you use the knowledge of probability to explain sex determination in man? ii. How will you use the knowledge of probability to explain sex linked traits in man? 2. The teacher writes the following activities for the students to carry out. 1. Toss an unbiased coin upwards, what is the probability that: a. the coin may fall with head side up?	1. Students discuss the questions raised in their various groups and they write the and answers on the cardboard sheet already titled "students' ideas about probability". 2. Students carry out the activities and write out the answers to the questions raised on their cardboard sheets, which is already tagged "students' ideas about probability".

	b. the coin may fall with tail side up? 2. When a ludo die is rolled out of its cup, what is the probability that the die will finally come to rest with the side containing a. 1 facing upwards? b. 2 facing upwards? c. 3 facing upwards? d. 4. facing upwards? e. 5 facing upwards? f. 6 facing upwards?	
2. Elicitation of the ideas or disequilibrium phase **3. Reformative**	The teacher acts as guide and facilitator. As the team leader presents the group's ideas, alternativeview-points are picked out and written on the board alongside the correct responses. During this phase the teacher discusses with the students the identified alternative view points. -The teacher acts as a guide and facilitator providing guiding questions that lead the students to the formulation of scientifically accepted responses. -Correct responses given by the students will be re-emphasized by the teacher. -As these discussions go on misconceived ideas written on the cardboard are being thrashed one after the other. -The teacher finally gives summary of the ideas arrived at and places more emphasis on those that constitute a common source of	The team leader of the group presents the ideas of the group about the topic. The leader also discusses the views of the group on probability. The students take part in the discussion and are made to understand their alternative view-points and scientifically accepted views. The team leaders are further made to give scientifically valid ideas about probability.

	misconceptions. The teacher asks questions on the application of the knowledge of probability to genetics.	
4. Application phase	1. Mrs Audu is pregnant, what is the probability that the expected baby will be: a. a boy? b. a girl? c. either a boy or a girl? d. a goat?	
5. Evaluation phase	Teacher acts as a guide and facilitatorand asks the following guiding and leading questions. 1. What is the probability in genetics? 2. What is the probability that two consecutive children of the same parents will be males? 3. How will you apply the knowledge of probability to explain the transmission of sex linked traits in man? The teacher makes a brief summary from the beginning to the end of the discussion.	Students discuss the answers to the questions in their small groups and arrive at concrete conclusions. Students discuss the questions and together are convinced of the probability in genetics.
6. **Assignment**	The teacher gives the following questions in preparation for the next lesson. Describe the applications of genetics i. in agriculture. ii. in medicine.	The students answer the questions in preparation for the next lesson.

TOPIC SIX

SCHOOL: Government Secondary School Sabon Afaka

DATE

SUBJECT

CLASS: SS3

TIME

DURATION: 80minutes

TITLE OF UNIT: Continuity of Life

TOPIC: Application of the principles of heredity in agriculture and medicine

TEACHING MATERIALS: cardboard sheets, drawing books, maize, sorghum

BEHAVIOURAL OBJECTIVES: by the end of the lesson, the students shouldbe able to:

1. differentiate between sexual and asexual reproduction.
2. differentiate between self fertilization and cross fertilization.
3. differentiate between inbreeding and out breeding
4. list and explain the applications of the principles of genetics in agriculture.
5. list and explain the applications of the principles of genetics in medicine.

Presentation

Steps	Teacher's Activities	Students' Activities
Orientation /Awareness	The teacher introduces the lesson by asking the following questions. 1. List the types of asexual reproduction. 2. List five organisms that can reproduce asexually. 3. List five organisms that can reproduce sexually. 4. What are the difference between self fertilization and cross fertilization? 5. In a tabular form state the differences between inbreeding and out breeding. 6. List and explain the applications of the principles of genetics in a. agriculture b. medicine.	Students discuss the questions raised in their various groups and they write the answers on the cardboard sheets already titled "students ideas about the application of the principles of genetics in agriculture and medicine".
Elicitation of ideas or disequilibrium phase	The teacher acts as a guide and facilitator. As the team leader presents the group's ideas, alternative view points are picked out and written on the chalkboard	The team leaders of groups present the ideas of the group about the topic. The leader also discusses the

