EFFECTS OF TEACHING-WITH-FIGURES OF COMPARISON ON SENIOR SCHOOL STUDENTS' ACHIEVEMENT IN GENETICS IN ILORIN METROPOLIS, NIGERIA

Ph.D. Oral Defence

By

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CERTIFICATION

This is to certify that this Ph.D. research work was carried out by SULAIMAN, Musa Mohammed (98/25OC250) in the Department of Science Education, Faculty of Education, University of Ilorin, Ilorin, Nigeria

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DEDICATION

This thesis is dedicated to the Almighty Allah for His favour and guidance.

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ABSTRACT

Genetics, the Biology of heredity, provides a unifying conceptual framework that links every life science together had been identified in literature as one of the hard-to-teach and hard-to-learn Biology concept. It has been established that the abstract nature of genetics and teaching strategies employed by teachers can significantly influence students' achievement in genetics. Figures of comparison, such as analogy and metaphor, have been identified as potent tools that can be used to enhance students' achievement in sciences but its efficacy in teaching genetics has not been fully explored. This study examined the effects of Teaching-With-Figures of Comparison on Senior School students' achievement in genetics in Ilorin, Nigeria. The objectives of the study were to: (i) compare the achievement of Senior School students taught genetics using analogy, metaphor and conventional teaching strategies; (ii) examine the effects of analogy and metaphor on students' achievement based on gender; (iii) determine the effects of analogy on students' achievement based on cognitive styles and score levels; (iv) investigate the effects of metaphor on students' achievement based on cognitive styles and score levels; and (v) establish the interaction effects among treatment, gender, cognitive styles and score levels.

The research adopted a quasi-experimental design of a pre-test, posttest, non-equivalent, non-randomised control group. The population was all Senior School students offering Biology in Ilorin, Nigeria, while the sample consisted of 174 Senior School III students from three purposively selected secondary schools in Ilorin. The research instruments were Genetic Achievement Test (GAT), Group Embedded Figure Test (GEFT), Teachers' Instructional Guides on Analogy, and Metaphor. The reliability coefficients of the GAT and GEFT were 0.81 and 0.79 respectively using Pearson's Product Moment Correlation statistics. Data were analysed using *t-test* and ANCOVA at 0.05 level of significance.

The findings of the study were that:

i. a significant difference exists in the achievement of students exposed to instruction with the use of analogy, metaphor and conventional teaching method in favour of analogy and metaphor groups $F_{(2,170)}$= 13.41, p < 0.05;
ii. no significant difference in the achievement of male and female students exposed to analogy and metaphor instructional strategies $t_{(53)}$=.65, p =.52, $t_{(60)}$=.40, p =.69, p > 0.05;
iii. no significant difference in the effects of analogy on the achievement of students based on their cognitive styles and score levels $F_{(2,51)}$=1.31, p =.29, p > 0.05;
iv. no significant difference in the effects of metaphor on the achievement of students based on their cognitive styles and score levels $F_{(2,58)}$ = .56,p =.57, p > 0.05; and
v. no interaction effect between treatment and gender; treatment and cognitive styles. However, there was a significant interaction effect of treatment and score levels $F_{(4,164)}$= 2.87, p < 0.05

The study concluded that the use of analogy and metaphor improves students' achievement in genetics. This implies that analogy and metaphor strategies significantly bring about conceptual understanding of genetics and by extension other Biology concepts. The study

recommended that analogy and metaphor instructional strategies be employed by teachers to teach genetics.

CHAPTER ONE

INTRODUCTION

Background to the Problem

Every community, including the school setting, requires effective communication among its members to bring about effective dissemination of information devoid of misconceptions. The effective classroom interaction that occurs between teachers and students goes a long way in bringing about meaningful learning. Communication among human beings, most especially in the classroom, requires the use of the appropriate language that is understood by both the teacher and the learners. Abimbola (2015) was of the view that communication is at the heart of any formal or informal teaching-learning process asit uses language as a vehicle for conveying feelings, thoughts, intentions, beliefs and so forth.

The place of the language of instruction in eliciting meaningful learning cannot be overemphasised especially in the field of science, which is rich in terminologies and words, whose meanings are different from common daily usage. Nygard Larsson (2011) asserted that language as a resource for learning science often poses a high challenge to students studying science through the second language because of its immense richness of words and the types of terms used in passinginformation.

Science has been mplified by different authors and researchers with diverse views based on its products, processes, or methods (Abimbola, 2017). Science is a body of knowledge, a way or method of probing in order to give theoretical explanations to phenomena or gain a better understanding of nature (Abimbola, 2013). It can also be described as any system of knowledge that entails carrying out unbiased observation and systematic experimentation concerning the physical world (Science, 2010). Similarly, science involves the pursuit of knowledge through conscientious observation of natural phenomena. Thayer (2012) stated that

the field of science has two major branches, namely: pure or theoretical science and applied or practical science.

Pure science explains phenomena, while applied science deals withtheeffective use and application of science to solve problems (Sulaiman, 2016). The field of pure science is divided into physical science, earth, and life sciences. The latter describes living organisms in relation to their internal processes and relationships with each other (infoplease.com, 2015). Life science is basically divided into the fields of Biology, Botany, and Zoology among others because it deals withthe study of life.

Biology as a branch of life science deals with the study of live and living things (Lumencadela, 2016). Its teaching has been of great significance as it equips learners with the vital skills essential to building a progressive society and also enables themto have a better comprehension of the world around them. The study is a prerequisite to studying medical related disciplines and life scienceprogrammes at the tertiary education level in Nigeria. It encompasses other fields of research, which are related to the sustainability of life, ranging from the ecosystem to the environment, to causes of illnesses, to the development of vaccines and medicine and in the process provide answers to global emerging issues of waste management, famine, environmental degradation, family and public health and population.

Biology is closely related to a number of fields of specialisation, such as Biochemistry, Bioengineering, Biotechnology, Biofeedback phenomenon, Biomedicine, Biophysics, Cell Biology, Developmental Biology, Evolutionary Biology, Marine Biology, Microbiology, among others (Abimbola&Omosewo, 2013).Ithas become a multidisciplinary subject which shares a close relationship with other science subjects like Physics, Chemistry and other subjects like Geology, Mathematics, Physical and Health Education among others.

Biology and its related disciplines are quite popular at all grades of the Nigerian educational system (Owoeye, 2016) and have a larger student enrollment than other science

subjects, most especially at the secondary level (Ahmed & Abimbola, 2011). The popularity Biology enjoys among students may not be unconnected with its autonomous nature which makes it unique. Mayr (2004) stated that Biology as a genuine science that consists of two aspects namely; functional and historical biology, is not guided by the presence of universal laws, essentialism, determinism, and reductionism that are found in other science subjects. Meanwhile, Adegboye, Bello and Abimbola (2017) affirmed that all natural laws of the physical sciences are applicable in functional biology but cannot be applied to historical biology. Theyfurther stated that these principles have been replaced with principles that are unique to living things since Biology deals with the study of living things.

Serrelli (2016) averred that the search for an answer to the question does Biology differ from other sciences was part of what led to the emergence of the field of philosophy of Biology. The researcher further pointed out that the philosophy of Biology provides an account of biological knowledge, aids scientific advancement in life sciences, monitors the natural hybridisation of Biology with extra-biological disciplines and as a fieldbecomes the crossing point between science and society among others.

Despite the importance of Biology to humankind, the performance of students over the years in Nigeria has not been very encouraging, except in the past eight years, where there has been a steady improvement in the percentage pass reported in the West African Senior School Certificate Examinations (WASSCE) as shown in Table 1. Biology, despite being restricted to the science students, still recorded the highest number of candidates when compared with other science subjects like Physics and Chemistry as also revealed in Table 1. The performance level of students in Biology has been gradually improving from the year 2013, where the percentage pass was 51.73 to 2019, where it had risen to 74.40. This performance, although is above 70% in the year 2019, shows that there is room for improvement as the aim of teaching and learning process is to bring about perfect understanding.

Table 1

Trends of Students' Enrollment and Performance in Biology, Chemistry and Physics in May/June Senior School Certificate Examinations, 2010-2019

Year	Biology			Chemistry			Physics		
	Total Entry	Credit Pass (A1-C6)	% Pass	Total Entry	Credit Pass (A1-C6)	% Pass	Total Entry	Credit Pass (A1-C6)	% Pass
2010	1,300,418	427,644	32.88	465,643	263,059	50.70	463,755	237,756	51.27
2011	1,505,199	479,432	38.50	565,692	280,280	49.54	563,161	360,096	63.94
2012	1,646,150	587,044	35.66	627,302	270,570	43.13	624,658	429,415	68.74
2013	1,648,363	852,717	51.73	639,296	462,517	72.34	637,023	297,988	46.77
2014	1,365,384	766,971	56.17	636,268	397,649	62.49	635,729	386,270	60.76
2015	1,390,234	798,246	57.42	680,357	412,323	60.60	684,124	410,543	60.01
2016	1,200,367	740,345	61.68	706,873	408,122	57.74	705,125	415,655	58.95
2017	580,499	394,898	68.03	377,970	320,635	84.83	377,851	205,757	54.45
2018	1,087,063	679,299	62.49	728,551	424,231	58.23	728,354	571,687	78.49
2019	1,033,305	775,103	75.01	726,132	566,156	77.97	725,853	565,746	77.94

Source: West African Examinations Council, Lagos, Nigeria

The importance of studying Biology to the survival of any nation cannot be overemphasised. But despite the numerous advantages students and mankind in general stand to gain from studying Biology, students are faced with many challenges. Some of these challenges are students-related (Danmole & Adebayo, 2005), teachers-related (Sakiyo & Waziri, 2015), and the content of the subject itself, which are not directly linked to societal and career needs of students (Olasehinde & Olatoye, 2014). Some other reasons adduced for students having difficulties in learning Biology concepts include the nature of the subject, methods adopted by teachers in teaching, and the abstract level of some concepts (Cimer, 2012)

or concepts that are filled with vocabularies that are quite different or strange because they have most of their origin in Greek and Latin, for instance,Zygo – Join, Phago – Eat, Olig – Few, Locus – Place among others (Wellington & Osborne, 2001).The list of abstract and important biological concepts include: water transportation in plants, respiration, Mendelian genetics, central nervous system, genes and chromosomes, mitosis and meiosis, evolution, ecology, reproduction, enzyme structure and functions (Chima & Onyebuchi, 2011; Cimer, 2012), most of which are closely related to issues in genetics (Yu-Chien, 2008).

In the secondary school Biology curriculum, genetics plays an essential role in precise innovations that affects the lives of human beings. Genetics as a branch of Biology deals with the study of inheritance and variation (Ramalingam, 2011). It is a branch that studies how genes are transferred from one generation to another, or the transmission of biological traits from parents to offspring through the activities of the genes (Ambuno, Egunyomi & Osakwe, 2008; Alabi, 2016). Genetics as a branch of Biology tries to account for the similarities and variations among individuals by studying the process in which hereditary factors are transferred from parents to offspring. Genetics is a vital aspect of everyday life because of its importance in determining the true paternity of a child, blood transfusion, crime detection, improving farm produce yield, and tracing individuals' pedigree. Genetics 101 (2019) highlighted some of the importance of studying genetics to include; ability to explain why man is unique, look like other members of one's familyand why some diseases run in one's family. Colia (2018) pointed out that the study of genetics has led to success in court cases with the use ofDNA samples and is also responsible for the production of new therapies for genetic diseases.

Genetics has been recognised as one of the important topics in Biology that students have difficulty in comprehending (Topcu & Sahin-Pekmez, 2009). This is because many genetic terms have no common usage outside the realm of genetics or are exemplified in defiance to related terms whose intents are quite distinct (Scott & Ed, 2013).

The West African Examinations Council (2009, 2010, 2012, 2013, & 2015) Chief Examiners' Report (CER) specifically reported that most Biology students did not attempt questions that are related to genetics, and that those who attempted it also performed very poorly. In the years 2010, 2012 and 2016, students were reported to have demonstrated poor knowledge of genetic crossing and did not understand that human sex determination is governed by the XX and XY chromosome pair,instead, they were using other alphabets like M for male and F for the female when answering questions related to genetics. WAEC CER (2015, 2017 & 2018) reported that many candidates avoide questions relating to genetics and failed to include "X" as a sign for crossing between gametes. Because of these difficulties, there is the need to examine the approaches teachers utilise in teaching Biology in general and genetics specifically.

In selecting the appropriate teaching strategy to be used, the area that requires special emphasis centres on teachers realising that Biology education should be made practical and social (Green, 1996). This is going to make the class active and also prepare the learners to be physically and mentally alive in the class. The non-utilisation of proper teaching strategy in secondary schools and undergraduate introductory courses which could make the students active in class will only promote rote learning. Anthony (2018) opined that the lecture method of teaching is widely practised in Nigeria, and has been pin pointed as one of the underlying factors responsible for students' poor achievement in schools since it makes the learners passive. The use of the lecture method as a medium of instruction, although has its own advantages by ensuring high coverage of the syllabus and useful in introducing new topics, has often led to rote learning, rather than ensuring actual understanding of abstract science concepts.

Majority of classroom teachers employ lecture method instead of innovative teaching strategies by laying blame on the working environment and lengthy curricula (Mehmood &

Zahoor-ur-Rehman, 2011). Thus, there is the need to critically examine the ways through which students could be taught genetics in a manner that will enhance meaningful learning. Some of the innovative strategies that have been used in teaching includes the following among others: demo kits, analogies, metaphors and concept maps, jigsaws, wisely managed classroom technology, project-based learning, quick response codes, and inquiry-based learning (Davis, 2017). Science educators have often made use of analogy and metaphor in their teaching most especially when trying to answer questions by trying to relate what is common in the environment or concepts students are familiar with to explain concepts they are not familiar with. In this study, effort was made to consciously use analogy and metaphor instructional strategies and then compare their effects on teaching genetics among senior school students.

Analogy and metaphor are examples of instruction in figures of comparison, since both techniques enable learners to explore their prior knowledge by matching what they had been previously taught, with unknown abstract concepts. Analogy, as explained by Aubusson, Treagust and Ritchie (2009), is the process of establishing the differences between two concepts and in the process using the known to explain the unknown. On the other hand, Rani Kanthan and Mills (2011) defined metaphor as a tune of expression where a word orremark that should normally denote one thing is used to connote another thing, and as such makes an implicit comparison.

Analogy and metaphor are common literary devices in everyday expression in communication, especially when an individual tries to make an unfamiliar thing familiar. Analogies and metaphors both have the potential of enhancing science teaching and learning; promoting higher-level thinking; and yielding new tools for interpreting science education research (Aubusson, Harrison & Ritchie, 2006). Both literary devices have played important roles in scientific discoveries and are used by teachers to make unfamiliar concepts more meaningful, or sparkle students' writing.

Both analogy and metaphor help to bridge gaps between a new concept and an old one, which learners are familiar with. Scientists often used them to communicate research findings and ideas between members of the scientific world. For instance, Darwins (1837) used"Tree of Life" to explain evolution theory of descent with modification; Oliver Lodge's classical analogy of water flowing through pipelines in the description of the electric circuit, Kekule's (1865) made use of image of snakes eating their tails in explanation of possible structure of benzene molecule, and Joseph Priestley's (1767) description of law of electrical force (Abimbola& Mustapha, 2001; Tom & Leonard, 2001). Metaphor differs from analogy in science teaching in the sense that metaphor assumes A to be B, while analogy assumes A is like B. Metaphors are associated with views of teaching, while analogies are more often than not associated with explanation of science content, and lastly, metaphors are covert while analogies are overt (Aubusson, Harrison & Ritchie, 2006).

Table 2
Differences between Analogy and Metaphor

	Analogies	**Metaphors**
1	This is a precise simile	This is an implied simile
2	They are precisely true	They are precisely false
3	Analogies are readily perceptible	Needs a bit more conception to interprete
4	An analogy is logically consistent	Metaphor is emotionally consistent
5	Analogies are overt	Metaphors are covert
6	Has its origin from the Greek word *analogia* meaning proportion	Has its root word in Greek word *Metaphora,* which means to transfer

Source: Aubusson, Harrison and Ritchie (2006); Guerra-Ramos (2011); stackexchange.com (2018)

Analogies in science teaching are mainly examples teachers use to make abstract concepts more understandable by using concepts that students are familiar with to illustrate unfamiliar concepts. Hence, an analogy is a manner of illustrating things that are not well-known in terms of things that are familiar (Abimbola, 2013). An analogy can be effectively used as an instructional strategy in a regular classroom teaching. For instance, Ruhl (2003) opined that analogy is the comparison of something unfamiliar with something familiar in order

to explain shared principle. Analogy has two major components: the “analog”, which is the domain used as the axiom for formative comparison and the “target”, which is the domain to be interpreted. An analogy is a strong link between similarities of concepts and helps to establish strong bridges between a familiar concept (analog) and an unfamiliar one (target) (Harman & Cokelez, 2017). An analogy can be represented either in verbal or pictorial terms. A typical example of a verbal analogy commonly used is the act of comparing the cell with a factory or the human brain with the computer.

On the other hand, metaphor evokes mental images that link past knowledge and experiences with new knowledge, concepts or experiences, and can be used to relate something that is unknown to something well known (Aubusson, Harrison & Ritchie, 2006; Rundgren, Hirsch &Tibell, 2009). Metaphors most often give clues from where conclusions can be made. Happel (2002) asserted that metaphors had helped scientists generate new insights in scientific reasoning, framed scientific terminologies and develop teaching. Like analogy,a metaphor is made up of two components: the tenor (target) and the vehicle (source).

Metaphors abound in the daily communication of human beings and they are often used without the concioussness of their usage. Lakoff and Johnson (1980) stated that the conceptual system of human beings play a significant role in defining their everyday realities and most of the time, human beings are not aware of this conceptual system. They further observed that one way human beings use to evaluate their conceptual system is by taking a close look at the language of communication which is commonly filled with metaphors.

Lakoff and Johnson (1980) also submitted that metaphor is prevalent in everyday life including in thoughts and actions and it goes beyond being a literary device used only in languages; they are used by all categories of people including scientists, in justifying their research findings to their colleagues and other members of the scientific world. In the same vein, Awofodu (2016) asserted that individuals move about with a large array of concepts that

govern their thought processes and everyday functioning that are better expressed through the use of conceptual metaphors.

Conceptual metaphors are concealed behind much of our day-to-day communication and are part of our conceptual system. Conceptual metaphor is noted to have a powerful influence on people by shaping their perspective actions (Gibbs, 2014). Some typical examples include comparing the ribosome to a construction site or the endoplasmic reticulum to a transport company. Metaphor is essential when learning abstract concepts that can only be learnt indirectly and its use has been widely practised in a variety of sciences since it has the tendency of reducing the risks of misunderstanding. Science is metaphoric in nature (Darmstadt, 2007) and utilises metaphors that have been drained of their poetic potentials (Rundgren, Hirsch & Tibell, 2009).

In making a distinction between analogies and metaphors, Guerra-Ramos (2011) stated that metaphors compare implicitly by presening features or relativeattributes that do not coincide in two domains, while analogies explicitly compare the structures of the two domains by indicating the similarity of parts, structures or functions. Norman (2008) noted that teachers always use analogies throughout their lessons, especially when answering questions raised by learners thereby assisting them to have a better grasp of concepts. Metaphors on the otherhand, assist both the teachers and learners to describe, visualise and initiate awareness of the world around them by creating mental images and in the process,they make sense of something complex. Teaching is quite complex, but metaphors offer a great way of creating images and less intimidating environment that allows students to become better learners (Garner, 2005; Gibbs, 2014). Fredriksson and Pelger (2016) submitted that metaphors describe an object by means of a mental image with which it shares something in common. Aside from the methodology used by teachers in explaining scientific concepts, other factors such as students'

gender, score level, and cognitive styles also play a vital role in ensuring better understanding and comprehension of abstract terms.

Studies that sought to appraise, the influence of students' gender on their academic achievement have been inconclusive. Some of these studies concluded that there was a significant disparity in the achievement of students based on gender, while others revealed that no significant relationship exists on student scholarstic accomplishment based on gender. For instance, Okoronka and Wada (2014) asserted that there was no notable discrepancy in the achievement of male and female learners. Several studies also concluded that gender had no effect on the academic achievement of students (Aderogba, 2006; Pinar &Tekkaya, 2008). However, others affirmed that gender had a cogent impact on how male students outperform their female counterparts in Science, Technology, and Mathematics (STM) (Adebayo, 2002) or female students outperforming their male counterparts (Danmole, 1998).

Achievement of students in sciences should be a matter of individual attitude and dedication but not necessarily on gender. This is in line with the assertions of Cimer (2012) and Alabi (2016) who both opined that performance of students in sciences might be as a result of the skills involved in the subject matter, variation in the cognitive skills of learners, teachers' teaching style and learners' learning and study habits.

In order for effective communication to take place between the teachers and the learners, the way learners reason, generate meaning and receive information in terms of their cognitive styles need to be examined. Ahmadzade and Shojae (2013) defined cognitive style as the process by which an individual receives and organises information. Several researchers such as Yunusa and Tukur (2013); Safyanu, Ado, and Olarinoye (2016) have documented the need to examine students' cognitive styles as a predictor of their academic achievement.

Cognitive styles are consistent characteristics that induces a student's usual manner of understanding, remembering and problem-solving skills. Okoronka (2009) submitted that

cognitive styles of students have a strong relationship with their achievement in sciences, and to a large extent, influence students' performance in sciences. Okoronka's view was corroborated by Aydin Ceran and Ates (2020) who averred that differences in cognitive styles of students are an effective factor in determining students' academic success. The type of cognitive styles exhibited by students can be a determinant of their academic achievement which in essence can be used to categorise them into the different scoring levels. This is because cognitive styles could be a double edged sword, which could have both convincing and contradictory relationships between motivation and students' academic achievement (Akhtar & Arif, 2010).

Banner (1989) inferred that in literature, varieties of cognitive styles ranging from convergence-divergence, assimilation-accommodation, field independence-dependence, deep and surface processors have been investigated. Umar (2013) reported that there are different types of names used in studying cognitive styles in literature, among which are Visual/ Haptic, Imager/ Verbalizer, Leveling/ Sharpening, Serialist/Holist, and Field Dependent/Field Independent (FD/FI). This present research, however, made use of the field dependence and independence cognitive styles. The reason for the choice of the FD/FI is that it involves structuring a stimulus field and deals with high information load. The way individuals process information is a key determinant to such an individual's ability level.

For meaningful learning to take place, the ability level of students has to be examined. Adeyemo (2010) opined that students' ability level is the capability to accomplisha meaningful educational task that demands greater cognitive functioning which is built upontheir academic ability. The ability level can also be used to categorise students into different score levels in a typical educational setting. Score level has been considered to be one of the factors that influence students' achievement in science. Alabi (2016) in a study used score level as an independent variable and observed that there was no statistically significant difference in the

achievement of low, medium and high scoring students taught genetics using logical prose. Gbigbadua (2014), however, conducted a study on the effects of pre-instructional word clearing strategy on senior school Biology students' achievement and observed that students classified as low and medium scorers had higher mean gain scores when compared with the high scorers. The fact remains that there has not been any consensus conclusion on the variables of interest in this study. Therefore, the research was tailored towards examining the effects of students' gender, score levels, and cognitive styles, on their achievement when taught genetics using analogy and metaphor instructional strategies.

Statement of the Problem

The concept of genetics has been idetified in literature to pose serious challenge to students and teachers (Cimer,2012). While science educators are of the opinion that a conceptual knowledge of genetics will help students to recognise the importance of continuity of life, students have continued to learn genetics by memorisation (Kilic & Saglam, 2014). To corroborate this assertion, the WAEC Chief Examiners' Reports (2009, 2010, 2015, 2017) reported that students often avoid answering questions related to genetics and that those who attempted answering displayed some levels of misconceptions.

The instructional strategy used to teach genetics is a critical factor in determining if meaningful learning of the concept is ever going to take place. This is because students most often come into the class with prior knowledge and beliefs that are not consistent with the nature of scientific facts (Sodervik, 2016). This naïve understanding is what several researchers have referred to as misconceptions or alternate misconceptions. According to Abimbola (2017), these misconceptions can be a result of misunderstood words in language communication.

In the light of this, there is the need for teachers to employ strategies that can draw on students' prior knowledge as a point of departure for developing conceptual change processes

in genetics. Strategies that have assumed to tap into students' prior knowledge involve the use of analogy and metaphor for meaningful learning (Rundgren, Hirsch, & Tibell, 2009); Mashood, Mehta & Mishra, 2018). Ayanda (2016) and Awofodu (2016) independently worked on the utilisation of analogy and metaphor instructional strategies respectively to teach ecology and both studies reported that the use of analogy and metaphor considerably enhanced students' performance when compared with the lecture method. Genc (2013) studied the efficacy of the use of analogy instructional strategy on students' acheivement. The study utilized the Solomon four group design. The content that were taught include but no limited to parts of cells and organelles, while the sample was made up of 6th grade students. This present study, however, adopted the quasi-experimental design and the content of interest was genetics. Ameyaw and Kyere (2018) examined the effect of analogy instruction on students' performance in Deoxyribonucleic Acid (DNA) in Ghana. The study was quasi in nature with a sample size of 39 students. Data gathered were analyzed using *t-test* and Wilcoxon signed rank tests. However, this study although also adopted the quasi-experimental design, analysed its data using the *t-test* and Analysis of Covariance and was carried out in Ilorin, Nigeria.

Tsipi (2016) examined the effects of using metaphors to teach genetics using the TWA model, on cognitive and hemispheric processing of metaphors among 12th grade Biology students. The study involved 214 12th grade Biology students, subjected separately to three experimental conditions. The instruments utilised for the data gathering process were the standadised knowledge test, misconception test, scientific creative thinking test and Students Motivation towards Science Learning questionnaire forms. The study established that learners that were exposed to familiar metaphors in the linguistics categorization of "A is B" were able to process the information faster than in the comparison "A is like B". This present study however is quasi in nature andutilised the use of Genetic Achievement Test and Group Embedded Figure Test for data gathering.

Both strategies have also been explored in different academic fields and are reported to bring about better comprehension and performance among students. For instance, Karahan (2015) made use of metaphor in teaching English language to non-English major learners, Casarett et al., (2010) employed the use of metaphors in the field of medicine; while Boero, Bazzini and Garuti (2001) employed the use of metaphor in Mathematics and theyall averred that the teachingapproach aided students' performance and understanding.

This study, therefore, employed the use of both analogy and metaphor instructional strategies in teaching genetics to Biology students in senior secondary schools in Ilorin, Nigeria. In addition, this study also considered the students' gender, score levels and cognitive styles as variables.

Purpose of the Study

The main purpose of this study was to determine the effects of the use of analogy and metaphor instructional strategies on senior school students' achievement in genetics, in Ilorin, Nigeria. Specifically, the study determined the:

1. effect of the use of analogy, metaphor and conventional instructional strategies on senior school students' achievement in genetics;
2. difference in the achievements of male and female senior school students taught genetics using analogy instructional strategy;
3. difference in the achievements of male and female students taught genetics using metaphor instructional strategy;
4. differences in the achievements of high, medium and low scoring students taught genetics using analogy;
5. difference in the achievements of high, medium and low scoring students taught genetics using metaphor;

6. influence of cognitive styles on senior school students' achievements when taught genetics using analogy;
7. influence of cognitive styles on students' achievements when taught genetics using metaphor;
8. interaction effect of treatment and gender on senior school students' achievement in genetics;
9. interaction effect of treatment and cognitive styles on students' achievement in genetics; and
10. interaction effect of treatment and score levels on students' achievement in genetics

Research Questions

Answers were sought to the following research questions in the course of this study:

1. is there any difference in the achievement of senior secondary school Biology students in genetics when taught using analogy, metaphor and conventional instructional strategies?
2. is there any difference in the achievements of male and female students taught genetics using analogy?
3. is there anydifference in the achievements of male and female students taught genetics using metaphor?
4. do senior secondary school Biology students with low, medium and high scoring levelsachieve differently when they are taught genetics using analogy?
5. willthere be any difference in the achievements of low, medium and high scoring students taught genetics using metaphor?
6. doesany difference exist in the achievements of field-dependent, field-neutral and field-independent students taught genetics using analogy?

7. is there any difference in the achievement of field-dependent, field neutral and field-independent students taught genetics with the use of metaphor?

8. what is the interaction effect of treatment and gender on senior school students' achievement in genetics?

9. What is the interaction effect of treatment and score levels on senior school students' achievement in genetics?

10. what is the interaction effect of treatment and cognitive styles on senior school students' achievement in genetics?

Research Hypotheses

The following null hypotheses raised in the study were tested:

H_{01}: There is no statistically significant difference in the effects of analogy, metaphor and conventional instructional strategy on the achievement of senior school students in genetics.

H_{02}: There is no statistically significant difference between the achievements of male and female students taught genetics with the use of analogy.

H_{03}: There is no statistically significant difference between the achievements of male and female students taught genetics with the use of metaphor.

H_{04}: There is no statistically significant difference in the achievements of low, medium and high scoring students when taught genetics using analogy.

H_{05}: There is no statistically significant difference in the achievements of low, medium and high scoring students when taught genetics using metaphor.

H_{06}: There is no statistically significant difference in the achievements of field-dependent, field-neutral, and field-independent students taught genetics using analogy.

H_{07}: There is no statistically significant difference in the achievements of field-dependent, field-neutral, and field-independent students taught genetics using metaphor.

H_{08}: There is no statistically significant interaction effect between treatment and gender on senior school students' achievement in genetics

H_{09}: There is no statistically significant interaction effect between treatment and score levels on senior school students' achievement in genetics.

H_{010}: There is no statistically significant interaction effect between treatment and cognitive styles on senior school students' achievement in genetics.

Scope of the Study

This study was conducted in Ilorin metropolisofKwaraState,Nigeria targeting specifically senior secondary school three (SSIII) students offering Biology. Senior secondary school III Biology students were appropriate because the content coverage was limited to genetics, a topic offered by all the sampled schools at the SS III class. Students' achievement in Biology was the dependent variable while the effects of two instructional strategies that served as the independent variables namely; analogy instructional strategy and metaphor instructional strategy were also examined. The moderating variable considered in this research were the students' gender (male & female), score levels (low, medium &high)and students' cognitive styles (field-independent, field-neutral & field-dependent) respectively.

Significance of the Study

The findings from this study were expected to be of remarkable relevance to students, Biology teachers, Biology textbook authors, teacher education institutions, educational researchers and policymakers in the field of Biology education. The outcome of this study would assist students in recognizing analogy and metaphor in textbooks and class lessons and assist them to develop competencies in the use of analogy and metaphor. It would equally help

the students to have a better understanding of genetics in particular, and other Biology concepts.

The results of the study would also be beneficial to Biology teachers by further strengthening their resolve to utilise innovative instructional strategies like analogy and metaphor that allow students to tap into their prior knowledge in their classes. Although teachers often used the strategies each time they intend to answer questions in the class, the outcome might allow them to consciously utilise them to assist students relate Biology concepts to their environment and also engage the students in critical thinking by allowing them generate other analogies and metaphors that could bring about effective learning.

Findings of this study would help textbook authors to effectively use analogies and metaphors in explaining abstract concepts in their textbooks in order to enhance meaningful learning. With this, the students could easily lay their hands on the textbooks even when the teachers are not available.

The findings of this study would stimulate curriculum developers to include the use of figures of comparison as part of the instructional strategies that could be adopted by Biology teachers who are the implementersof the curriculum,in their teaching in order to engender better understanding of hypothetical Biology concepts.

This study could be of benefit to teacher educational institutions such as faculties of education in universities and colleges of education, since its findings may lay bare the need for the teacher training institutions to sustain pre-service Biology teachers' pedagogical skills and abilities by exposing them to instructional strategies like the use of analogy and metaphor as a way of enhancing meaningful learning among students.

Lastly, the findings of this research work would help to guide future researchers in the field of Biology education, as it would serve as a rich literature material. The instruments used in the study could even be adopted or adapted and improved upon by other researchers.

Clarification of Major Terms and Variables

The following major terms and variables are operationally defined as they relate to this study:

Students' Achievement:scores obtained by the students in the pretest and post-test of the Genetics Achievement Test

Genetics Achievement Test: researcher-designed multiple choice questions that were used to evaluate the students' understanding of key genetics concepts they were taught.

Metaphor:an expression in which a word or phrase is applied to an idea in order to connote sameness.

Analogy: the act of comparing things in terms of their similarities or resemblance using "such as" or "is like"

Score levels: students' grouping based on their performance in the third term promotion examination that was used in promoting them into SS 3

High Scorers: students in the upper quartile range in theterminal results

Medium Scorers: students with scores that fall between the middle quartile range of the terminal result obtained from the schools.

Low Scorers: students whose score fall between the lower quartile range

Cognitive style:the way an individual thinks, perceives, processes and remembers information

Field-dependent: students that exhibit weak information processing skills and occupied the 35^{th} percentile score in the cognitive style test

Field-neutral: students with average information processing skills and were in the 70^{th} percentile score in the GEFT

Field-inependent: students with good information processing skills and 100th percentile score in the cognitive style test

CHAPTER TWO

REVIEW OF RELATED LITERATURE

This chapter presents a review of literature related to this study under the following sub-headings:

- Theoretical Framework for the Study
- Objectives and Content of the Nigerian Senior Secondary School Biology Curriculum
- Factors Influencing Students' Performance in Science
- Empirical Studies on Students' Understanding of Genetics
- Empirical Studies on the Effects of Analogies as an Instructional Strategy on Students' Academic Achievement in Science
- Empirical Studies on the Use of Metaphors in Teaching and Learning Process
- Empirical Studies on the Influence of Gender on Students' Achievement in Science
- Studies on the Effects of Cognitive Styles onStudents' Achievement in Science
- Empirical Studies on the Influence of Score Level on Students' Achievement in Science
- Appraisal of the Reviewed Literatures

Theoretical Framework for the Study

The theoretical framework that served as pivot on which this study is hinged on is the constructivist theory postulated by a philosopher of science and cognitive psychologist namely Vygotsky. Lev Vygotsky's (1978) work is one of the foundation works in the field of child development psychology and the theory is known as the Theory of Social Development. Vygotsky (1978) was of the view that all cognitive development emanates from social learning and that intelligence is not static but rather dynamic in nature and tends to develop through the act of learning and cultural interactions (KnowledgeBanks, 2017). Vygotsky's (1978) theory examined human development from the perspective of the socio-genetic process which involves students gaining mastery over cultural tools and signs in the course of interacting with

others who might be their peers or other people who are more knowledgeable than them in their environment (Hogan &Tudge, 1999)

Khalid (2015:p317) stated that Vygotsky work was based on three major assumptions which are:

1. A child cognitive skills cannot be measured until his/her stage of development is carefully defined
2. Cognitive skills are propitiated through cognitive tools such as language, words, mnemonics and counting systems that can aid assessment of personality study and function
3. Cognitive styles originate in socio-cultural backdrop.

Vygotsky's (1978) theory is a good basis for this research because it assumes the presence of the teacher who is more knowledgeable to explain abstract concepts to the students by making use of analogy and metaphor which are linguistic tools to help connect prior knowledge with the present situation.Constructivists presume that scholarship is an interpretive process, as new instruction is given meaning in terms of the student's premonition (Roth, 1993). From a constructivist point of view, each learner can actively construct and reconstruct his/her understanding rather than receive it from a more authoritative source such as a teacher or a textbook. Consequently, constructivism implies that learners must be given opportunities to experience what they are to learn in a direct way and the time to think and make sense of what they are learning. Analogy and metaphor facilitate conceptual change because they are tools that can stimulate the conceptual bridge between what the students are earlier aware of with abstract concept that they are to learn by making use of their previous ideas.

Chu (2008) reported that in the classroom teaching, genetics vocabulary is introduced to students by three main sources which are; the teachers, the textbooks, and examination requirement and that the vocabulary is not used consistently by the three sources. The teacher who is expected to be more knowledgeable than the students, therefore, needs to have an

adequate pedagogical content knowledge, which he must use to explain the genetic concept in a more vivid way for students to grasp.

The main principle underlying Vygotsky's theory of cognitive development lies in the role of the more knowledgeable others (MKO) which could be the parents, teachers at school or peers and the Zone of Proximal Development (ZPD) (KnowledgeBanks, 2017). The implication of this in a typical Biology class is that learners have a limit to what they can learn on their own and because of this, the teacher who is regarded as being more knowledgeable is saddled with the responsibility of guiding students in making meanings from their prior experience. The teacher through the use of analogy and metaphor instructional strategies provides a scaffold that assists students to form mental image of abstract concepts they intend to learn. Constructivists' approach to learning is based on the premise that learning is basically constructed with the use of previously acquired knowledge in order to understand unfamiliar subject matter (McGuiness, 2017).

Prior knowledge has been described in diverse ways by different scholars. Dochy (1994) averred that prior knowledge could be viewed as the whole of a learners' genuineknow-how that is available before a certain learning task, structured in schemata, partly explicit and tactic, which is dynamic in nature and stored in the knowledge base. From this definition, it can be deduced that prior knowledge is an integral ingredient that can either improve student's performance or hinder it. One major teaching strategy that taps into learners' prior knowledge is the use of analogies and metaphors, which both tend to explain the abstract or unknown with the known.

Analogies and metaphors are some of the innovative instructional approaches that have been proven to be effective for use in the classroom. Both literal devices are typical examples of the constructivist-based methods of teaching which allow students relate new information

to their existing prior knowledge by making connections between the new information and their past individual experiences.