	alongside the correct responses.	views of the group on the application of the principles
Reformative	During this phase the teacher discusses with the students the identified alternative viewpoints. The teacher acts as a guide and facilitator providing guiding questions that lead the students to the formulation of scientifically accepted responses. Correct responses given by the students will be reemphasized by the teacher. As these discussions go on misconceived ideaswritten on the cardboard are being thrashed one after the other.	of genetics in agriculture and medicine. The students take part in the discussions and are made to understand their alternative viewpoints and scientifically accepted views. The team leaders are further made to give scientifically valid ideas about the applications of the principles of genetics in agriculture and medicine.
Application phase	The teacher finally gives the summary of the ideas arrived at and lays more emphasis on those that constitute a common source ofmisconceptions. The teacher asks the following questions on the applications of the principles of genetics in agriculture and medicine. i. Differentiate between inbreeding and out-	Students discuss the answers to the questions in various groups and arrive at concrete conclusions.
Evaluation phase	breeding. ii. How are the principles of genetics applied to a. agriculture. b. medicine. iii. State the advantages of the application of heredity to agriculture and medicine. The teacher acts as a guide and facilitator. The teacher asks the following questions.	Students discuss the answers to the questions and together are convinced of the applications of the principles of genetics in agriculture and medicine.

	Explain the various ways in which the knowledge of genetics can be applied in a. Medicine b. agriculture	

APPENDIX H

CONTROL GROUP

LECTURE METHOD

TOPIC ONE

SCHOOL: Government Secondary School Hayin Banki

DATE

SUBJECT Biology

CLASS: SS3

TIME

DURATION 80minutes

TITLE OF UNIT Continuity of Life

TOPIC: Transmission and expression of characters in organisms.

BEHAVIOURAL OBJECTIVES:by the end of the lesson, the students should able to:

1. define the term genetics.
2. define heredity.
3. define variations.
4. state the types of variations.
5. list at least five examples of hereditary variations in humans.
6. state the characteristics that can be transmitted in man.
7. list the characteristics that can be transmitted in plants.
8. explain how characteristics are transmitted from parents to offspring.
9. explain how characteristics behave from generation to generation.

References :

1. Ndu, F. O. C; Asun, and P. Aina J. O. (2001) Senior Secondary Biology book 3 New Edition Longman Nigeria Plc.

2. Ndu, F. O. C; Edward, A. W. A., Danquah, K. and Ezenkwe, M. U. (2001) Round Up Biology for West African Senior Secondary School Certificate Examination. A complete guide. Longman Nigeria Plc.

Previous knowledge: Students are familiar with different plants and animals.

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

What is variation?

What is genetics?

Presentation or Development

Step I The teacher leads the students on to the definitions of variation andgenetics.

Step II The teacher gives the types of variations to the students and lists the examples of hereditary variations in humans.

Step III The teacher explains the characteristics that can be transmitted in Plants and in man

Step IV The teacher further explains to the students how characteristics are transmitted from parents to offspring and how characteristics smanifest from generation to generation.

Students Activities: The students answer the teacher's questions and asks questions when necessary. They also copy note in their exercise books.

Summary: The teacher briefly goes over the lesson and lays more emphasis onthe important points.

Evaluation: The teacher asks questions on the topic to assessthe success of the lesson.

1. Define the term genetics.
2. Define heredity.
3. Define variations.
4. State the types of variations.
5. List five examples of hereditary variations in humans.
6. State the characteristics that can be transmitted in man.
7. List the characteristics that can be transmitted in plants.
8. Explain how characteristics are transmitted from parents to offspring.
9. Explain how characteristics behave from generation to generation.

TOPIC TWO

SCHOOL: Government Secondary School Hayin Banki
DATE
SUBJECT
CLASS: **SS3**
TIME
DURATION: 80minutes
TITLE OF UNIT: Continuity of Life
TOPIC: Mendel's work in genetics
BEHAVIOURAL OBJECTIVES: By the end of the lesson, the students should be able to:

1. explain why Mendel chose pea plant for his experiments.
2. list Mendel's traits correctly.
3. explain Mendel's experimental methods correctly.
4. explain Mendel's experimental factors i.e. germinal units.
5. explain dominant and recessive traits.
6. state the law of segregation of germinal units.
7. state the law of independent assortment of germinal units.