Constructivism is a pattern of learning that presumes learning as a process by which individuals construct meaning or new knowledge hinged on their preconception and experience (Johassen, 1991). The basic principle underlying the use of analogy and metaphor is premised on the fact that students already had some experiences which the teacher intends to build on. The experience also referred to as the prior knowledge is what the teacher uses in explaining the unknown concepts thatisintended to be taught.

Although the teacher's responsibility is that of teaching the students, making meaning of what has been taught by the teacher mostly resides in the students' ability to reconcile their prior knowledge with the present knowledge they seek to learn. Students can form mental images that match their past knowledge with the new knowledge they learn by banking on teachers' use of analogies and metaphors.

The elaboration theory which was articulated by Glynn and Duit (1995) is another constructivist theory on which this research is hinged on.It isthe fundamental principle of assessing cognitive processes involved in constructing relations between what is already known and a new concept to be learnt. Elaboration is any enhancement of information that clarifies or specifies the relationship between information to be learnt and the learner's prior knowledge (Maharaj-Sharma & Sharma, 2015). Elaboration allows students to make sense of abstract things that are difficult to visualise by the use of analogy and metaphor by present information in progressive order. Elaboration allows the students to associate new knowledge with concepts they are already familiar with and as such it often assist in the development of students' critical thinking skills.

Objectives and Content of the Nigerian Senior Secondary School Biology Curriculum

Different authors have defined the term curriculum in so many different ways. Olorundare (2014) viewed curriculum as representing a set of intentions and structured series of intended learning outcomes. Abimbola and Mustapha (2001) stated that curriculum means educational programmes of what goes on in and outside the school. Lawal (2014) stated that the curriculum can be conceptualised as the nucleus of the whole process of education. Its importance to the educational process is so basic and crucial that bypassing it will result in phenomenal disaster (Oladosu, 2014)

In Nigeria, the government in her quest to develop a scientifically-literate society that meets the demand and needs of her citizens, set up and organisedseries of commissions, committees and conferences to develop a viable curriculum for the country geared towards achieving technological development. The 2008 edition of the Biology curriculum covers four major themes namely:

1. Organisation of life
2. Organisms at work
3. The organisms and its environment
4. Continuity of life

These themes are expected to prepare students for meaningful and relevant knowledge in the field of Biology, and enable them to apply the scientific knowledge acquired to their personal lives. In planning the 2008 Biology curriculum, the spiral approach to sequencing course was adopted. In the approach, the concepts to be taught are arranged in such a way that they run throughout the three-year of senior secondary school course, hence, the curriculum is organised into six sections, which are: topics, performance objectives, content, teachers and students' activities, teaching and learning materials, as well as an evaluation guide.

In order to ensure that the stated objectives are achieved, teachers need to be abreast of the topics under each of the themes in the curriculum. Genetics, which is also referred to as the Biology of heredity, is under the fourth theme i.e. continuity of life. The content of Biology of heredity as spelt out in the 2008 Biology curriculum is divided into six major sub-headings, which are:

1. transmission and expression of characters in organisms; which comprised of hereditary variation, characters that can be transmitted, how they are transmitted, and, how characters manifest from generation to generation;

2. chromosome, the basis of hereditary, its location, structure, and roles in the transmission of characters are expected to be discussed;
3. probability in genetics;
4. application of the principles of heredity in agriculture and medicine; and
5. explaining terms such as cross fertilisation, self-fertilisation, in and out-breeding using Mendelian crosses (NERDC, 2008).

Genetics as a concept in Biology is usually among the last set of topics treated by teachers in most secondary schools because of its position in both the curriculum and examinations syllabi. However, students often performed poorly in genetics because of their inability to connect the concept with other relevant Biology concepts such as cell structure and functions, and cell division which are prerequisites of genetics (Alabi, 2016). The position of genetics in the curriculum also contributes to students' poor performance since it is the period that students are already preparing for the external examinations and as such tensions and anxiety are high.

The West African Senior Secondary School Certificate Examinations (WASSCE) is derived from the curriculum of the member countries writing the examinations administeredby the West African Examinations Council. The content of genetics in the syllabus is broken down into the following content areas:

1. Genetic terminologies;
2. Transmission and expression of characteristics in organisms, which include studies on hereditary variation, Mendel's work in genetics;
3. Chromosomes, the basis of hereditary, where the structure of the chromosome and the processes involved in the transmission of characters from one generation to another;
4. Probability in genetics;
5. Linkage, sex determination and sex linked characters; and
6. Application of the principles of heredity in agriculture and medicine (pg 7)

Factors Influencing Students' Performance in Science

The major aim of teaching is to facilitate learning and bring about change in an individual that has been exposed to it. This change is often measured in terms of performance and as such it would be expected that students that had been exposed to teaching should be able to remember what had been taught and therefore, exhibit high level of performance. This has however, not been the case most of the time and had prompted educational researchers to investigate factors that influence students' performance in Biology and other subjects. Dinah (2013) asserted that various reasons had been adduced to be the cause of poor performance of students by many researchers in the field of education. Some of the reasonsare teacher-related, student-related and or infrastructural-related factors.

Cimer (2012) shows that teachers' pedagogical knowledge, the nature of the topic, students' attitude to learning, low-self esteem and attitudes towards Biology and lack of resources are some of the factors that influence students' performance in Biology. Kola (2012) conducted a research on factors affecting students' performance in sciences in Nigeria secondary schools and identified poor teaching method adopted by the teachers, poor laboratory facilities, teachers' attitude to work coupled with the poor remunerations of teachers by the government, and large class size as key factors that affect students' performance in

science. The researcher also noted that, inadequacy of practical equipment and lack of qualified hands to handle most of the science subjects could be a barrier to enhancing students' performance since students who were taught by qualified and experienced teachers achieved better than those taught by unqualified and less experienced teachers.

Kimani, Kara and Njagi (2013) while examining teachers' factors that could influence students' performance in Biology concluded that teachers' age, gender, professional qualification and experience did not affect students' performance. The researchers however, concluded that teachers' job group and workload significantly affect the students' performance.These often determine the frequency of assignments the teacher gives to the students among other things.

In addition, Mlozi, Kaguo and Nyamba (2013) identified absence or inadequate laboratory facilities, over-crowded classrooms, and non coverage of syllabus as some of the factors that affect students' performance in sciences. Dinah (2013) identified students' attitude, availability of textbooks, laboratory apparatus and other learning resources as factors that affect students' performance in Biology in Kenya.

Ali, Toriman and Gasim (2014) in a study that seek to examine students achievement in Biology in selected secondary schools in Kano, Nigeria concluded that lack of qualified teachers, lack of or insufficient library and laboratory facilities, extensive use of lecture method with little practical activities among others are some of the factors that often result in poor academic achievement of students.

Daworiye, Alagoa, Enaregha and Eremasi (2015) identified poor students' attitude to Biology, overloaded curriculum, poor communication skills and teachers' lack of subject matter knowledge as some of the factors affecting students' performance. From the forgoing it can be deducedthat many factors which either emanate from the students, teachers or government among others have been contributing to poor performance of students in

variousexternalexaminations. Therefore, it will take a mutual effort from all the stakeholders in the field of education to subdue this obnoxious trend.

Empirical Studies on Students' Understanding of Genetics

Genetics is a special branch of Biology that deals with the study of the basic scientific concepts related to transmission of hereditary traits from generation to generation. Teaching the concept of genetics has been widely researched into based on its perceived difficult nature.

Kakudi and Salisu (2019) examined the impact of animated-media instructional strategy on senior school students' achievement in genetics. The study involved 202 SS II students that were randomly selected from four secondary schools in Tarauni LGA, Kano State, Nigeria. Genetics Performance Test was used in gathering data which was analysed using the *t-test* statistics. Findings from the study revealed that students that were exposed to animated-media instructional strategy performed significantly better than their counterparts that were taught genetics using the lecture method. It was therefore, recommended that teachers should incorporate the use of animated-media instructional strategy in their teachings so as to enhance students' academic performance.

Furthermore, Alabi (2016) conducted a research to determine effects of text structures on senior secondary school Biology students' achievement in genetics in Ilorin, Nigeria. The two main forms of text structures employed were the logical prose structure and concept map structure. Also, two stimulus instruments and one response instrument which is the Achievement Test in Genetics were employed in the study. Data collected from both pre-test and post-test were analysed using the *t-test* and Analysis of Covariance (ANCOVA). The finding of the research showed that logical prose had a positive impact on the achievement of students in genetics. The finding, thus, implies that there was a significant difference in the achievement of students taught genetics using logical prose than those taught using the conventional lecture method.Furthermore, the finding of the research showed that concept map

positively promotes the achievement of students in genetics with a mean gain score of 64.25 when compared with the control group that had a mean score of 58.77. However, further analysis revealed that the logical prose achieved best with a mean score of 17.24, followed by the concept map group and the least being the conventional lecture method group with 16.29 and 12.69 mean scores respectively. It was therefore, recommended that teachers should adopt the use of logical prose and concept maps in teaching other difficult Biology concepts.

Isiaku (2015) carried out a research on the effects of problem-solving and discussion teaching methods on students' achievement in genetics. The study adopted a quasi-experimental research design of the pre-test, post-test, non-randomised control group. The samples for the study were 122 SS III Biology students whose schools were purposively selected. The instrument used for the study was the Genetics Achievement Test (GAT) and data collected were analysed using mean, standard deviation and ANCOVA. Analysis of the data obtained from both the pre-test and post-test scores revealed that the students taught genetics using the problem-solving teaching strategy outperformed their counterparts taught the same concept using the lecture method.

Busari (2014) also studied effects of pre-teaching mathematical components of genetics on the achievement of senior secondary students in Oyo State, Nigeria. The research study was a quasi-experimental design that adopted a pretest, post-test non-randomisedcontrol group design. The target population for the study was all SS 2 Biology students in Oyo State from where a sample of one hundred and seventy-six students were purposively selected using the purposive sampling technique. The instrument adopted by the researcher was Genetics Achievement Test adopted from past WAEC questions and the data collected were analysed using mean, standard deviation, *t-test*, and Analysis of Covariance (ANCOVA). Findings of the study revealed that students in the experimental group achieved significantly better than those in the control group that were not taught the pre-mathematics components.

Impact of video games on high school students' engagement and learning about genetics was examined by Leonard, James, Shawn and Meng-Tzu (2009). The study employed the quasi-experimental of post-test only control group design which consisted of 2 experimental groups and 3 control groups. The treatment group played a MEGA that focused on core genetic principles. The experimental group exposed to MEGA consisted of sixty-six students (35 males and 31 females), while the control group consisted of 63 students (28 males and 35 females). Findings from the study revealed that there was no difference in students learning when video games were used and not used, but there was a significant difference in the level of engagement by the participants when video games were used.

It can therefore be deduced that a lot of effort in terms of research has been madetowardsknowingthe effect of teaching and learning of genetic concepts over the years. The research findings have also confirmed the effectiveness of most of the learning strategies employed by the researchers. Therefore, it can be inferred that the persistent low performance recorded on yearly basis might not be solely due to the teachers' teaching strategy but might be as a result of students' interest in the subject. This research, therefore, seeks to explore the use of analogies and metaphors in teaching genetics by allowing both the teacher and the students to generate relevant analogies and metaphors that could bring about effective teaching and learning of genetics.

Empirical Studies on the Effects of Analogy as an Instructional Strategy on Students' Academic Achievement in Science

The use of analogy as an instructional strategy is appealing to many researchers, most especially in the field of Biologyeducation. Ameyaw and Kyere (2019) asserted that analogies seem especially appropriate for science instructions since they allow learners to visualise abstract concepts. For instance, concepts such as Kekule's benzene ring werevisualised via the image of a snake eating its own tail and the pump model for circulatory system among others

are quite numerous in the field of science. The significance of analogy in the teaching and learning of abstract scientific concepts cannot be over emphasised. Many studies have been carried out on the effect of analogy on students' achievement.

Ziyad (2020) studied effects of analogy instructions on first grade intermediate female students' achievement and development of creative thinking. The sample for the study was made up of 60 female students that were randomly assigned into experimental and control groups of 30 students each. Findings from the study revealed that the use of analogy instructional strategy had significant impact on the achievement of the students when compared with the mean scores of the students taught using the conventional teaching method. Based on the findings it was recommended that teachers should adopt the use of analogies during class instructions.

Okafor (2019) examined the effect of kitchen-explanation analogy model on students' achievement in Chemistry. All students in co-educational public schools offering chemistry in Lagos state constituted the target population. The purposive sampling technique was used in selecting two intact classes comprising 53 girls and 48 boys who served as the sample for the study. Three research instruments: KEAM teaching manual, Explanation teaching manual and Achievement test in Chemistry were used for data collection. Gender was considered as a moderating variable in the study. Result from the study revealed that students that were exposed to the use of analogy performed significantly better than there counterpart that were not exposed to analogy. It was therefore, recommended that KEAM strategy should be promoted in the teaching of chemistry and other science subjects.

Ameyaw and Kyere (2019) studied the effects of three teaching methods namely analogy, animations and lecture method on students performance in human blood circulatory system. The study was conducted in Tano North and South Municipals of Abafo Region in Ghana. The study adopted a quasi experimental design that involved 123 respondents that were

randomly sampled. The stimulus instruments were the analogy-based, animation-based and the traditional lecture-based teaching methods, while the response instrument was the Circulatory-system Achievement Test (CAT). Statistical tools such as the mean, paired *t-test*, ANOVA, ANCOVA and box plot were used in answering the research questions and hypotheses. The findings of the study revealed that students that were exposed to analogy-based teaching method exhibited higher level of performance and retention than their counterpart that were exposed to the concept of human blood circulatory system through traditional lecture based teaching method. The researchers thereby recommended that analogy-based teaching method should be embraced by Biology teachers and students in the teaching and learning of the human blood circulatory system.

Akintola and Ayanlola (2019) studied the effects of analogy instructional strategy on students' achievement in Biology in Ogbomosho south, Nigeria. The researchers adopted the quasi-experimental design. The samples for the study were 172 senior school II students randomly selected from four secondary schools. The data collected through the use of Biology Achievement Test were analysed using the *t-test* statistics. The findingsof the study revealed that students exposed to analogy instruction achieved significantly better than their counterpart that were taught using the conventional teaching method.

Lanshima, Chado, Isa and Mohammed (2019) determined the effects of problematic analogy strategy on students' achievement and retention in Chemistry. The study was a quasi-experimental design and the sample was made up of 81 respondents that were selected usingthe simple random sampling technique in Bosso LGA, Niger State, Nigeria. The instrument for gathering data was the Chemical Equation Achievement Test (CEAT) made up of thirty multiple choice test items. The mean, standard deviation and ANCOVA statistical tools were used in analysing the data. The finding from the study, revealed that students that there existed a significant difference in the achievement of students' taught Chemistry using problematic

analogy strategy and students exposed to the conventional teaching approachinfavour of the analogy group. The researchers, therefore, recommended that science educators should incorporate innovative instructional strategies like problematic analogy strategy into their teaching.

Ameyaw and Kyere (2018) also examined the role of analogy-based instructional strategy on students' performance in studying DNA concepts. The research design adopted in the study was quasi-experimental research design with non-randomisation of the subjects. A total sample of 39 students made up of seventeen males and 22 females constituted the sample for the study. Molecular Concept Achievement Test (MCAT) was the instrument used for the data collection. All the 39 respondents were initially taught DNA concept without the use of analogy-based instructional strategy and then tested using the MCAT to get the pre-test scores. The same sets of students were thereafter, subjected to analogy-based instructional strategy for another two weeks before administering the post-test. The findings from the study revealed that there was a significant difference in the performance of students in the concepts of DNA because the analogy-based instructional strategy drastically improved students' performance when compared with the conventional lecture-based instruction with a mean difference of 10.51.

Ayanda (2016) studiedeffects of analogies and concept maps on senior school students' achievement in ecological concepts involving 267 students. The study was a quasi-experimental design of pre-test, post-test, non-randomised control group involving a 3 x 3 x 2 factorial matrix. The sample for the research was SSS II Biology students. Six intact classes from six public co-educational schools took part in the study. The respondents were divided into three groups; analogy instruction group, concept map group, and the control group. The Biology Achievement Test was used in gathering data that wereanalysed using mean-scores, the *t-test,* and Analysis of Covariance.Result from the study revealed that students taught

ecology with the use of analogies had a higher mean gain score than students in the control group that were taught using the conventional lecture method. Hence, students in the analogy instruction group were reported to perform statistically significantly different from students that were not exposed to analogy instruction.

Nwankwo and Madu (2014) conducted a research that sought to examine the effect of analogy-based instruction on students' conceptual change in Physics. The study was a quasi-experimental design involving intact two classes of 111 students that were purposively sampled. The research instrument utilised for gathering data was the Physics Concept Test (PCT) which comprised 20 short answer questions. The finding of the study revealed that there was a significant difference between the conceptual change scores of students that were exposed to analogy-based instruction and those that were taught refraction of light using the traditional lecture method in favour of the analogy-based group. The researchers thereafter recommended that teachers need to adopt the use of instructional models like analogy when they intend to bring about positive change in students prior knowledge.

Genc (2013)examined the effect of analogy-based teaching on students' achievement and views about the use of analogy in learning. The researcher adopted the Solomon group design and sampled 108 students in four 6^{th} grade classes. The study revealed that students in the analogy group achieved significantly better than students in the control group. It was thereby recommended that teachers should embrace the use of analogy instructional strategy so as to bring about improvement in students' achievement.

The effect of teachers'utilisation of analogy on the achievement of students in Biology was investigated by Ayanda, Abimbola and Ahmed (2012). The study was quasi in nature and adopted a 2 x 3 x 2 factorial design comprising non-randomised, non-equivalent intact groups. The sample for the study was made up of 199 SS II Biology students. Data were gathered using the Biology Achievement Test and findings from the study revealed that there was a significant

difference in the achievement of students taught animal cell using analogy instructional strategy and those taught using the conventional teaching method in favour of the analogy group.

Biology as a subject is filled with concepts that might be difficult to comprehend.Hence, these could bring about misconceptions on the part of the learners. Refik and Bahattin (2008) examined how analogy could be used to bring about students' success and also eliminate misconceptions. The study was a quasi-experimental design involving two groups of students (students taught with the use of analogy and those taught using the conventional lecture method). A total number of 78 participants participated in the study and both groups were ensured to have similar history. The independent group t-test was used in comparing the effectiveness of analogical instruction and the traditional lecture method.Thefindings from the study revealed that analogical instruction helped students change their pre-existing conceptions and alternative conceptions with the scientific one by activating their alternative conceptions, and that students in the experimental group also achieved better than their counterparts in the control group that were instructed using the traditional lecture method.

Empirical Studies on the Use of Metaphors in Teaching and Learning Process

The significance of conceptual metaphor in meaning making and making abstract concepts understandable cannot be overstated. It has been employed in diverse discipline by researchers in the field of sciences, languages, and education because metaphoris not just a figures of speech but an essential mechanism of the mind that allows learners link present knowledge with their prior knowledge. McGuiness (2017) asserted that the use of metaphor engages the human brain in a more conceptual manner than simple hard facts about topics.In line with this assertion, Adesina (2019) examined the effects of metaphor instruction on students' achievement and retention in cell biology in Ilorin, Nigeria. The study was a quasi-experimental design of the 2 x 2 x 3 factorial design. The sample was made up of 118

participants (62 males and 56 females). Data for the study were gathered using metaphor instructional strategy and Cell Biology Achievement Test. The findings from the study revealed that there was a statistically significant difference in the performance of students that were taught cell biology using metaphor instructional strategy and those that were taught without the use of metaphor instructional strategy in favour of those in the metaphor instructional strategy. It was therefore recommended that the use of metaphor instructional strategy should be embraced by teachers since it is an effective instructional strategy that has the potential of improving students' performance.

Aje (2018) investigated the effect of metaphor instruction on senior school Biology students' achievement in cell structure in Ilorin, Nigeria. The researcher adopted a quasi-experimental design. A total of 380 students comprising 180 females and 200 males were sampled in the research. Three instruments namely; Field-Dependent or Field-Independent Biology Figure Sorting Test, Cell Achievement Test and Metaphor Instructional Strategy were used as stimulus and response instruments in the study. The findings from the study revealed that a significant difference existed in the achievement of students exposed to metaphor instructional strategy and those that were not exposed to the strategy in favour of the metaphor group. The researcher concluded that metaphor as an instructional strategy has significant effect on learning of cell structure and, hence, recommended that Biology teachers should embrace the use of metaphor instructional strategy in their teaching to bring about effective teaching.

Awofodu (2016) conducted a research on the differential effect of metaphors and problem-solving strategies on senior secondary students' achievement in Ecology in Ijebu-Ode, Nigeria. The study was a quasi-experimental design that adopted pre-test, post-test control group factorial design. A total of 267 senior secondary school 2 students consisting of 147 and 120 females and males respectively drawn from six secondary schools in Ijebu-Ode constituted

the sample population. The instruments for gathering data for the research were the Cognitive Achievement Test in Ecology (CAT) and Practical Skills Achievement Test (PSAT). Data collected were analysed using Mean, Standard Deviation and Multivariate Analysis of Covariance (MANCOVA). The findings indicated that metaphor instructional strategy enhances students' cognitive achievement and practical skills in Ecology. Some of the implications of the study are that metaphor could be used in enhancing teachers' development since teachers' professional competencies among other things could help in improving students' learning outcome.

The use of metaphor is also prominent in the field of medicine, where doctors often employ its use in explaining different types of ailments to their patients. Pinheiro, et al., (2017) investigated the use of metaphorinillustrating molecular testing to cancer victims. The design of the study was a cross-sectional observational study in which the oncologist-patient conservation was recorded, transcribed and coded for metaphors used by both the physicians and the patients. The sample was made up of sixty-six patients and nine oncologists. Results of the study revealed that twenty-five out of sixty-six participants heard a metaphor, thirteen of the twenty-five were questioned and eleven of the thirteen respondents demonstrated understanding and reported the metaphors as being useful.

Cetin (2016) analysed metaphors used by high school students to describe Physics, Physics lessons and Physics teachers respectively. A sample of 313 students drawn from different high school types in Siirt, Turkey, participated in the study using the criterion sampling technique. The study was a qualitative research of phenomenology study design, that is, a research that attempts to define the essence of a phenomenon. Data were collected using a metaphorical perception form constructed by the researcher. The data collected were analysedusing the following criteria: codification, classification, category development, reliability and validity, and transferring data to computers. Results from the data analysis

revealed that 125 metaphorical icons were produced out of which 34 metaphors from 49 students who perceived Physics to be complex and difficult, 17 metaphors from 38 students stated that it was made up of wide subject matter and 12 by 33 students as related to daily life.

Similarly, Karahan (2015) conducted a research on the effect of conceptual metaphors on learners' comprehension. The researcher employed two groups of students. One of the groups was taught using the conventional method, while the second group was taught using orientational metaphors. The outcome of the study revealed that students taught in the experimental groupusingmetaphorachievedslightly better than the ones in the control group.

Umar and Hui (2012) investigated the influence of learning styles, metaphor and pair programming on students' performance in C++ language. The study was a quasi-experimental that adopted the 3 x 2 factorial design. The sample was made up of 120 first year computing students from private institutions in Malaysia. The findings from the study revealed that the use of metaphor assisted the visual students in developing deeper conceptual understanding of abstract concepts by allowing them to link the known to the newly acquired concepts.

Seung, Park, and Narayan (2011) investigated how to inquire into elementary pre-service teachers' assumptions about science teaching and learning as informed in their metaphor writing. The study employed a qualitative research design using qualitative data as a primary data source. Participants for the study included 106 elementary teachers made up of 98 females and eight males. Three consecutive semesters in the two universities that were sampled in the study was used in collecting relevant data. At the beginning of the semester, the participants were asked to formulate their own personal metaphors that reflect their beliefs concerning the role of science teachers and science teaching through writing metaphors.

The data obtained were analysed using constant comparative methods by two researchers, thus, the level of agreement between the two researchers was computed in form of codes. The initial codes identified by the two researchers were then compared and grouped into

16 categories, which were further grouped into three themes, through the comparison of traditional, constructivist and neutral views

Casarett, et al., (2010) studied the effect of metaphors and analogies in communicating with seriously ill patients. The design of the study was a cross-sectional observational study of audio-recorded conversation between patients and physicians. The sample was made up of ninety-four patients and fifty-two physicians. Conversations were reviewed and coded for the presence of metaphors and analogies. The result of the research showed that in a sample of 101 conservations, 193 and 75 metaphors and analogies were identified respectively. The researchers observed that most of the participants made use of metaphors in their conversations, and, that physicians who employed the use of metaphors bring forth better patient ratings of communication than those who used analogies. It was thus concluded that metaphors and analogies may enhance physician ability to communicate. This finding is of significance because, without adequate communication, the tendency of having misconception would be relatively high.

An overview of the reviewed literature revealed dearth of research in the use of metaphor in teaching sciences in general, and Biology in particular.Themethod is often employed by scientists in explaining abstract science concepts such as the black hole among others. Most of the literatures revealed the use of metaphors in explaining specific types of ailments to patients and also in the field of languages. This, therefore, leaves a gap for the researcher and other people in the field of science education to fill by exploring the use of metaphors in teaching science concepts.

Empirical Studies on the Influence of Gender on Students' Achievement in Science

Several researches have been carried out over the years on the influence of gender on students' achievement in science and non-science related disciplines. The results of such studies however remain inconsistent, with some of the researchers reporting the fact that male

students outperformed their female counterparts, some reporting that female students outperformed male students, while some simply stated that there was no significant difference in the performance of both male and female students. This makes it important to carry out more studies on the influence of students' gender on their academic achievement.

Ahmed, Shittu, Yahaya and Dada (2021) examined the effects of concept-mapping strategy on students' achievement in Biology. Quasi-experimental research design was adopted by the researchers for the study. The population for the study were all SS II students offering Biology form where a sample of 149 students from two intact class were drawn. Two research instruments were utilised in the study and data gathered were analysed using ANCOVA. The study revealed that there was no significant difference in the achievement of male and female students that were exposed to concept-mapping instructional strategy. Based of the findings, it was concluded that gender does not influence students achievement in science and was therefore recommended that teachers can utilised the strategy in a mixed gender classroom to bring about effective teaching and learning.

Oniya and Adefila (2020) investigated the effects of analogy-enhanced instructional strategy of students' achievement in basic science practical skills. The study was quasi experimental in nature and the sample for the study comprised of 128 Upper Basic II selected using multistage random sampling technique. Data gathered through the use of Basic Science Practical Achievement Test and Basic Science Practical Skills Rating Scales were analysed using *t-test* and ANCOVA. Findings from the study revealed that analogy-enhanced instructional strategy is not gender sensitive and could be used in a mixed gender classroom.

Apata (2020) researched into the effects of cooperative learning strategy on senior school students' performance in physics. The study adopted quasi-experimental design and utilised questions extracted from past WAEC questions to gather data. Data collected were analysed using ANCOVA. A total number of 82 students comprising of 47 males and 37

females from two intact classes randomly assigned served as sample for the study. Findings from the study revealed among other things, that the gender of the students does not have any significant impact on their achievement in physics. Based on the findings, it was recommended that physics teachers should embrace the use of cooperative learning strategies because of it is gender friendly.

Agbowuro, Nanso, Maigoro, Mauchin and Oche (2019) examined the effects of Socratic questioning teaching strategy on the achievement of senior school Biology students. The study was conducted in Langtan North of Plateau state, Nigeria. The research design adopted in the research was quasi-experimental in nature. A sample of 96 students (50 males and 46 female) was purposively selected from the population. The instrument for data collection was the Biology Achievement Test, while the hypotheses formulated were tested using the *t-test* statistics. Result from the research revealed that there was no significant difference in the achievement of male and female students that were taught Biology using the Socratic questioning strategy.

Eyo (2018) investigated the effects of computer assisted multimedia instruction on students' achievement in Biology in Niger State, Nigeria. The study adopted a quasi-experimental design. A total of 364 students (206 boys and 158 girls) purposively selected from two educational zones in Niger State constitute the sample for the study. The instruments utilised in gathering data were the Biology Achievement Test (BAT) and the Computer Assisted Multimedia Instruction (CAMI). The ANOVA and *t-test* statistics were used in analysing the data gathered. Findings from the study revealed that there was no statistically significant difference in the achievement of male and female students that were exposed to instruction with the CAMI. It was therefore, recommended that teachers should embrace the use of CAMI in as a means of enhancing students' performance in Biology.

Ibrahim, Tukura, Adamu, Ajiboye, Mohammed and Opalere (2018) investigated the roles of concept mapping instructional strategy on students' achievement in Biology in Minna metropolis of Niger State. The study adopted a quasi-experimental design. A sample of 86 low-achievers of senior secondary school I from two senior secondary schools in Minna metropolis was sampled in the study. Data for the study were collected using the Biology Achievement Test. Result from the study revealed that there was no significant difference between the achievement scores of male and female low achiever students that were taught photosynthesis using the concept mapping instructional strategy. It was recommended that teachers should be trained on using concept mapping instructional strategy to enhance the achievement and retention of low-achieving Biology students in schools.

Omiola, Awolere and Ajala (2017) examined the effect of hypermedia assisted instruction on students' achievement in photosynthesis. The study was conducted in Dutsin-ma Local Government Area of Katsina State. The study was a quasi-experimental type and involved 60 students which constituted the experimental and control groups. Data were collected using the Hypermedia Biology Achievement Test (HBAT). The study indicated that gender does not significantly influence the achievement of students exposed to hypermedia assisted instruction. It was therefore, recommended that Biology teachers should adopt the use of the instructional strategy because it could benefit both male and female students.

Adeoye, Abimbola, Ahmed and Sulaiman (2017) examined the effect of demo kit on teaching and learning of Biology among senior secondary school students in Omu-Aran, Nigeria. The study was quasi-experimental design of the pre-test, post-test control group. The sample was made up of one hundred and seventy-three senior school students and the instrument for data collection was the Biology Achievement Test (BAT). The research questions and hypothesesformulatedwere tested using descriptive and inferential statistics respectively. The findings from the study revealed that there was no significant difference in

the achievement of male and female students when they learnt using demo kit. The study, therefore, concluded that male and female students achieved equally when they learn Biology with the use of demo kits.

Iji, Ochu, Adikwu, and Atamomokhai (2017) examined the effects of collaborative instructional strategy on male and female students' achievement in Chemistry in Benue State, Nigeria. The researchers adopted a quasi-experimental type of research that included 216 senior secondary students from four schools. Data weregathered using Chemistry Achievement Test. The finding from the study showed that there was no significant difference in the achievement scores of students exposed to collaborative instructional strategy based on gender. It was hence recommended that teachers should embrace the use of collaborative instructional strategy in their classrooms since students from both gender group benefitted immensely from its utilisation in teaching Chemistry.

Awofodu (2016) used gender as a moderating variable in a research on differential effects of metaphors and problem-solving strategy on students' achievement in Ecology. A total number of 267 senior secondary 2 students comprising 147 females and 120 males were selected from the same population. The result of the study revealed that both male and female students that took part in the study did not outperformeach other. The researcher therefore, recommended the use of both metaphors and problem solving strategies in mixed gender classrooms.

Gongden (2016) examined the effects of two metacognive instructional strategies (analogies & concept maps) on students' problem solving ability in selected Chemistry concepts. The study adopted a quasi-experimental design. Senior secondary school II students in Plateau North educational zone were randomly sampled. The instruments for data collection were the Chemistry Achievement Test and the Mathematics Skills Test. The statistical tools employed in testing the stated hypotheses were the *t-test* and ANOVA. The findings from the

study revealed that a significant difference existed in the achievement of male and female students that were examined for their ability to solve Chemistry problems with the use of analogy instructional strategy in favour of the male students who recorded a higher mean score than their female counterparts.

Asogwa*etal* (2016) examined the effects of interactive computer simulation package on students' achievement and retention in genetic concepts. The study was a quasi-experimental type of research with a sample of 121 students that were purposively selected from two co-educational schools from Gombe central educational zone. The Genetic Achievement Test and Genetic Retention Test were utilised in the data gathering process. The result from the research revealed that gender those not significantly influence the achievement of students exposed to interactive computer simulation package. It was therefore, recommended that teachers should embrace the use of Interactive computer simulation package in their teaching since it is not gender bias.

Owoeye and Agbaje (2016) examined students' attitude and gender as correlates of their academic performance in Biology. The research design adopted was a descriptive survey research. Questionnaire forms entitled: Biology Attitudinal Scale (BAS) and Gender and Academic Performance in Biology (GAPB) were the instruments used for data collection. The samples for the study were 180 SSII Biology students randomly drawn from secondary schools in Ikere Local Government Area. The Pearson's product moment correlation statistics was used in analysing the data obtained. The result of the analysis showed that gender had no significant relationship with students' academic performance in Biology.

Ibrahim,Sabitu and Magaji (2016) examined pre-degree students of Federal University Dutsin-ma performance in Biology, Chemistry and Physics based on their gender. A total of 83students(56 males and 27 females)were involved as sample for the study. An ex-post factor design was adopted in the research since the data that was used were already on the ground,

without alteration. Descriptive statistics of mean scores and the independent sampled*t-test* were used answer the research question and test the hypothesis. Result from the study revealed that there was no significant difference in the performance of male and female students in Biology, Chemistry and Physics.

Nawaf (2016) conducted a research that sought to examine the effectiveness of analogy instructional strategy on student's understanding of organic chemistry conceptsm in Jordan. The study adopted the quasi-experimental design and the sample for the study was made up of 97 students who enrolled in organic chemistry course. Data gathered using the chemical concept achievement test were analysed using independent *t*-test and ANCOVA. Findings from the study revealed that both male and female students benefitted almost equally from receiving instruction through the use of analogy.

Busari (2014) conducted a research on effect of pre-teaching mathematical component of genetics on senior school students' achievement in genetics.The study was conducted in four local governments of Oyo state, Nigeria. Genetics Achievement Test was the response instrument used in gathering data. Gender was used as a moderating variable, and it was observed that there was no significant difference in the achievement of male and female students. Hence, the researcher came to the conclusion that gender had no significant effect on students' performance.

Effects of analogy instructional strategy on students' achievement in some Physics concepts was examined by Okoronka and Wada (2014) using gender as a moderating variable. The subjects for the study were 82 senior secondary (SS) 2 Physics students made up of 37 boys and 45 girls. The findings of the study revealed that students' gender had no significant effect on students' achievement.

Akinsola and Odeyemi (2014) assessed the effects of preconception and mnemonics on students' achievement in mathematics. The study was a quasi-experimental type and involved

288 students selected from six secondary schools from three local government areas of Oyo state. Data were collected with the use of two instruments namely Students' Mathematics Achievement Test and Numerical Ability Test. The collected data were analysed using Analysis of Covariance and Multiple Classification Analysis. The findings from the study showed that gender had a significant influence on the achievement of students exposed to mnemonics and prior knowledge in favour of the male students.

Ahmad and Munawar (2013) researchedinto the effect of concept mapping strategy on students' academic achievement in sciences. The study was a quasi-experimentaltypethat adopted a 2x2 factorial design. 167 students made up of 81 males and 86 females constituted the sample for the study. One of the major objectives of the study was to find out the differential effect of concept mapping on the academic achievement of male and female students. The researchers employed the use of a two-way ANOVA to determine the main and interaction effects of gender and teaching-learning strategy on the students' academic achievement.The result of the analysis revealed a significant effect of treatment on both genders with the male students performing significantly better than their female counterparts in both the experimental and control groups.

Another research was carried out by Ezenwosu and Nworgu (2013) on the efficacy of peer tutoring and gender on students' achievement in Biology in Anambra state. The population for the study was all 1731 year two senior secondary students in all public secondary schools in Aguata educational zone. The purposive sampling technique was used in selecting two co-educational schools with a population of 228 students. The Biology Achievement Test was used in collecting data which were analysed using mean, standard deviation and Analysis of Covariance (ANCOVA). The results, among other things, revealed that male students performed slightly better than their female counterparts.

Muraya and Kimamo (2011) examined the effects of cooperative learning approach on students' achievement in Biology. The study utilised the Solomon Four Non-Equivalent Control Group design. The target population was all form two biology students from where a sample of 187 was purposively selected. Data were collected using the Biology Achievement Test (BAT). The statistical tool employed in testing the hypotheses wastheindependent sample *t-test*. The result of the study revealed that there was no difference in the performance of male and female students when exposed to cooperative learning approach, and thus concluded that gender had no significant influence on achievement.

Empirical Studies on the Influence of Cognitive Styles on Students' Achievement in Sciences

The rate at which people process information differs from one person to another. This assertion, according to Graham (2015) is the basis on which the idea of cognitive styles was premised. This becomes more important in educational settings where we have a wide array of students with different abilities to process and comprehend information given by the teachers. A teacher having this background knowledge will, therefore, know that students in the class cannot learn at the same speed and will have to cater for all the categories of students in his or her class.

Several studies have been carried out to examine the effects of cognitive styles on students' achievement at different levels of the educational setting globally.Aydin Ceran and Ates (2020) examined the influence of students' cognitive styles on their conceptual understanding of the unit of force. The study was a casual-comparative study and the sample for the study was 80 seventh-grade students in a public school in Ankara, Turkey. Two instruments namely: Group Embedded Figure Test and Life Based Concept Test were used in gathering data. Data obtained were analysed using MANOVA, one-way ANOVA and *t-tests*. Result of the analysis revealed that their was a significant difference in the level of conceptual understanding of students based on their cognitive styles in favour of the students who had the

field-independent cognitive styles. It was therefore, recommended that future researchers could carry out researches that deals with new generation science questions and different cognitive styles features.