References :

1. Ndu, F. O. C; Asun, and P. Aina J. O. (2001) Senior SecondaryBiology book 3 New Edition Longman Nigeria Plc.
2. Ndu, F. O. C; Edward, A. W. A., Danquah, K. and Ezenkwe, M. U. (2001) Round Up Biology for West African Senior Secondary School Certificate Examination. A complete guide. Longman Nigeria Plc.

Previous knowledge: Students have been taught transmission and expression of characters in organisms.
Introduction : The teacher introduces the lesson by asking the students the following questions.

1. Define the term genetics.
2. Define heredity.
3. Define variations.
4. State the types of variations.
5. List five examples of hereditary variations in humans.
6. State the characteristics that can be transmitted in man.
7. List the characteristics that can be transmitted in plants.
8. Explain how characteristics are transmitted from parents to offspring.
9. Explain how characteristics behave from generation to generation.

Presentation or Development
Step I The teacher explains the Mendel's experimental methods and Mendel's traits to the students.
Step II The teacher gives the reasons why Mendel chose pea plants for his experiments.
Step IV The teacher further explains thegerminal units, dominantand recessive traits and gives the two Mendelian laws to the students.
Students Activities: The students answer the teacher's questions and ask questions.
They also copy note in their exercise books
Summary: The teacher briefly goes over the lesson laying more emphasis
on important points.
Evaluation: The teacher asks questions on the topic to assess the success of thelesson.

1. Explain why Mendel chose pea plant for his experiments.
2. List Mendel's traits correctly.

3. Explain Mendel’s experimental methods correctly.
4. Explain Mendel’s experimental factors i.e. germinal units.
5. Explain dominant and recessive traits.
6. State the law of segregation of germinal units.
7. State the law of independent assortment of germinal units.

TOPIC THREE

SCHOOL: Government Secondary School Hayin Banki

DATE

SUBJECT: Biology

CLASS: SS3

TIME

DURATION: 80minutes

TITLE OF UNIT Continuity of Life

TOPIC: Mendel's work in genetics

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

1. explain Mendel's result of crossing pea plants.
2. list and explain the traits that are inherited in Mendel's pattern.
3. explain the meaning of some genetic terms.
4. explain sex determination in man.
5. explain sex linkage.
6. list sex linked traits in man.

References :

1. Ndu, F. O. C; Asun, and P. Aina J. O. (2001). SeniorSecondary Biology book 3 New Edition Longman Nigeria Plc.
3. Ndu, F. O. C; Edward, A. W. A., Danquah, K. and Ezenkwe, M. U. (2001) Round Up Biology for West African Senior Secondary School Certificate Examination. A complete guide. Longman Nigeria Plc.

Previous knowledge: Students are familiar with plants and animals and they have been taught Mendel's work in genetics.

1. Explain why Mendel chose pea plant for his experiments.
2. List Mendel's traits correctly.
3. Explain Mendel's experimental methods correctly.
4. Explain Mendel's experimental factors i.e. germinal units.
5. Explain dominant and recessive traits.
6. State the law of segregation of germinal units.
7. State the law of independent assortment of germinal units.

Introduction: The teacher introduces the lesson by asking the students some questions.

Presentation or Development

Step I The teacher explains to the students the Mendel's result of crossing pea plants and lists the traits that are inherited in Mendel's pattern.

Step II The teacher gives the meaning of some genetic terms.

Step III The teacher explains sex determination in man.

Step IV The teacher further explains to the students the meaning of sex linkage and lists the sex -linked traits in man.

Students Activities: The students answer the teacher's questions and ask questions. They also copy note in their exercise books

Summary: The teacher briefly goes over the lesson laying more emphasisonimportant points.

Evaluation: The teacher asks questions on the topic to assess the success of the lesson.

1. Explain Mendel's result of crossing pea plants.
2. List and explain the traits that are inherited in Mendel's pattern.

3. Explain the meaning of some genetic terms.
4. Explain sex determination in man.
5. Explain sex linkage.
6. List sex linked traits in man.