Olanrewaju (2019) examined effects of video assisted instructional package on secondary schools students' achievement in photosynthesis in Omu-aran, Nigeria. The Study adopted a 2 x 2 x 2 quasi-experimental research design. The entire population for the study was all senior school students offering Biology in Omu-aran, Nigeria while the entire senior secondary school I students offering biology constituted the target population. A total of 118 senior school students (44 males and 74 females)served as sample for the study. Three research instruments namely: Photosynthesis Achievement Test (PAT), Cognitive Style Checklist (CSC) and Video Assisted Instructional Package in Photosynthesis (VAIP) were used for getting data. The finding from the study revealed that there was no significant difference in the achievement of field-dependent and field-independent students that were exposed to VAIP. The researcher therefore, recommended that teachers should adopt the use of VAIP in teaching other hard-to-teach Biology concepts.

Safyanu,Ado and Olarinoye (2016) examined the influence of cognitive styles on the academic performance of senior secondary school Biology students in science process skills. The researchers adopted an ex-post-factor research design with a sample size of 216 students offering Biology in four senior secondary schools in Jigawa State, Nigeria. The sample was selected using the proportionate random sampling technique. Data for the study were collected using the Group Embedded Figure Test (GEFT) and Biology Science Process Skills Achievement Test. The findings from the study revealed that a significant relationship existed between Senior Secondary School Biology students' cognitive styles and their achievement in science process skills.

Ashiru and Sadiq (2016) in a research examined the impact of cognitive styles on students' performance in practical Biology in Kano State. The research design was a quasi-experimental pre-test, post-test design of two groups without a control group. The sample was made up of 134 Senior School II students. Three instruments: Biology Practical Attitude Questionnaire, Biology Practical Performance Test, and Field-Dependent/Field-Independent Biology Figure Sorting Test, were used for data collection. The study revealed a significant difference in the attitude and academic performance of the field-dependent and field-independent students' taught Biology practical using discovery learning strategy.

Ellah and Ancho (2015) conducted a study on cognitive styles and attitude of high cognitive ability level students to sciences. The study adopted a correlational survey research design and the samples for the research were 553 high ability students drawn from thirty-five intact classes. The researchers also made use of two instruments which are Science Students' Attitude Scale and Group Embedded Figure Test for collecting data. From the research, it was observed that the high cognitive ability students were both field-dependent and field-independent in nature and that both categories of cognitive style had a positive attitude towards science.

In another study on the interaction effect of cognitive style and instructional mode on students' achievement in Integrated Science, Agboghoroma (2015) employed the use of a 2 x 2 quasi-experimental design of non-equivalent pretest-posttest control group design. The target population for the study was all Junior Secondary School III students. The sample for the study was 360 students in six different schools which were drawn from six local government areas that participated in the study using random sampling. The students were evenly spread among schools in the urban and rural areas.The study made use of two different instruments:the Cognitive Style Test (CST) and Test of Knowledge of Integrated Science (TKIS). Students in the experimental group were exposed to guided inquiry method, while the control group was

taught the same concept using the predominant expository teaching approach. The findings of the study revealed that there was a significant main influence of cognitive style on students' knowledge of Integrated Science. Therefore, it was concluded that cognitive style influence students' understanding of Integrated Science.

Barnabas and Emmanuel (2015) observed that high cognitive ability students can be categorised as both being field-dependent or field-independent and that irrespective of the categorisation, both groups have positive attitudes towards science. The researchers further submitted that there was a significant difference between the cognitive styles of male female science students of high cognitive ability levels.

In another study, Adebisi, Seweje and Ajayi (2015) examined the effects of cognitive styles and understanding of concepts on senior school students' achievement in practical Physics. The study was a quasi-experimental design that utilised the pre-test, posttest control group using an intact class. The sample for the study was 240 Senior Secondary School II students selected using the multi-stage sampling technique.The researchers made use of two instruments namely: Physics Practical Test and Cognitive Test in Physics for data collection. The data collected were analysed using descriptive statistics of ANCOVA and the *t-test.*The findings from the study revealed that cognitive style has a significant effect on students' achievement and that there was a significant interaction effect of cognitive styles and concept understanding. The researchers, however, failed to categorise the students into the different cognitive styles and this is quite essential in their study as it would have afforded the readers the opportunity of knowing which of the cognitive styles performed better.

In the same vein, a study that seeks to determine the effect of analogy instructional strategy, cognitive styles and gender on students' achievement in physics was conducted by Okoronka and Wada (2014). The studywasa quasi-experimental design ofthe2 x 2 x 2 matrix, pretest-posttest and control group. Relevant data were gathered using the Cognitive Style Test

and Physics Achievement Test. A total of 82 students offering Physics took part in the research and they were selected from four different schools. The findings of the study revealed that there was no significant influence of cognitive styles on students' achievement in Physics but observed a significant interaction effect between cognitive styles and students' gender. It was therefore, established that students' cognitive style and gender barely had little or no influence on the achievement of students in Physics.

A research that examined the relationship between students' cognitive styles and their achievement in Mathematics was conducted by Ramlah (2014). The study used the survey method in eliciting responses from students using questionnaire forms whose inventory were made up of the Group Embedded Figure Test (GEFT). A total of 150 students (112 field-dependent and 38 field-independent) were selected as sample for the study. The findings from the researchshowed that very little positive relationship existed between students' cognitive styles and their performance in Mathematics.

A research on the influence of cognitive styles on senior secondary school students' achievement in Mathematicswas also conducted by Yunusa and Tukur (2013). The study employed an ex-post-factor research design. The sample was made up of 49 dependent and 51 field independent cognitive style students. The sample was drawn from the population using the multi-stage sampling technique. The researchersutilisedthe Participants' Cognitive Styles Questionnaire (PCSQ) and Mathematics Achievement Test (MAT) as instruments for data collection. Findings from the research showed that the field-independent cognitive style students achieved higher in the MAT than their field-dependent counterpart.

Tinajero, Lemos, Araujo, Ferracesi and Paramo (2012) also reported in their study that cognitive style and learning strategies significantly contributed to students' academic achievement. The researchers made use of 313 first year university students between the ages 17-30 as the sample and also used the GEFT and the mean marks that the students obtained in

the first-semester examination as the research instruments. The finding of the study revealed that out of the three categorisations of the cognitive styles vis-a-vis field-dependent, field-neutral and field-independent, the field-dependent students had the worst academic achievement when compared to other cognitive styles.

Empirical Studies on the Influence of Score Level on Students'Achievement in Science

Researchers over the years have held contrasting views on the relation between students' score levels and their academic achievement in Biology. Score levels however tends to impact the degree to which meaningful learning takes place among students.

Obochi (2021) researched into the effects of problem-solving strategy on senior school students' achievement in Biology. The study adopted the quasi experimental design and the sample for the study comprised of 113 males and 72 females selected using simple random sampling technique. The researcher employed the use of Biology Performance Test and Student Attitude Questionnaire for gathering data. Data collected with the use of BFT was analysed using *t*-test and ANCOVA. Findings from the study revealed that there was a significant difference in the achievement of low, medium and high scoring students in favour of the low scoring students. It was therefore concluded by the researcher that problem-solving instructional strategy should be adopted in teaching students with low ability as it is more effective than the teacher-centred method of teaching.

Badmus, Bello, Hamzat and Sulaiman (2019) examined the effect of Webquest instructional package on secondary school students' achievement in cell division in Ilorin, Nigeria. The research was quasi-experimental in nature. The sample for the research was made up of 53 SS One students that were purposively drawn from two co-educational schools in the metropolis. Two research instruments namely: the Cell Division Achievement Test (CDAT) and WebQuest Instructional Package on Cell Division (WQIPC) were utilised in collecting data. The result from the research revealed that there was a significant difference in the

achievement of high, medium and low scoring students that were taught cell division with the aid of WQIPC, in favour of the low scoring students.

Alabi (2016) conducted a research on comparative effects of text structure on students' achievement in genetics. The study among other thing examined the effect of text structure on the achievement of students with different score levels. The researcher employed the use of a proforma to obtain the past scores of the students that participated in the research. This was used in categorising the students into the three score levels (high, medium and low scorers). The findings from the study revealed that there was no statistically significant difference in the achievement of low, medium and high scoring students taught genetics using logical prose and concept maps. The researcher reported that low-scoring students benefitted the most, followed by the medium scoring students and lastly the high scoring students for the logical prose group. However, for the concept map group, the medium score students benefitted the most, it was followed closely by the low score students and consequently the high score students.

Score level as a moderator variable was examined by Ayanda (2016) in a study that found out differences in students' achievement based on score levels when they are taught ecological concepts using concept maps and analogies. The findings from the study revealed that the post-test scores of students taught Biology using analogies and concept maps has no statistically significant difference in their means. Further analysis by the researcher, however, showed that the high scorers had the highest mean gain score followed by the medium scorers and then the low scorers for both categories of students taught ecological concepts using concept maps and analogies.

A research work that sought to examine the effect of pre-teaching mathematical component of genetics was conducted by Busari (2014). One of the research hypotheses sought to find out the influence of students' score levels on their achievement in genetics when taught the pre-mathematics component of genetics. The result revealed that there were differences

based on students' score level since students in all the three levels exhibited a gain in their main scores between post-test and pre-test scores with the low scoring students having the highest mean gain score followed by the medium scorers and then the high scores.

Adesoji (2008) examined students' score levels and effectiveness of the problem-solving instructional strategy. The researcher compared the performance of students in the high, medium and low ability levels in a problem-solving task after exposing them to a teacher-centered problem-solving instruction. The sample comprised 120 senior secondary two (SS2) Chemistry students randomly selected from four schools. The participants were then stratified into three score groups from the scores of students obtained from their previous examination. All the categories of students were taught electrolysis using problem-solving strategy. However, pretest was administered before instruction and posttest after being exposed to problem-solving strategy. The pretest and post-test scores were analysed usingtheAnalysis of Variance and Analysis of Covariance respectively. The findings from the study revealed that there was no significant difference in the performance of low, medium and high scoring students after receiving instruction using the problem-solving strategy.

Empirical Studies on Interaction Effect of Treatment and Moderating Variables on Students' Achievement in Science

Ibe and Abamuche (2019) examined the effects of audiovisual technological aids on students' achievement and interest in Biology. The sample consisted of 150 senior secondary two students that were picked at random from two intact classes. Data was gathered using the Biology Achievement Test and Interest Scale, while the collected data were evaluated using inferential and descriptive statistics of mean, standard deviation and ANCOVA. The findings from the study revealed that there is no significant interaction effect of treatment and gender on students' achievement in Biology.

Badmus, Bello, Hamzat and Sulaiman (2019) examined the effects of Webquest on students' achievement in cell division. The study was quasi-experimental in nature and adopted the pre-test, posttest control group design. The sample for the study was made up of fifty-three students that were purposively sampled from two co-educational schools. The findings from the study revealed that there was no significant interaction effect among treatment, gender and score levels on students' achievement in cell division.

Mbonu and Okoli (2019) examined the effects of multimedia integrated instruction on students' achievement in integrated science. The study adopted a quasi-experimental research design of the non-control group design. A sample of 98 Junior School 2 students was randomly selected from a population of 1,093 students in 155 public co-educational schools in Awka south LGA. Data for the research was gathered using the Basic Science Achievement Test, while the hypothesis formulated were tested using ANCOVA. The result from the study showed that there is no significant interaction effect between teaching method and gender on the students' achievement in Basic Science.

Abdulrahim (2018) investigated the effects of Learning cycle and concept-mapping instructional strategies on senior school students' achievement in ecology. The study was quasi-experimental in nature and adopted the 3 x 2 x 3 x 2 factorial design. The sample for the study comprised of 229 (88 males & 141 females) students that were purposively selected from three public secondary schools in Ilorin, Nigeria. Data was collected using a researcher-designed Ecology Achievment Test (EAT). The research questions raised were answered using mean gain scores while the hypotheses were tested using ANCOVA at 0.05 level of significance. Findings from the study revealed that there was no significant interaction effect among treatment and gender, treatment and cognitive styles. It was however, observed that, there was a significant interaction effect between treatment and score levels. It was therefore,

concluded that learning-cycleand concept-mapping instructional strategies improved students' achievement in ecology.

John, Musa and Waziri (2018) investigated the effects of multimedia instructional strategy on senior school students' achievement in Biology. The study adopted a quasi-experimental design of the pre-test, post-test, non-equivalent control group. The sample for the study was made up of 286 senior school II students purposively selected from two co-educational schools. Data collected with the use of Biology Achievement Test were analysed using ANCOVA. One of the finding indicated that there was no significant interaction effect of treatment and gender on students' achievement in Biology.

Sudarman, Kuswandi and Dwiyogo (2016) determined the effect of problem-based learning and direct instruction on students' mathematical problem-solving learning outcome. The study adopted a quasi-experimental research design. Grade V students from the state elementary school served as the population for the study. One hundred and forty-one students randomly selected formed the sample that partook in the study. Data was collected through the use of the Group Embedded Figure Test (GEFT) and Assessment Performance for Learning Achievement. The data collected were analysed using the Analysis of Variance (ANOVA). One of the finding from the study revealedthat there was significant interaction between treatment and cognitive style on students' learning outcomes.

The interaction effects of cognitive styles and instructional mode on students' knowledge of integrated science was examined by Agboghoroma (2015). The study adoptedaquasi-experimental of the 2 x 2 factorialdesign. The sample was made up of 360 field-dependent and field-independent Junior School III students drawn from 6 secondary schools. The instruments used for data collection were the Cognitive Style Test (CST) and Test of Knowledge in Integrated Science (TKIS). Analysis of Co-variance was utilised in testing the

hypotheses that were formulated. The findings from the study revealed that there was a significant interaction of cognitive style and instructional mode on students' knowledge of Integrated Science.

Appraisal of the Reviewed Literature

The review of literature has been centred on studies that are germane to the present study. The review revealed that students do experience difficulty in answering questions that are related to genetics despite the importance of genetic study. Hence, in other to bring about perfect understanding of genetic concepts, several teaching strategies have been employed by different researchers in the field of science education. For instance, Kakudi and Salisu (2019) examined the impact of animated-media instructional strategy on students' achievement in genetics, Alabi (2016) employed the use of logical prose, Isiaku (2015) used problem solving strategy among others. Most of the researches reviewed adopted the quasi-experimental research design with very few using questionnaire forms and case studies, and data were analysed using descriptive statistics. The present research, however, will adopt the use of a quasi-experimental research design using analogies and metaphors as an instructional strategy which is quite distinct from the previous researches which had used different other teaching strategies.

Aboyeji (2019) examined the effects of metaphor on students' performance and retention in cell Biology in Ilorin, Nigeria. The variables of interest were the students' gender and score levels. This study however, is employing the use of analogy and metaphor instructional strategies in teaching genetics. This study also considered students' gender, score levels and their cognitive styles as moderating variables.

Awofodu (2016) explored the use of metaphors and problem-solving strategies on senior secondary school students' achievement in ecology. The study investigated the differential effects of metaphor and problem-solving strategies on senior secondary school II

students in Ijebu-Ode Local Government Area of Ogun State, Nigeria. The present research, however, compared the effects of analogy and metaphor on senior school III students who were taught genetics. The researcher considered the influence of the students' gender and ability levels on the strategies, while this present study examined the influence of students' gender, score level and cognitive styles on the use of analogy and metaphor instructional strategies

Another research that examined the effect of conceptual metaphor on students' conceptual change is that of Menia*et. al.* (2016). Findings from the study showed that students' exposed to metaphor outperformed their counterparts that were not exposed to metaphor. Unlike this present research work that is taking place in Ilorin, Nigeria, their study was carried out in Turkey. Data were collected through the use of achievement test, questionnaire and interview, while data for this study was gathered mainly through achievement test. Data from their work were analysed using Whitney U test, but the present study made use of the *t-test* and ANCOVA.

Findings from the reviewed studies on use of analogy as an instructional strategy also revealed that there was an increase in students' conceptual understanding of abstract scientific concepts and this had subsequently led to increase in performance. Ayanda (2016) worked on the effects of analogy and concept map instructional strategies. The instructional strategies were used in teaching ecological concepts in Oro, Nigeria. The moderator variables employed by the researcher were gender and score levels. This present study, however, employed the use of analogy and metaphor instructional strategies to teach genetics while, the moderator variables were students' gender, cognitive styles, and score levels.

Okoronka and Wada (2014) examined the impact of analogy instructional strategy, students' cognitive styles and gender on their achievement in some Physics concepts. The study was a quasi-experimental type and it used students' gender and cognitive styles as moderator variables. Data were collected using Cognitive Style Test and Physics Achievement Test.

However, this present study joined the use of analogy as an instructional strategy with metaphors. Students' cognitive styles and gender were used as moderator variables but data were collected using the Genetics Achievement Test and Group Embedded Figure Test. The present study is in the field of Biology as against Physics that the other researchers worked on.

In addition to the aforementioned, the instruments employed by majority of the studies reviewed were achievement tests used for data gathering, and descriptive statistics inform of Analysis of Covariance (ANCOVA), MANCOVA and the *t-test* along with other descriptive statistical tools for data analysis. This study like the previous ones made use of ANCOVA and the *t-test* mainly as the statistical tool for data analysis.

The literature reviewed revealed that there has not been any consistent result on whether gender, students' score levels and cognitive styles affect students' achievement. This is one of the reasons why the three variables were also chosen as moderator variables in this particular study. None of the studies reviewed combined the use of analogy and metaphor instructional strategies in a single research. This present study deliberately attempted to investigate the comparative effects of analogy and metaphor on senior secondaryschool students' achievement in genetics, a concept that has been widely reported to be abstract and which students often avoid.

CHAPTER THREE

RESEARCH METHOD

This chapter explains the procedures that were employed in the collection of data for this study. Thiswasreviewed under the following sub-headings: research design, population, sample and sampling techniques, research instruments, validation of research instruments, procedure for data collection and data analysis techniques.

Research Design

The research designemployed in the study was a quasi-experimental thatadopted the non-randomised, pre-test, posttest, control group design of 3 x 2 x 3 x 3factorial design. The first number 3 of the factorial design represents the three instructional strategies used in this study, which are analogy, metaphor and the conventional method of teaching, while the next number 2, represents students' gender which exists in two levels as male and female. The third number 3 represents students' score levels as high, medium and low, while thefourth number 3 stands for students' cognitive styles that is field-dependent, field-neutral and, field-independent.

The pre-test and post-test scores of students in the Genetics Achievement Test served as the dependent variable. The independent variables in this study are the instructional strategies (analogy, metaphor and the conventional methods); gender, score levels and students' cognitive styles serves as the moderator variables.

The research design layout is illustrated below:

	Pre-Test	Treatment	Post-Test
EG1	O_1	X_1	O_2
EG2	O_1	X_2	O_2
CG	O_1		O_2

Where

EG_1 = Experimental Group 1

EG_2 = Experimental Group 2

CG = Control Group

O_1 = Pre-test administered to all the groups,

O_2 = Posttest administered to all the groups

X_1 =Treatment for experimental group A (analogy), and

X_2 = Treatment for experimental group B (metaphor)

Population, Sample and Sampling Technique

The population for the study consisted of all senior school students offering Biology in Ilorin, Nigeria, while the target population was all senior secondary schoolThree (SSS III) students offering Biologyin Ilorin, Nigeria. Thesamplefor this study consists of 174(95 males and 79 females) Senior Secondary School III students. The choice of SS III students was considered appropriate because the content that was taught (Biology of Heredity) is one of the topics in the Biologycurriculum usually scheduled for SS III by most secondary school Biology teachers.Moreover, the students would have already been exposed to cell division which is part of the prerequisite for studying genetics.

The purposive sampling technique was employed in selecting three co-educational senior secondaryschoolsin Ilorin. The co-educational schools were purposively selected based on the following criteria: the schools must not be situated close to one another, they must have a Biology teacher teaching SS III class, and the population of students in the class must be above 30. However, simple random sampling technique was employed in assigning the

purposively selected senior secondary schools into experimental group 1, experimental group 2 and the control group. Students that received instruction with the use of analogy and metaphor instructional strategies were assigned into experimental group 1 and 2 respectively, while students in the control group were taught genetics using the conventional method.

Research Instrument

Four research instruments wereutilised in this study. The instruments were categorised as stimulus and response instruments. The stimulus instruments are:

- Teachers' Instructional Guide on Analogy Teaching Strategy (TIGATS), and
- Teachers' Instructional Guide on Metaphor Teaching Strategy (TIGMTS)

The response instruments were

- Genetics Achievement Test (GAT), and
- Group Embedded Figure Test (GEFT)

The GAT wasa researcher-designed test used to determine students' achievement on the selected genetics concepts taught in the study. It consisted of 50 multiple-choice test items with four options A-D.The table of specification for the GAT was also prepared using the revised edition of the Bloom's taxonomy of educational objective as shown in Table 3.

Table 3

Table of Specification for the Genetics Achievement Test

Contents	Cognitive domain							
	Remember	Understand	Apply	Analyse	Evaluate	Create	**Total No. of items**	**Percentage**
Transmission and expression of characters in organisms	9	11	5	4	2	1	32	64
Chromosomes, the bases of heredity	7	2	2	1	2		14	28
Probability in genetics			1	2	1		4	8
Total	16	13	8	7	5	1	50	100
Percentage	32	26	16	14	10	4	100	

The GEFT was a standardised test instrument developed by Witkin, Oltman, Raskin and Karp (1971). It was made up of three major sections and was used in classifying students into different cognitive styles. The original version of GEFT consisted of three sections. The first section consisted of the biodata of respondents, while the second and third parts were made up of an example and 20 embedded figure items respectively. This instrument was adapted to include name of schools,while the figures originally placed at the back of the instruments are moved to the front part such that the students could easily look at the shapes and locate them accordingly in the figures provided.

Lesson plans (TIGATS & TIGMTS) were also prepared for the study. The TIGATS and TIGMTS consisted of detailed lesson plan outlining the activities the teachers and students were expected to carry out at each stage of the lesson by consciously making use of analogies and metaphors already embedded in the lesson plan to explain key genetic terms to the students. The first and second lessons were developed to teach introduction to genetics and Mendel's works in genetics. This was done in the second week of the research. The third and fourth

lessons covered sex determination in human and probability in genetics and the topics were covered in the third week.

Validation of Research Instruments

The face and content validity of the lesson planand GAT was established by giving the instruments to three experienced Biology teachers in senior secondary schools with a minimum of five years teaching experience,threescience education lecturers that specialised in Biology from the Department of Science Education, and a Senior lecturer from the Department of Zoology, University of Ilorin, Ilorin, Nigeria. The Biology teachers and university lecturers assisted the researcher to determine the suitability of the contents for the intended use and also corrected grammatical errors that were present in the test items. Thereafter, the researcher made all necessary corrections based on the submissions of the lecturers. Validated versionsofthe instrumentsafter necessary corrections have been made were administered on students who did not participate in the main research but shared similar characteristics with the final set of students that took part in the research.

The GAT was also subjected to item analysis so as to determine the appropriateness of the items by computing the difficulty and discriminating indices. The indices were evaluated by utilising the responses of students that were not part of the sampled students that took part in the main research. Result from the item analysis led to the jettisoning of three items and restructuring of two other items.

The instrument after restructuring based on the item analysis and the GEFTweretrial tested using the test-retest method in order to determine its reliability. The instruments were administered on another set of students who didnottake part in the main research within an interval of three weeks.The Pearson's Product Moment Correlation statistics was used to analyse the data collected during the trial testing stage and reliability co-efficient of 0.81 and 0.79 were obtained for the GAT and GEFT respectively

Procedure for Data Collection

The researcher collected a letter of introduction from the Department of Science Education, University of Ilorin, Ilorin. The letter was presented to the principals of the participating schools to seek for their permission to engage their teachers and students in the study. Copies of Informed Consent Forms that contained detailed information about the research were given to the students to take home for their parents to indicate their willingness to allow their wards to partake in the research.

All the participants that participated in the study were assured that all information provided shall be treated with utmost confidentiality. All other ethical issues such as: anonymity, confidentiality, risks, benefits and rights of volunteers were carefully spelt out for the participants. Furthermore, the personalities of the participants were not disclosed at any stage of the research. The researcher also informed the participants that the lessons would take place inside their classrooms at the particular time it was scheduled to hold in the school time table.Consequently, no risk was envisaged on their personality during the course of the study since they were most likely to benefit more in terms of obtaining good grades in Biology in WASSCE and any other public examination required for admission into higher institutions of learning. Finally, the researcher ensured that all studies cited were referenced, paraphrased as much as possible and also subjected toplagiarism test to ensure a high level of originalityof the thesis.

The experiment lasted for four weeks in each of the selected schools. The first week was used for administering of the GEFT and GAT. The GEFT was used in classifying the students that participated in the research into their respective cognitive styles, while the GAT was administered as a pre-test and the data that was gotten from it was used as covariates during data analysis. The researcher also collected copies of the students SSS II end of session results

in Biology. The end of session results were used in placing the students in the appropriate score levels that they belonged to.

The second and third weeks were used in teaching the various groups that took part in the study simultaneously. The first and second groups were taught genetics using analogy and metaphor instructional strategies,while the third group was taught using the conventional teaching strategy during the two weeks period. The teaching exercises were carried out by the Biology teachers in the various schools that partook in the study respectively. The fourth week was used for administering the posttest to all the groups.

Data Analysis Techniques

The data collected from the research were analysed using descriptive and inferential statistics. The research questions were answered using the mean and standard deviation, while the hypotheses were tested using the *t-test* and Analysis of Covariance (ANCOVA) at 0.05 level of significance. Hypotheses one, four, five, six and seven were tested using the One-way ANCOVA, hypotheses two and three were tested using the *t-test.* Hypotheses eight, nine and ten were analysed using the Two – way ANCOVA. All statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 22.0.

CHAPTER FOUR

DATA ANALYSIS AND RESULTS

This chapter deals with the computation of results from data obtained from the administration of the test instruments. The data were collated, analysed and interpreted by employing both inferential and descriptive statistics.

The demographic characteristics of the participants in Table 4 reveals that 95 (54.60%) of the participants were male students and 79 (45.50%) were females. Based on the cognitive styles of the students, 117 (67.24%) of the participants were field-dependent, 46 (26.44%) were field-neutral and only 11 (6.32%) were field-independent. The classification of the participants based on their scoring level revealed that 18 (10.34%) were high scorers, 87 (50.00%) were medium scorers and a total of 69 (39.66%) were students with low scoring abilities. Table 4 further showed that 55 (31.61%) of the students were exposed to analogy instructional strategy, 62 (35.63%) were exposed to metaphor instruction, while 57 (32.76%) were exposed to the conventional method.

Table 4:

Demographic Characteristics of Participants Based on Gender, Cognitive Styles and Score Levels

		Groups			
Variables	Levels of Representation	Analogy	Metaphor	Control	Total
Gender	Male	28(50.91%)	36(58.06%)	31(54.39%)	95(54.60%)
	Female	27(49.09%)	26(41.94%)	26(45.61%)	79(45.40%)
	Total	**55(31.61%)**	**62(35.63%)**	**57(32.76%)**	**174(100%)**
Cognitive Styles	Field Dependent	25(45.45%)	54(87.10%)	38(66.67%)	117(67.24%)
	Field Neutral	27(49.09%)	6(9.68%)	13(22.81%)	46(26.44%)
	Field Independent	3(5.45%)	2(3.23%)	6(10.53%)	11(6.32%)
	Total	**55(31.61%)**	**62(35.63%)**	**57(32.76%)**	**174(100%)**
Score Levels	High	7(12.73%)	3(4.84%)	8(14.04%)	18(10.34%)
	Medium	24(43.64%)	29(46.77%)	34(59.65%)	87(50.00%)
	Low	24(43.64%)	30(48.39%)	15(26.32%)	69(39.66%)
	Total	**55(31.61%)**	**62(35.63%)**	**57(32.76%)**	**174(100%)**

Research Question 1

Is there any difference in the achievement of senior secondary school Biology students in genetics when taught usinganalogy, metaphor and conventional instructional strategies?

Table 5 shows the mean gain scores of students in each of the groups that participated in the study. The mean gain score of students that were taught genetics with the use of analogy was 11.16, those taught with metaphor recorded a mean gain score of 8.29, while the students taught with the conventionalinstructional strategy had a mean gain score of 4.21. The mean gain score of the analogy group was 2.87 higher than those of the metaphor groups. The metaphor group also outperformed the students in the control group by having a mean gain score that was 4.08 higher than the mean gain score recorded by the students in the conventional instructional strategy group. Theseresults suggest that analogy and metaphor enhanced the achievement of students in genetics than the conventional method of teaching.

Table 5

Mean Gain Scores of Students' Achievements for Both Experimental and Control Groups

Group	Group Statistics	Pretest	Posttest	Mean gain Scores	Difference
Analogy	N	55	55		
	Mean	37.84	49.00	11.16	2.87
	Std Dev.	13.14	16.39		
Metaphor	N	62	62		
	Mean	29.48	37.77	8.29	
	Std Dev.	6.43	7.82		
Control	N	57	57		4.08
	Mean	26.91	31.12	4.21	
	Std Dev.	7.40	7.82		

H_{01}: There is no statistically significant difference in the effects of analogy, metaphor and conventional instructional strategy on the achievement of senior school students in genetics.

The ANCOVA test output in Table 6 reveals that there was a statistically significant difference in the achievement of students in Experimental Groups 1 and 2, that is, students

exposed to analogy and metaphor, respectively and those in the control group (students exposed to conventional method), $F_{(2,170)}$= 13.41, p<.00. Table 6 further showed that 14% ($^{\eta}p^2$ .14) of the variance in students' achievement was due to the three instructional strategies. Hence, hypothesis 1 was rejected which implies that there is a statistically significant difference in the effects of analogy, metaphor and conventional instructional strategy on the achievement of senior school students in genetics.

Table 6

Summary of Analysis of Covariance (ANCOVA) of Mean Scores of Students Taught Genetics with Analogy, Metaphor and Conventional Method

Source	Type III Sum of Squares	df	Mean Square	*F*	Sig.	$^{\eta}p^2$
Corrected Model	21785.20[a]	3	7261.73	137.10	.000	.71
Intercept	1488.64	1	1488.64	28.11	.000	.14
Pretest	12658.77	1	12658.77	239.00	.000	.58
Treatment	1420.39	2	710.19	13.41	.000	.14
Error	9004.21	170	52.97			
Total	297397.00	174				
Corrected Total	30789.41	173				

P<0.05

Further analysis was carried out to identify the direction of the significant difference in the students' achievement by making use of Bonferroni post hoc analysis. The result of the analysis presented in Table 7 reveals that the students exposed to the use of analogy, with the highest mean score accounted for the significant difference. The mean gain difference between the analogy group and the metaphor group was 3.53, but the difference between the analogy group and the conventional group was 7.81. This result, thus, indicated that Analogy Instructional strategy improved students' achievement in genetics more than either the Metaphor or conventional method.

Table 7

Bonferroni Post Hoc Analysis Showing the Source of the Significant Difference in the Achievement of Students in the Analogy, Metaphor and Conventional Instructional Strategies

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
Analogy Group	Metaphor Group	3.53*	1.44	.05	.05	7.00
	Conventional	7.81*	1.52	.00	4.13	11.49
Metaphor Group	Analogy Group	-3.53*	1.44	.05	-7.00	-.05
	Conventional	4.28*	1.34	.01	1.03	7.53
Conventional	Analogy Group	-7.81*	1.52	.00	-11.49	-4.13
	Metaphor Group	-4.28*	1.34	.01	-7.53	-1.03

Based on estimated marginal means

*. The mean difference is significant at the .05 level

Research Question 2

Is there any difference in the achievements of male and female students taught genetics using analogy?

To answer research question two, the pre-test and post-test scores were subjected to descriptive statistics. Table 8 shows the difference in the mean gain scores of male and female students exposed to analogy instructional strategy. Male students exposed to analogy recorded a mean gain score of 12.22, while the female students had a mean gain score of 10.07. The difference in the mean gain score between the two genders was 2.15 in favour of the male students. The result suggests that males benefitted more from the use of analogy than their female counterparts.

Table 8

Mean Gain Scores of Male and Female Students taught Genetics using Analogy Instructional Strategy

Group	Group Statistic	Pretest	Posttest	Mean Gain Score	Difference
Male	N	28	28		
	Mean	38.96	51.18	12.22	
	SD	14.75	18.96		
					2.15
Female	N	27	27		
	Mean	36.67	46.74	10.07	
	SD	11.40	13.20		

H_{02}: There is no statistically significant difference in the achievement of male and female students taught genetics with the use of analogies.

The independent sample*t-test* was employed in testing the hypothesis as shown in Table 9. Table 9 reveals that a *t*-value of 0.65 computed at degree of freedom (1, 53), yielded a p-value of 0.52. Since the p-value is greater than the alpha value of 0.05, the hypothesis was not rejected. Hence, there was no significant difference in the achievements of both male and female students taught genetics using analogy, at *t*-value $t_{(53)}$=.65, p =.52.

Despite the insignificance in the achievement, the male students had a mean gain score of 12.22, while the female had a mean gain score of 10.07 as revealed in Table 8. This shows that the male students achieved slightly better than their female counterparts.

Table 9

Independent Sample t-test of Students Exposed to Analogies Based on Gender

Treatment	Gender	N	*M*	SD	*df*	*t*	Sig.	Remark
Analogy	Male	28	51.18	18.96	53	.65	.52	NS
	Female	27	46.74	13.20				

Research Question 3

Is there any difference in the achievements of male and female students taught genetics using metaphor?

Table 10 shows the pre-test and post-test scores of male and female students taught genetics using metaphor. The mean gain score of male students was 17.32, while that of the female was 19.19. The mean gain score of the male students taught genetics using metaphor was 1.87 lower than that of the female students. Hence, it could be deduced that the female students performed slightly better than the male students.

Table 10

Mean Gain Scores of Male and Female Students taught Genetics using Metaphor Instructional Strategy

Group	Group Statistic	Pretest	Posttest	Mean Gain Score	Difference
Male	N	35	35		
	Mean	29.77	47.09	17.32	
	SD	6.32	7.92		
					1.87
Female	N	27	27		
	Mean	29.11	48.30	19.19	
	SD	6.67	8.01		

H_{03}: There is no statistically significant difference in the achievement of male and female students taught genetics with the use of metaphors.

The independent sample *t-test* was employed in testing hypothesis three as shown in Table 11. Table 11 reveals a *t*-value of 0.40 at a degree of freedom (1, 60), yielded a p-value of 0.69. The obtained t-value $t_{(60)}$=.40, p =.69 was not significant since the p-value was greater than 0.05. Therefore, the null hypothesis which states that there was no statistically significant difference in the achievement of male and female students taught genetics with the use of

metaphor was not rejected. This implies that a statistically significant difference does not exist in the achievements of male and female students that received instruction via metaphor instructional strategy.

Table 11

Independent Sample t-test of Students Exposed to Metaphor Based on Gender

Treatment	Gender	N	*M*	SD	*df*	*t*	Sig.	Remark
Metaphor	Male	35	47.09	7.92	60	.40	.69	NS
	Female	27	48.30	8.01				

Research Question 4

Do senior secondary school Biology students with low, medium and high scoring levels achieve differently when they are taught genetics using analogy?

Table 12 shows the pre-test and post-test mean scores of the low, medium and high scoring students taught genetics using analogy instructional strategy. The mean gain score of the low scoring students was 10.17, while those of the medium and high scoring students were 11.04 and 15.00 respectively. The analysis thus revealed that the high scoring students had the highest mean gain score followed by the medium and lastly the low scoring students. The difference between the mean scores of the low scoring students and the medium scorers was 0.87, while the difference between the high scorers and the medium scorers was 3.96. This implies that the high scoring students achieved slightly better than the medium and low scoring students.

Table 12

Mean Gain Scores of Low, Medium and High Scoring Students taught Genetics using Analogy Instructional Strategy

Group	Group Statistics	Pretest	Posttest	Mean gain Scores	Difference
Low Scorer	N	24	24		
	Mean	26.75	36.92	10.17	0.87
	Std Dev.	5.24	8.75		
Medium Scorer	N	24	24		
	Mean	41.63	52.67	11.04	
	Std Dev.	5.55	11.20		
High Scorer	N	7	7		3.96
	Mean	62.86	77.86	15.00	
	Std Dev.	7.10	5.90		

H_{04}: There is no statistically significant difference in the achievements of low, medium and high scoring students when taught genetics using analogies.

Table 13 reveals that there was no statistically significant difference in the achievements of low, medium, and high scoring students, $F_{(2,51)}$=1.31, p =.29. Since the p-value calculated was more than the critical value of .05, the hypothesis was not rejected. This implies that there was no statistically significant difference in the achievements of low, medium and high scoring students when taught genetics using analogies.

Table 13

Summary of Analysis of Covariance (ANCOVA) of Mean Scores of Low, Medium and High Scoring Students taught Genetics with Analogy

Source	Type III Sum of Squares	df	Mean Square	*F*	Sig.	η p ^{2}
Corrected Model	10577.34[a]	3	3525.78	45.72	.00	.73
Intercept	446.76	1	446.76	5.79	.02	.10
AnalogyPre	921.36	1	921.36	11.95	.00	.19
AnalogyScore	202.57	2	101.29	1.31	.29	.05
Error	3932.66	51	77.11			
Total	146565.00	55				
Corrected Total	14510.00	54				

a. R Squared = .729 (Adjusted R Squared = .713)

Research Question 5

Will there be any difference in the achievements of low, medium and high scoring students taught genetics using metaphors?