TOPIC FOUR

SCHOOL: Government Secondary School Hayin Banki
DATE
SUBJECT
CLASS: SS3
TIME
DURATION: 80minutes
TITLE OF UNIT Continuity of Life
TOPIC: Chromosomes: the basis of heredity
BEHAVIOURAL OBJECTIVES: By the end of the lesson, the students should be able to:

1. identify chromosomes in permanently prepared slides of cells.
2. recall that chromatin granules, the precussors of chromosomes are present in the nucleus.
3. infer that chromosomes carry genes
4. infer that genes are responsible for inherited characters.
5. describe the structure of chromosomes.
6. list the number of chromosomes present in the somatic cells of at least three plants and five animals.
7. describe the molecular structure of DNA.
8. list the components of the nucleotide.
9. explain the role of chromosome in the transmission of hereditary characters.
10. explain the process of transmission of hereditary characteristics.

References:

1. Ndu, F. O. C; Asun, and P. Aina J. O. (2001) Senior Secondary Biology book 3 New EditionLongman
Nigeria Plc.
3. Ndu, F. O. C; Edward, A. W. A., Danquah, K. and Ezenkwe, M. U. (2001) Round Up Biology for West African Senior Secondary School Certificate Examination. A complete guide. Longman Nigeria Plc.

Previous knowledge: Students have been taught Mendel's work in genetics.
Introduction: The teacher introduces the lesson by asking the students the following questions

1. What is a germinal unit?
2. State.the first and second Mendel's laws.

Presentation or Development
Step I The teacher explains the chromatin granules, the precussors of chromosomes are located in the nucleus to the students.
Step II The teacher describes the structure of chromosomes and gives the number of chromosomes present in the somatic cells of some plants and animals.
Step III The teacher also explains the roles of chromosomes in the transmission of hereditary characters to the students.
Step IV The teacher further explains to the students the molecular structure of DNA.
Students Activities: The students answer the teacher's questions and ask questions when necessary. They also copy note in their exercise books
Summary: The teacher briefly goes over the lesson and lays more emphasis

on important points.

Evaluation: The teacher asks the following questions on the topic to assess the success of the lesson.

1. The precussors of chromosomes present in the nucleus are called ___________.
2. Chromosomes carry______________
3. ____________ are responsible for inherited characters.
4. Describe the structure of chromosomes.
5. List the number of chromosomes present in the somatic cells of at least three plants and five animals.
6. Describe the molecular structure of DNA.
7. List the components of the nucleotide.
8. Explain the role of chromosome in the transmission of hereditary characters.
9. Explain the process of transmission of hereditary characteristics.

TOPIC FIVE

SCHOOL: Government Secondary School Hayin Banki
DATE
SUBJECT: Biology
CLASS: SS3
TIME
DURATION: 80minutes
TITLE OF UNIT Continuity of Life
TOPIC: Probability in genetics
BEHAVIOURAL OBJECTIVES: By the end of the lesson, the students should be able to:

1. define probability.
2. apply the knowledge of probability to the formation of gametes.
3. apply the knowledge of probability to the formation of offspring.
4. apply the knowledge of probability to the determination of sex of a child in man.
5. apply the knowledge of probability to the transmission of sex linked traits in man.

Previous knowledge: Students are familiar with ludo and playing cards and they have been taught Chromosomes: the basis of heredity.

References:
1.Ndu, F. O. C; Asun, P. and Aina J. O. (2001) Senior Secondary Biology book 3 New Edition Longman Nigeria Plc.
2. Ndu, F. O. C; Edward, A. W. A., Danquah, K. and Ezenkwe, M. U. (2001) Round Up Biology for WestAfrican Senior Secondary School Certificate Examination. A complete guide.Longman Nigeria Plc.

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

1. The precussors of chromosomes present in the nucleus are called ___________.
2. Chromosomes carry_______________
3. _____________ are responsible for inherited characters.
4. Describe the structure of chromosomes.
5. List the number of chromosomes present in the somatic cells of at least three plants and five animals.
6. Describe the molecular structure of DNA.
7. List the components of the nucleotide.
8. Explain the role of chromosome in the transmission of hereditary characters.
9. Explain the process of transmission of hereditary characteristics.
10. What is probability?
11. What is genetics?