Table 14 shows the differences in mean gain scores between the low, medium and high scoring students taught genetics using metaphor instructional strategy. The analysis revealed that the low scoring students had the highest mean gain score of 20.40, followed by the medium and high scoring students with 16.55 and 10.66 respectively. The difference in the mean score of low and medium scorers was 3.85, while the difference between the medium and high scoring students was 5.89. This implies that the low scoring students benefited most from receiving instruction via the use of metaphor instructional strategy.

Table 14

Mean Gain Scores of Low, Medium and High Scoring Students taught Genetics using Metaphor Instructional Strategy

Group	Group Statistics	Pretest	Posttest	Mean gain Scores	Difference
Low Scorer	N	30	30		
	Mean	24.27	44.67	20.40	3.85
	Std Dev.	3.31	7.64		
Medium Scorer	N	29	29		
	Mean	33.31	49.86	16.55	
	Std Dev.	2.84	7.15		
High Scorer	N	3	3		5.89
	Mean	44.67	55.33	10.66	
	Std Dev.	4.62	7.57		

H_{05}: There is no statistically significant difference in the achievements of low, medium and high scoring students when taught genetics using metaphors.

The Analysis of Covariance in Table 15 reveals that at $F_{(2,58)} = .56, p = .57$.Thus, the analysis reveals thattherewas no significant difference in the achievements of low, medium and high scoring students. Since the p-value is greater than the critical value of 0.05, hypothesis 5 was not rejected.

Table 15

Summary of Analysis of Covariance (ANCOVA) of Mean Scores of Low, Medium and High Scoring Students Taught Genetics with Metaphor

Source	Type III Sum of Squares	df	Mean Square	*F*	Sig.	η^2_p
Corrected Model	1048.98[a]	3	349.66	7.31	.00	.27
Intercept	191.28	1	191.28	4.00	.05	.07
MetaphorPre	463.05	1	463.05	9.68	.00	.14
MetaphorScore	53.61	2	26.80	.56	.57	.02
Error	2773.73	58	47.82			
Total	144376.00	62				
Corrected Total	3822.71	61				

NS = Not Significant at $p > 0.05$

Research Question 6

Does any difference exist in the achievements of field-dependent, field-neutral and field-independent students taught genetics using analogy?

Table 16 reveals that differences existed in the mean gain score of field-dependent, field-neutral and field-independent students that were taught genetics using analogy as an instructional strategy. The analysis revealed that the field-independent students had the highest mean gain score (M = 15.33), followed by field-neutral (11.08) and lastly the field-dependent (10.76). The mean gain difference between the field-independent and field-neutral students was 4.25 while the difference between the field-neutrals and field-dependent was 0.32. These results suggest that cognitive style does not affect students' achievement when they were taught genetics using analogy.

Table 16

Mean Gain Scores of Field-Dependent, Field-Neutral and Field-Independent Students taught Genetics using Analogy Instructional Strategy

Group	Group Statistics	Pretest	Posttest	Mean gain Scores	Difference
Field Dependent	N	25	25		
	Mean	37.48	48.24	10.76	0.32
	Std Dev.	12.03	16.34		
Field Neutral	N	27	27		
	Mean	36.59	47.67	11.08	
	Std Dev.	13.66	15.26		
Field Independent	N	3	3		4.25
	Mean	52.00	67.33	15.33	
	Std Dev.	13.11	22.03		

H_{06}: There is no statistically significant difference in the achievements of field-dependent, field-neutral and field-independent senior school students taught genetics using analogy

The result in Table 17 reveals that there was no significant difference in the achievement mean scores of field-dependent, field-neutral and field-independent learners exposed to analogy instructional strategy at $F_{(2,51)} = .13$, p = .88. The *p*-value 0.88 was greater than 0.05 alpha level of significance. Therefore, the null hypothesis six which states that there is no statistically significant difference in the achievement of students taught genetics using analogies based on their cognitive styles was not rejected. This implies that a statistically significant difference does not exist in the achievements of field-dependent, field-neutral and field-independent students.

Table 17

Summary of Analysis of Covariance (ANCOVA) of Mean Scores of Field-Dependent, Field-Neutral and Field-Independent Students Taught Genetics with Analogy

Source	Type III Sum of Squares	df	Mean Square	*F*	Sig.	ηp^2
Corrected Model	6677.19[a]	3	2225.73	42.96	.00	.72
Intercept	116.87	1	116.87	2.26	.14	.04
AnalogyPost	6030.42	1	6030.42	116.39	.00	.70
AnalogyCog	13.65	2	6.83	.13	.88	.01
Error	2642.34	51	51.81			
Total	88057.00	55				
Corrected Total	9319.53	54				

a. R Squared = .716 (Adjusted R Squared = .700)

Research Question 7

Is there any difference in the achievement of field-dependent, field-neutral and field-independent students' taught genetics using metaphor?

The mean gain score of field-dependent, field-neutral and field-independent students exposed to metaphor instructional strategy is as shown in Table 18. The field-dependent students recorded the highest mean gain score (20.40), followed by the field-neutral (16.55) and lastly the field-independent students with a mean gain score of 10.66. The difference between the mean gain score of the field-dependent and field-neutral students was 3.85, while the mean gain difference between the field-neutral and field-independent students taught genetics using metaphor was 5.89. This suggests that the field-dependent students benefitted most from the use of metaphor instructional strategy while the field-independent students had the least gain.

Table 18

Mean Gain Scores of Field-Dependent, Field-Neutral and Field-Independent Students taught Genetics using Metaphor Instructional Strategy

Group	Group Statistics	Pretest	Posttest	Mean gain Scores	Difference
Field Dependent	N	54	54		
	Mean	29.00	47.37	20.40	3.85
	Std Dev.	6.42	7.91		
Field Neutral	N	6	6		
	Mean	32.33	47.67	16.55	
	Std Dev.	4.63	9.07		
Field Independent	N	2	2		5.89
	Mean	34.00	54.00	10.66	
	Std Dev.	11.31	2.83		

H_{07}: There is no statistically significant difference in the achievements of field-dependent, field-neutral and field-independent senior school students taught genetics using metaphor

The one-way ANCOVA test output in Table 19revealsthat when $F_{(2,58)} = .45$, $p = .64$. Hence, the null hypothesis which states that there is no statistically significant difference in the achievement of students taught genetics with the use of metaphor instructional strategy based on their cognitive styles, was not rejected. This implies that a statistically significant difference does not exist in the achievement of field-dependent, field-neutral and field-independent students taught genetics with the use of metaphor instructional strategy.

Table 19

Summary of Analysis of Covariance (ANCOVA) of Mean Scores of Field-Dependent, Field-Neutral and Field-Independent Students Taught Genetics with Metaphor

Source	Type III Sum of Squares	df	Mean Square	*F*	Sig.	ηp^2
Corrected Model	1038.87[a]	3	346.29	7.22	.00	.27
Intercept	1787.85	1	1787.85	37.25	.00	.39
MetaphorPre	954.09	1	954.09	19.88	.00	.26
MetaphorScore	43.50	2	21.75	.45	.64	.02
Error	2783.84	58	48.00			
Total	144376.00	62				
Corrected Total	3822.710	61				

a. R Squared = .272 (Adjusted R Squared = .234)

Research Question 8

What is the interaction effect of treatment and gender on senior school students' achievement in genetics?

Table 20 reveals that the total mean score of the male (M = 49.44) and those of the female students (49.04) were almost the same with a marginal difference of 0.40. These results suggest that the achievements of the male and female students were comparable in relation to the treatments.

Table 20

Descriptive Statistics of Interaction Effect between Treatment and Gender

Gender	Treatment	N	Mean	Standard Deviation
Male	Analogy	28	61.18	18.96
	Metaphor	36	46.83	6.80
	Conventional	31	40.32	7.41
	Total	**95**	**49.44**	**11.06**
Female	Analogy	27	56.74	13.20
	Metaphor	26	48.69	9.28
	Conventional	26	41.69	8.92
	Total	**79**	**49.04**	**10.47**

H_{08}: There is no statistically significant interaction effect between treatment and gender on senior school students' achievement in genetics

The 3 x 2 ANCOVA test between treatment and gender as shown in Table 21 reveals that there was no significant interaction effect of treatment and gender on senior school students' achievement in genetics. Table 21 revealed that the calculated *F* value 2.21 computed at degree of freedom (2,167) yielded a *p* value of 0.11. Since the *p* value is greater than the alpha value of 0.05, hypothesis eight was not rejected. This implies that there is no statistically significant interaction effect of treatment and gender on senior school students' achievement in genetics.

Table 21

ANCOVA Result of the Interaction Effect between Treatment and Gender on Students' Achievement in Genetics

Source	Type III Sum of Squares	df	Mean Square	*F*	Sig.	η^2_p
Corrected Model	22482.02[a]	6	3747.00	70.86	.00	.72
Intercept	5537.22	1	5537.21	104.71	.00	.38
Pretest	12817.31	1	12817.31	242.39	.00	.59
Treatment	1380.21	2	690.11	13.05	.00	.14
Gender	40.28	1	40.28	.76	.38	.01
Treatment * Gender	233.16	2	116.58	2.21	.11	.03
Error	8830.83	167	52.88			
Total	449577.00	174				
Corrected Total	31312.86	173				

a. R Squared = .718 (Adjusted R Squared = .708)

Figure 1 reveals that the interaction between treatment and gender is an ordinal interaction and this suggests that the performance of male and female students were similar based on the interventions.

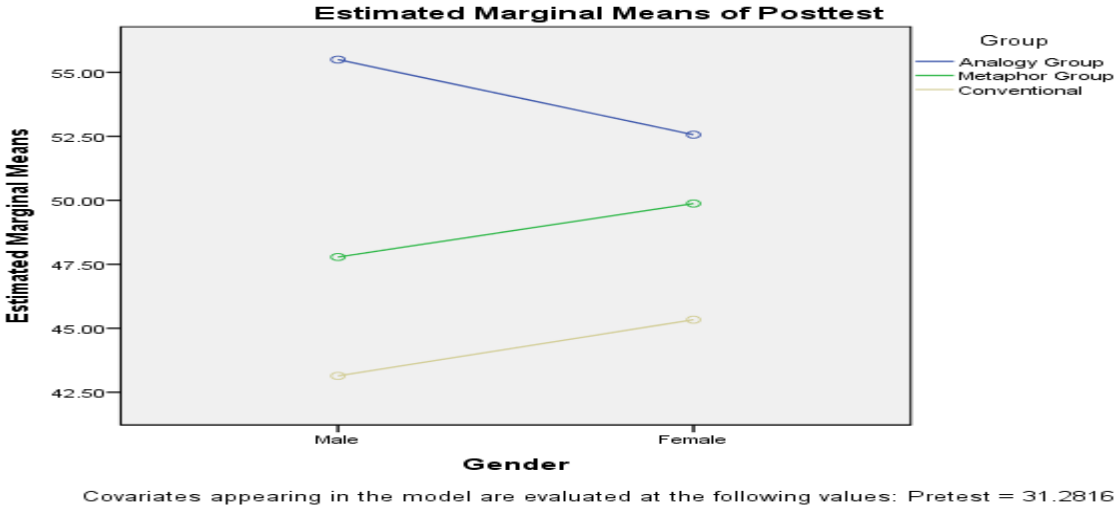


Figure 1: Profile plot of the interaction effect between treatment and gender

Research Question 9

What is the interaction effect of treatment and cognitive styles on senior school students' achievement in genetics?

Table 22 reveals that the total mean score of the field-dependent (M = 48.80) and field-neutral (M = 48.96) students were homogenous. Meanwhile, the field-independent students (M = 57.33) benefitted most from the interventions. The result, therefore, suggests that the performance of the field-dependent and field-neutral students were similar in relation to the interventions.

Table 22

Descriptive Statistics of the Interaction Effects between Treatment and Students' Cognitive Styles

CognitiveStyle	Group	N	Mean	Std. Deviation
Field Dependent	Analogy	25	58.24	16.34
	Metaphor	54	47.37	7.91
	Conventional	38	40.79	8.93
	Total	**117**	**48.80**	**11.06**
Field Neutral	Analogy	27	57.67	15.26
	Metaphor	6	47.67	9.07
	Conventional	13	41.54	4.01
	Total	**46**	**48.96**	**9.45**
Field Independent	Analogy	3	77.33	22.03
	Metaphor	2	54.00	2.82
	Conventional	6	40.67	10.17
	Total	**11**	**57.33**	**11.67**

H_{09}: There is no statistically significant interaction effect between treatment and cognitive styles on senior school students' achievement in genetics.

The 3 x 3 ANCOVA between students' cognitive styles and the treatment in Table 23 reveals that the interaction between treatment and cognitive styles was not statistically significant $F_{(4, 164)} = .45$, $p = .77$. Therefore, the null hypothesis was rejected since $p > 0.05$.This

implies that there is no statistically significant interaction effect of treatment and cognitive styles on senior school students' achievement in genetics.

Table 23

ANCOVA Result of the Interaction Effect between Treatment and Cognitive styles on Students' Achievement in Genetics

Source	Type III Sum of Squares	df	Mean Square	*F*	Sig.	η^2_p
Corrected Model	22348.48[a]	9	2483.16	45.43	.00	.71
Intercept	4480.23	1	4480.23	81.96	.00	.33
Pretest	11871.65	1	11871.65	217.19	.00	.57
Treatment	1060.05	2	530.03	9.70	.00	.11
Cognitive style	85.90	2	42.95	.79	.46	.01
Group * Cognitive Style	98.70	4	24.67	.45	.77	.01
Error	8964.38	164	54.66			
Total	449577.00	174				
Corrected Total	31312.86	173				

a. R Squared = .714 (Adjusted R Squared = .698)

Figure 2 reveals that the lines are ordinal in nature and parallel to one another. This suggests that the achievement of the students irrespective of their cognitive styles was enhanced by the different forms of treatments utilised in the research.

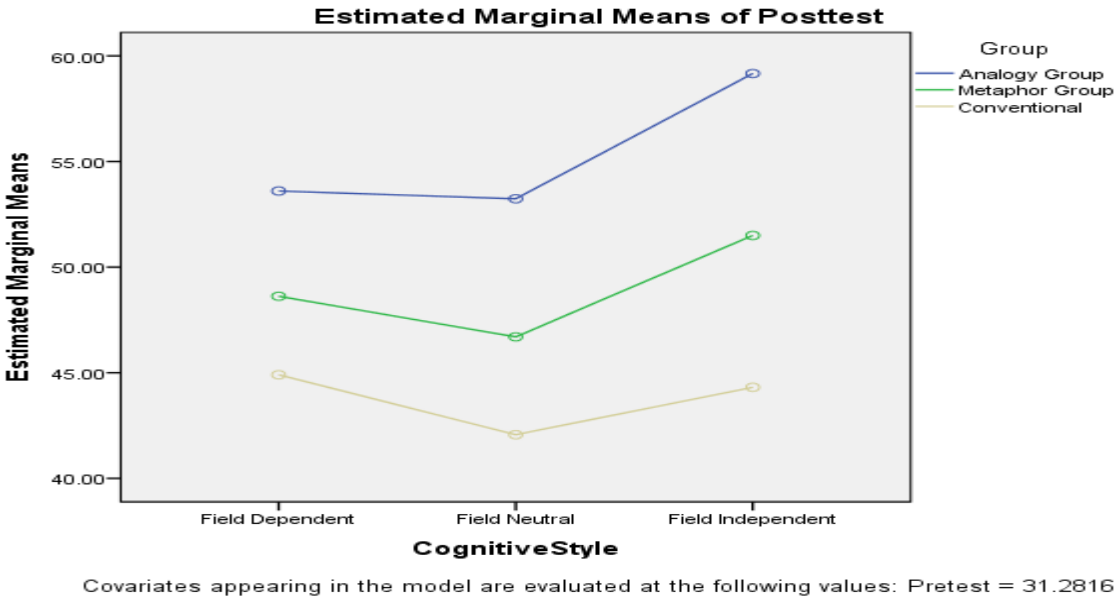


Figure 2: Plot of the Interaction effect between treatment and cognitive styles

Research Question 10

What is the interaction effect of treatment and score levels on senior school students' achievement in genetics?

Table 24 shows that the mean scores of the three groups were different with respect to the treatments. The low, medium and high scoring students recorded mean scores of 42.13, 51.31 and 64.50 respectively. These results suggest that the students' score levels had effect of the treatments they were exposed to.

Table 24

Descriptive Statistics of Interaction Effect of Treatment and Score Levels

Score Levels	Group	N	Mean	Std. Deviation
Low	Analogy	24	46.92	8.75
	Metaphor	30	44.67	7.64
	Conventional	15	34.80	7.44
	Total	**69**	**42.13**	**7.94**
Medium	Analogy	24	62.67	11.20
	Metaphor	29	49.86	7.15
	Conventional	34	41.41	6.20
	Total	**87**	**51.31**	**8.18**
High	Analogy	7	87.86	5.90
	Metaphor	3	55.33	7.57
	Conventional	8	50.50	6.74
	Total	**11**	**64.5**	**6.74**

H_{010}: There is no statistically significant interaction effect between treatment and score levels on senior school students' achievement in genetics.

The 3 x 3 ANCOVA between treatment and score levels in Table 25 reveals that interaction existed between treatment and score levels $F_{(4,164)}$ =2.87, p = .02. Thus, the hypothesis that states that there was a statistically significant interaction effect between treatment and score levels on senior school students' achievement in genetics was rejected since the p-value < 0.05. This implies that there is a statistically significant interaction effect of treatment and score levels on senior school students' achievement in genetics.

Table 25

ANCOVA of Interaction Effect between Treatment and Score Levels on Students' Achievement in Genetics

Source	Type III Sum of Squares	df	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	22900.40[a]	9	2544.49	49.61	.00	.73
Intercept	1107.08	1	1107.08	21.58	.00	.12
Pretest	2038.98	1	2038.98	39.75	.00	.20
Group	917.52	2	458.76	8.94	.00	.10
ScoreLevel	3.65	2	1.83	.04	.97	.00
Group * ScoreLevel	590.45	4	147.61	2.88	.02	.07
Error	8412.46	164	51.30			
Total	449577.00	174				
Corrected Total	31312.86	173				

a. R Squared = .731 (Adjusted R Squared = .717)

The profile plot in Figure 3 shows that the lines are not perfectly parallel to each other and if stretched further they are likely to meet indicating that there is a significant interaction between the groups and score levels. This also corroborates the figures gotten on Table 25.