Presentation or Development

Step I The teacher leads the students on the definition of probability in genetics.

Step II The teacher explains the application of the knowledge of probability in the formation of gametes and offspring to the students.

Step III The teacher further explains to the students the application of the knowledge of probability to the determination of sex of a child in man and to the transmission of sex linked traits in man.

Students Activities: The students answer the teacher's questions and ask questions They also copy note in their exercise books.

Summary: The teacher briefly goes over the lesson and lays more emphasis on the important points.

Evaluation: The teacher asks the following questions on the topic to assess the success of the lesson.

1. Define probability.
2. How will you apply the knowledge of probability to the formation of gametes?
3. How will you apply the knowledge of probability to the formation of offspring?
4. How will you apply the knowledge of probability to the determination of sex of a child in man?
5. How will you apply the knowledge of probability to the transmission of sex linked traits in man?

TOPIC SIX

SCHOOL: Government Secondary School Hayin Banki
DATE
SUBJECT: Biology
CLASS: SS3
TIME
DURATION: 80minutes
TITLE OF UNIT Continuity of Life
TOPIC: Application of the principles of heredity in agriculture and medicine
BEHAVIOURAL OBJECTIVES: by the end of the lesson, the students should be able to:

1. differentiate between sexual and asexual reproduction.
2. differentiate between self fertilization and cross fertilization.
3. differentiate between inbreeding and out breeding
4. list and explain the applications of the principles of genetics in agriculture.
5. list and explain the applications of the principles of genetics in medicine.

Previous knowledge: Students are familiar with variation and genetics.They are also familiar with plant and animal breeding.

References:

1. Ndu, F. O. C; Asun, P.and Aina J. O. (2001). Senior Secondary Biology book 3 New Edition Longman Nigeria Plc.
2. Ndu, F. O. C; Edward, A. W. A., Danquah, K. and Ezenkwe, M. U. (2001) Round Up Biology for West African Senior Secondary School Certificate Examination. A complete guide. Longman Nigeria Plc.

Introduction : The teacher introduces the lesson by asking the students the following questions: What is heredity?

What is variation?

Presentation or Development

Step 1 The teacher leads the students on to the differences between sexual and asexual reproduction.

Step II The teacher gives the differences between self fertilization and cross fertilization and inbreeding and out breeding.

Step III The teacher further lists and explains to the students the applications of the principles of genetics in agriculture and in medicine.

Students Activities: The students answer the teacher's questions and ask questions where necessary. They also copy note in their exercise books

Summary: The teacher briefly goes over the lesson laying more emphasis on important points.

Evaluation: The teacher asks questions on the topic to assess the success of the lesson.

APPENDIXI

SUMMARY TABLE FOR ITEM ANALYSIS OF THE INSTRUMENT

ITEMS	**RIGHT**	**WRONG**	**DIFFICULTY INDEX**	**DISCRIMINATION INDEX**
1	20	10	0.666	0.50
2	10	20	0.333	0.50
3	19	11	0.633	0.42
4	15	15	0.5	0.0 **
5	9	21	0.3	0.57
6	17	13	0.566	0.235 RR
7	10	20	0.333	0.50
8	5	25	0.1666	0.8 **
9	16	14	0.5333	0.125 **
10	3	27	0.1	0.888
11	13	17	0.433	0.235 RR
12	2	28	0.066	0.928
13	5	25	0.166	0.8 **
14	5	25	0.166	0.8 **
15	11	26	0.133	0.846
16	8	22	0.266	0.636
17	17	13	0.566	0.235 RR
18	7	28	0.233	0.928
19	7	23	0.233	0.695
20	14	16	0.466	0.125 **
21	6	24	0.2	0.75
22	12	18	0.4	0.333
23	17	13	0.566	0.235 RR
24	11	19	0.366	0.421
25	18	12	0.6	0.333
26	10	20	0.333	0.50
27	14	16	0.466	0.125 **
28	10	20	0.333	0.50
29	4	26	0.133	0.846
30	6	24	0.2	0.75
31	2	28	0.066	0.0769
32	9	21	0.3	0.57
33	6	24	0.2	0.75
34	13	17	0.433	0.235 RR
35	2	28	0.066	0.928
36	3	27	0.1	0.888
37	9	21	0.3	0.57
38	10	20	0.333	0.50
39	13	17	0.433	0.235 RR
40	10	20	0.333	0.50
Reliability r= 0.82				

APPENDIX J

Pretest and Posttest Reliability Using PPMC

Appendix J: Raw scores of the two sets of tests for determining the coefficient of reliability of the test 00000000instrument

S/NO	X	Y	X^2	Y^2	XY
1	14	27	196	729	378
2	14	29	196	841	406
3	14	29	196	841	406
4	13	26	169	676	338
5	12	23	144	529	276
6	13	25	169	625	325
7	22	26	484	676	572
8	25	22	625	484	550
9	23	21	529	441	483
10	23	23	529	529	529
11	31	20	961	400	620
12	23	24	529	576	552
13	25	29	625	841	725
14	27	25	729	625	675
15	26	26	676	676	676
16	35	24	1225	576	840
17	33	31	1089	961	1023
18	32	23	1024	529	736
19	34	22	1156	484	748
20	31	25	961	625	775
21	32	26	1024	676	832
22	32	30	1024	900	960
23	30	35	900	1225	1050
24	35	24	1225	576	840
25	24	26	576	676	624
26	26	30	676	900	780
27	28	35	784	1225	980
28	23	24	529	576	552
29	26	26	676	676	676
30	28	33	784	1089	924
N=30	∑X=754	∑Y=789	∑X2=20410	∑Y2=21183	∑XY =19851

Note: X and Y are First and Second Tests Scores for Genetic Performance Test

Statistics for Finding Reliability

Pearson Product Moment Correlation computed for theReliability index for the instrument used in the pilot study of the research.

The formula for Pearson Product Moment Correlation is given below:

R= N(∑xy) - (x) ∑Y

(($N(X^2)$ - $(NY^2)-(Y)^2$)

N=Number of respondents

X is test scores at pre test

Y is test scores at post test

∑x is scores at pretest is summed

∑y is scores at Post test is summed

$\sum x^2$ is scores at pre test is squared and summed

$\sum Y^2$ is scores at post test is squared and summed

$(\sum x)^2$ is scores at pre test is summed and squared

$(\sum Y)^2$ is scores at post test is summed and squared

Where:

N=30	∑X=**754**	∑Y=**789**	∑X2=**20410**	∑Y2=**21183**	∑XY =19851

Pearson Product Moment Correlation formula is:

r= N(∑xy) - ∑ (x) ∑Y

(($N(\sum X^2)$ - $(N*\sum Y^2)-(\sum Y)^2$

= **30*19851 - 754*789**

$30*(20410)^2$- $30*21183-(789)^2$

=0.822

R= 0.82

APPENDIX K

Six Schools selected for Pretest

Descriptive

Scores

	N	Mean	Std. Deviation	Std. Error
School A	15	22.2000	4.17817	1.07880
School B	15	15.0000	2.29907	.59362
School C	15	22.3333	4.16905	1.07644
School D	15	15.6000	2.44365	.63095
School E	15	22.8000	4.69346	1.21185
School F	16	23.6250	4.09675	1.02419
Total	91	20.2967	5.10445	.53509

ANOVA

Scores

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	**1139.506**	**5**	**227.901**	**16.070**	**.000**
Within Groups	**1205.483**	**85**	**14.182**		
Total	**2344.989**	**90**			

APPENDIX L

Scheffe's Post Hoc Tests Multiple Comparisons of Scores
Dependent Variable: Scores

(I) schools	(J) schools	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
School A	School B	7.20000*	1.37512	.000	2.5147	11.8853
	School C	-.13333	1.37512	1.000	-4.8187	4.5520
	School D	6.60000*	1.37512	.001	1.9147	11.2853
	School E	-.60000	1.37512	.999	-5.2853	4.0853
	School F	-1.42500	1.35346	.952	-6.0365	3.1865
School B	School A	-7.20000*	1.37512	.000	-11.8853	-2.5147
	School C	-7.33333*	1.37512	.000	-12.0187	-2.6480
	School D	-.60000	1.37512	.999	-5.2853	4.0853
	School E	-7.80000*	1.37512	.000	-12.4853	-3.1147
	School F	-8.62500*	1.35346	.000	-13.2365	-4.0135
School C	School A	.13333	1.37512	1.000	-4.5520	4.8187
	School B	7.33333*	1.37512	.000	2.6480	12.0187
	School D	6.73333*	1.37512	.001	2.0480	11.4187
	School E	-.46667	1.37512	1.000	-5.1520	4.2187
	School F	-1.29167	1.35346	.969	-5.9032	3.3199
School D	School A	-6.60000*	1.37512	.001	-11.2853	-1.9147
	School B	.60000	1.37512	.999	-4.0853	5.2853
	School C	-6.73333*	1.37512	.001	-11.4187	-2.0480
	School E	-7.20000*	1.37512	.000	-11.8853	-2.5147
	School F	-8.02500*	1.35346	.000	-12.6365	-3.4135
School E	School A	.60000	1.37512	.999	-4.0853	5.2853
	School B	7.80000*	1.37512	.000	3.1147	12.4853
	School C	.46667	1.37512	1.000	-4.2187	5.1520
	School D	7.20000*	1.37512	.000	2.5147	11.8853
	School F	-.82500	1.35346	.996	-5.4365	3.7865
School F	School A	1.42500	1.35346	.952	-3.1865	6.0365
	School B	8.62500*	1.35346	.000	4.0135	13.2365
	School C	1.29167	1.35346	.969	-3.3199	5.9032
	School D	8.02500*	1.35346	.000	3.4135	12.6365
	School E	.82500	1.35346	.996	-3.7865	5.4365

***. The mean difference is significant at the 0.05 level.**

Homogeneous Subsets

Scores

Scheffe

Schools	N	Subset for alpha = 0.05	
		1	2
School B	15	15.0000	
School D	15	15.6000	
School A	15		22.2000
School C	15		22.3333
School E	15		22.8000
School F	16		23.6250
Sig.		.999	.954

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 15.158.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

The analysis showed that schools A, C, E and F are schools that are with the same level of scores and so would be chosen for the main study.

APPENDIX M

WASSCE May/June 2005- 2018 Questions on Genetic Concepts

2005 Objective Questions 48, 49, 50, 51, 52, 53, 54, 55, 56

Theory Questions 7ai, ii, iii, iv, 7b ci, &ii

2006 Objective Questions 53, 54, 55, 56, 57, 58

2007 Objective Questions 4, 52, 53, 54, 55, 56, 57, 58

Theory Questions 3ai, ii bi, ii, c & d

2008 Objective Questions 46, 47, 48, 49, 50, 51, 52, 53, 54, 55

Theory Questions 4a, b

2009 Objective Questions 11, 12, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58

Theory Questions 4a, b, c, d

2010 Objective Questions 44, 46, 47, 48, 49, 51, 52, 53, 54, 55, 56, 59

Theory Questions 4a, b, ci, & ii

2011 Objective Questions 24, 51, 52, 54, 55, 56, 57, 60

Theory Questions 4ai, ii, bi, ii

2012 Objective Questions 6, 10, 11, 50, 51, 53, 54, 55, 56, 57, 58

Theory Questions 4ai, ii, bi, ii, iii & c

2013 Objective Questions 48, 49, 50, 51, 52, 53, 54

2014 Objective Questions 40, 41, 42, 43, 44, 45, 46, 47

Theory Questions 4ai, ii, iii, b

2015 Objective Questions 11, 40, 41, 42, 43, 44, 45, 46, 47

Theory Questions 4ai, ii, bi, ii

2016 Objective Questions 3, 40, 41, 42, 43

Theory Questions 4ai, ii, 6g

2017 Objective Questions 43, 44, 45, 46, 47

Theory Questions 4ai

2018 Objective Questions 38, 39, 40, 41, 42, 43, 44, 45, 46

Theory Questions 4ai, ii, iii, b, c

2019 Objective Questions 5, 6, 41, 42, 43, 44, 45, 46, 47, 48,