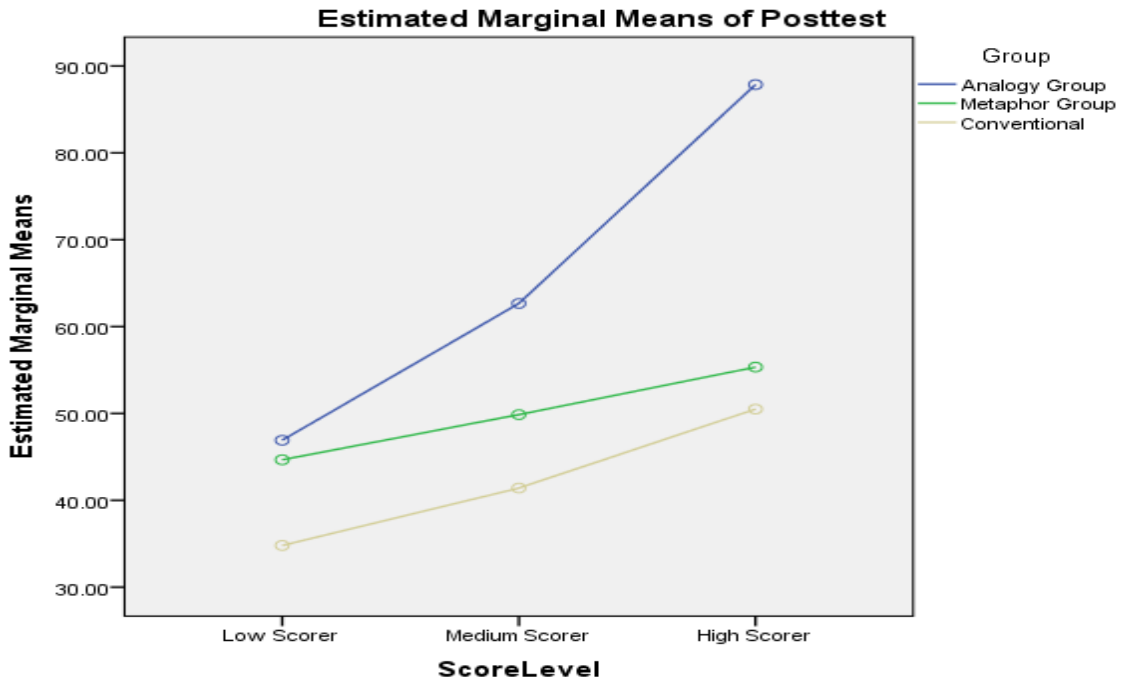


Figure 3: Plot of the Interaction effect between treatment and score levels

Summary of the Findings

Based on the data collected, analysed and interpreted, the following findings were obtained:

1. There was a statistically significant difference in the achievement of students that were taught genetics using analogy, metaphor and the conventional method in favour of those exposed to analogy.
2. There was no statistically significant difference in the achievements of male and female students that were taught genetics with the use of analogy.
3. There was no statistically significant difference in the achievements of male and female students taught genetics using metaphor
4. No statistically significant difference in the achievements of field-dependent, field-neutral, and field-independent students that were taught genetics using analogy.
5. There was no statistically significant difference in the achievements of field-dependent, field-neutral, and field-independent students that were taught genetics with the use of metaphor
6. There was no statistically significant difference in the achievements of low, medium, and high scoring students taught genetics using analogy.
7. There was no statistically significant difference in the achievements of low, medium, and high scoring students that were taught genetics with the use of metaphor.
8. There was no statistically significant interaction effect of treatment and gender on students achievement in genetics.
9. There was no statistically significant interaction effect of treatment and cognitive styles on students achievement in genetics.
10. There was a statistically significant interaction effect of treatment and score levels on senior school students achievement in genetics.

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

This chapter deals with the discussion of findings upon which conclusions were drawn and relevant recommendations made.

Discussion

The study investigated the effect of use of analogy and metaphor instructional strategies which are typical types of instructions in figures of comparison on senior school students' achievement in genetics. The finding of the study revealed that all the three teaching methods have the potential of improving students' achievement in genetics. However, students exposed to instruction with the use of analogy performed better than students taught with metaphor, while theconventional teaching method was the least effective teaching method in terms of enhancing students' achievement among the three methods. This could be attributed to the fact that analogy allows students to make direct comparison between what they are familiar with and abstract concepts they were taught. As such, students were able to relate genetic concepts such as heredity variation, with the act of having different denominations of money in one's purse. The pedagogical implication of this is that analogy instructional strategy can be employed to enhance meaningful learning of genetics and by extension other similar abstract Biology concepts that are hard-to-teach and hard-to-learn.

The finding is in line with that of Ziyad (2020) and Ameyaw and Kyere (2019) who separately observed that analogy instructional strategy enhances students' academic performance. It is also in line with those of Genc (2013) who reported thatstudentsexposedto instruction using analogy had better achievement than their counterpart that were taught with the conventional teaching method.The finding is however, in contrast with those of Tsipi (2016) who observed that students exposed to metaphor of the category A is like B, were no able to process information faster when compared with those exposed to the category of A is

B. The similarity in findings could be as a result of the statistical instrument employed in analysing the data.

Another finding from the study revealed that metaphor instructional strategy also enhances students understanding of genetics more than the conventional teaching method. This result could be attributed to the fact that students that were exposed to metaphor instructional strategy were able to relate better the abstract genetic concepts with what they are familiar with, hence, performed significantly better than students taught using the conventional teaching approach. The implication of this is that metaphor instructional strategy can be employed by Biology teachers to teach genetics and other hard-to-teach concepts in Biology. The finding is in line with those of Aboyeji (2019) who examined the effect of metaphor instructional strategy on students' performance in cell Biology and reported that the use of metaphor enhances students' performance in cell Biology. The finding isalsosimilar to those of Aje (2018) who also reported that the use of metaphor instructional strategy improves students' performance significantly in cell Biology. In similar vein, the result is in line with the findings of Awofodu (2016) who observed that metaphor instructional strategy enhances students' achievement in ecology better than the conventional method of instruction.The finding is also similar to those of Tsipi (2016) who observed that students exposed to metaphors of the catagorisation A is B, achieved significantly faster than there counterparts exposed to metaphors of the categorisation A is like B. The similarity in the findings of all the studies could be as a result of the fact that the geographical location from where the samples were drawn are similar or that the samples were drawn from the same population.

Another finding from the study also revealed that there was no significant variance in the achievements of male and female students that were taught with the use of analogy instructional strategy. This finding could be as a result of the fact that the use of analogy in lesson delivery allows students from both gender group to participate effectively in the lesson,

since they both have some levels of prior knowledge that they could hinge the learning of the new concept on. The implication of this in a regular classroom setting is that the strategy could be employed by Biology teachers as an effective teaching strategy in a mixed gender classroom. This finding aligns with those of Ahmed *et al* (2021) who submitted that gender does not influence the achievement of senior school students in Biology. The finding is also line with Nawaf (2016) submission that analogy instructional strategy has effect on senior secondary school students' achievement in sciences and that there was no significant difference in the achievements of male and female students taught using analogy instructional strategy. This is, however, contrary to the findings of Jiya (2011) who examined the effects of teaching with analogy on students' achievement in evolution and observed that male students performed significantly better than their female counterparts when taught evolution using analogy instructional strategy. The findings is also contrary to the findings of Akinsola and Odeyemi (2014) who reported that male students performed significantly better than female students that were exposed to innovative teaching strategies. This finding might have been contrary to those of Jiya (2011) due to the fact that the location where Jiya carried out the research do not really encourage the girl child education, hence the reason why the instructional strategy favoured the male students.

In addition, the finding from the study showed that there was no difference in the achievement of male and female students that were taught genetics using metaphor. The finding might not be unconnected with the fact that both male and female students were given equal opportunity to think of and generate other metaphoric terms that can be employed to explain key genetic terms and as such they were not passive learners. The achievement could also be attributed to the fact that the strategy was used consciously by the teacher and hence, they were carefully selected. The pedagogical implication of this finding is that metaphor as an instructional strategy can be used in a mixed gender class. This finding is in line with the

findings of Aje (2018) and Aboyeji (2019) who reported separately in different researches that the use of metaphor instructional strategy did not have any significant influence on the achievements of male and female students that were exposed to instruction via metaphor instruction. The finding is also in line with the findings of Awofodu (2016) who reported that both male and female students that were taught Ecology with the use of metaphor instructional strategy benefited equally and, thus, concluded that there was no significant variance in the performance of male and female students exposed to the use of metaphor instruction. The similarity in findings might not be unconnected with the fact that the population for the studies were located in almost the same geographical zone and as such could have shared similar characteristics

Furthermore, findings from the study revealed that there was no significant difference in the achievement of field-dependent, field-neutral and field-independent students that were taught genetics using analogy. This finding could be as a result of the fact that the instructional strategy allows students of different cognitive styles to process information in their own ways. This could also be attributed to the fact that the students were able to relate familiar concepts they were conversant with easily with the unfamiliar genetic concepts and as such were able to make a mental image of the abstract genetic concepts. The finding implies that analogy instructional strategy can be effectively utilised to aid students' achievement in genetics and other hard-to-teach concepts irrespective of the ways the students' processes information.This finding is in line with those of Abdulrahim (2018) whose research finding showed that both field-dependent and field independent students significantly benefitted when taught Biology concepts with the use of learning cycle and concept-mapping instructional strategies.The finding however, is contrary to those of Safyanu, Ado and Olarinoye (2016); Aje (2018) whose findings in separate researches revealed that the field independent students achieved better score than the field-dependent students when they were exposed to innovative instructional

strategies. The contradiction in findings could be as a result of the statistical tools utilised by the researchers. The present study made use of ANCOVA while Safyanu, Ado and Olarinoye (2015) and Aje (2018) utilised the *t-test* statistics.

Achievement of field-dependent, field-neutral and field-independent students that were exposed to metaphor was also found not to be statistically significant. One plausible reason for this finding might not be unconnected with the fact that metaphor allows students to think critically and also assist students to form mental images of abstract genetics concepts. This implies that field-dependent, field-neutral and field-independent students all benefitted from the use of metaphor instructional strategy, and as such, the strategy can be used in mixed class that consists of students with different cognitive styles. The finding of this study is in line with those of Okoronka and Wada (2014) who observed that there was no significant difference in the achievement of field-dependent and-field-independent students that were taught basic Physics concept using analogy. The result, however, is contrary to those of Ashiru and Sadiq (2016) who reported that there was a significant difference in the achievement of field-dependent and field-independent students taught abstract Biology concept. The similarity in the findings with those of Okoronka and Wada (2014)could be as a result of utilizing the same teaching strategies, while the contradiction with those of Ashiru and Sadiq (2016) could be as a result of the instructional strategies used by the researchers or the geographical location where the research was conducted.

From the study, there was no statistically significant difference in the achievements of low, medium and high scoring students that were exposed to analogy and metaphor instructional strategies. The descriptive statistics of the score levels of students exposed to analogy however, revealed that the high scoring students benefitted most, followed by the medium scoring students and lastly the low-scoring students. A plausible reason for this might be that the high scoring students were able to relate the abstract concepts with concepts they

are familiar with by engaging themselves in critical thinking better than the medium and low scoring students. This implies that, analogy instructional strategy can be used in a mixed score level classroom, however, the teacher must endeavour to state the limitations of the analogy so that the low scoring students would be able to identify when the analogy breaks down when they are processing the information in their cognition. The result is in line with the findings of Alabi (2016) and Ayanda (2016) who both reported that there was no significant difference in the achievement of high, medium and low scoring students. The similarity in findings could be as a result of the geographical location or statistical instruments adopted in the researches, which are similar. It can therefore, be implied that students in the geographical region can be exposed to different instructional strategies and still get similar results.

Another finding from the study revealed that there was no statistically significant difference in the achievement of students with different score levels exposed to metaphor instructional strategy. The descriptive statistics, however, revealed that the low scoring students benefitted most from receiving instruction with metaphor. This finding might be due to the fact that metaphor assisted the students in the various scoring levels to form a cognitive bridge that assists the students to relate abstract genetic concepts with familiar concepts. With this experience, they tend to have had better grasp of the concepts under discourse and hence, all achieved significantly better. This implies that the strategy can be employed in a classroom with different score levels of students. The finding corroborates the findings of Alabi (2016) and Awofodu (2016) who both submitted that there was no significant difference in the achievement of low, medium and high scoring students that were sampled in their various researches. The finding, however, is contrary to the findings of Obochi (2021) who reported that the low scoring students achieved significantly better than the medium and low scoring students. The finding also contradicts those of Olanrewaju (2019) who observed that the high scorers achieved better than the low and medium scoring students.

A finding from the study also revealed that there was no statistically significant interaction effect of treatment and gender on senior school students' achievement in genetics. This finding might be as a result of the fact that students from both gender groups were equivalent and are exposed to the same learning condition. This implies that the treatments could be used successfully in co-educational institutions. This finding is in line with the findings of Ibe and Abamuche (2019) who submitted that there was no significant interaction effect of treatment and gender on students' performance in Biology. It is also similar to the findings of Badmus, Bello, Hamzat and Sulaiman (2019) who found out that there was no significant interaction effect between treatment and gender on students' achievement in Ecology.

The finding of this study also revealed that there was no statistically significant interaction effect of treatment and cognitive styles on students' achievementin genetics. This may be due to the fact that students' cognitive style is independent of the teaching strategies employed by the teacher or that the students were able to actually construct their own personal knowledge by using their previous knowledge as a pivot to having better understanding of abstract genetics concepts. This finding is in line with the findings of Sudarman, Kuswandi and Dwiyogo (2016) who found out that there was no significant interaction effect between treatment and cognitive styles on students' achievement in Mathematics respectively. The finding, however, is contrary to the findings of Agboghoroma (2015) who observed that there was a significant interaction effect of treatment and cognitive styles on students' knowledge of Integrated Science.

Finally, the study revealed that a significant interaction effect existed between treatment and score level. This finding implies that the instructional strategies are significantly dependent on the students' score level to determine students' achievement in genetics. One plausible reason for this finding might be because the high scorers benefitted most with the use of

analogy instructional strategy, while the low scorers had the highest mean gain score when they were exposed to instruction with metaphor. This finding is contrary to the findings of Akinjiola (2017); Awofodu (2016) who submitted that there was no significant interaction effect of treatments and score levels on senior school students' achievement. It is also not in conformity with the findings of Olanrewaju (2018) who observed that there was no significant interaction of Webquest, gender and score level on Chemistry students' performance.

Conclusion

The study focuses on assessing the comparative effects of figures of comparison on senior school students' achievement in genetics. The study concluded that analogy and metaphor instructional strategies are effective strategies for teaching genetics. This is because the findings of the study revealed that students taught genetics using analogy and metaphor instructional strategiesachievedsignificantlybetter than students exposed to the conventional method of teaching. The study also concluded that gender had no significant effect on students' achievement when exposed to analogy and metaphor instructional strategies. The study revealed that both male and female students benefited immensely from the two strategies. Also, students with different score level benefitted from the instructional strategies without discrimination.

Students achievement in genetics was not affected by the way students' process information. It is, therefore, concluded that cognitive style of the students does not have significant effect on the achievement of students since all the students irrespective of their cognitive style benefitted immensely from both analogy and metaphor instructional strategies.

Recommendations

The following recommendations were considered appropriate based on the conclusions of this study:

1. The study has shown that the use of analogy and metaphor greatly enhances students' achievement by having a positive effect on their achievement in genetics, unlike the conventional teaching method. In view of this, it is recommended that analogy and metaphor instructional strategies should be utilised by teachers and students to enhance effective teaching and learning of genetics and other biology concepts.
2. Male and female students should be encouraged to explore the use of analogy and metaphor instructional strategies so as to enhance their achievement in Biology since the finding revealed that both strategies are not gender bias.
3. Cognitive styles had no influence on students' achievement as revealed in the findings of this research.Itis therefore, recommended that teachers should adopt the use of both analogy and metaphor instructional strategies in their teaching so as to cater for the diverse ways through which students process information based on their cognitive styles.
4. Teachers that would be adopting the use of both instructional strategies should consider the different categories of students in the class with varying score levels since there was an interaction between the treatments and students' score level.
5. Textbook authors should incorporate the use of figures of comparison in their textbooks to bring about meaningful learning on the part of the students when reading the recommended textbooks.
6. Educational institutions like the colleges of education and faculties of education in Nigerian universities should also prepare pre-service teachers who would be able to utilise figures of comparison in their regular classrooms to teach biological concepts
7. Curriculum developers should incorporate the use of figures of comparison into the Biology curriculum as part of the list of instructional strategies so as to enrich the quality of classroom instruction

Suggestions for Further Studies

1. Studies similar to this one could be replicated using other topics in Biology or science concepts in other geographical locations within the country
2. Other researchers could also employ the use of mixed method research that will involve the use of both quantitative and qualitative research.
3. The result obtained revealed that metaphor does not enhance students' achievement like analogy. Therefore, there is the need for other researchers to combine the use of metaphor with other instructional strategies like problem-solving strategy, collaborative instructional strategies and so forth so as to further acknowledge the efficacy of metaphor instructional strategy.
4. Other figures of comparison such as simile can also be investigated to ascertain their effects on students' achievement in other Biology topics
5. Similar studies could also be carried out with the inclusion of other variables like students' interest, views, and retention

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APPENDIX I

UNIVERSITY OF ILORIN, ILORIN, NIGERIA

DEPARTMENT OF SCIENCE EDUCATION

INFORMED CONSENT FORM FOR PRINCIPALS

Dear Sir/Ma,

I, SULAIMAN, Musa Mohammed, a postgraduate student of the Department of Science Education, University of Ilorin, Ilorin, Nigeria is currently embarking on a Ph.D. work entitled "Effects of Teaching-With-Figures of Comparison on Senior School Students' Achievement in Genetics in Ilorin, Nigeria".

The purpose of this study is to seek for a better learning strategy that will improve students' academic achievement in Biology. To this end, the purpose of this form is to seek your consent for the participation of your teachers and students in this study, which will be conducted in your school during the regular school hours only. All information and data gathered will be treated with utmost confidentiality and used for research purpose solely.

Principal's Agreement: I hereby voluntarily consent to the participation of my teachers and students in the study. I also understand that if I have any question with regards to the study, I may contact the Department of Science Education, University of Ilorin, Ilorin, Nigeria or call the researcher on cell phone number 080374104 or send an e-mail to sulaiman12003@gmail.com

Name:…….

Signature:……

Date:……..

APPENDIX II
UNIVERSITY OF ILORIN, ILORIN, NIGERIA
FACULTY OF EDUCATION
DEPARTMENT OF SCIENCE EDUCATION
INFORMED CONSENT FORM

Dear Participants,

Please be informed that you are selected to participate in a research study. Your consent is hereby required to take part in the study. Detailed information about the research is provided below. Kindly endorse this consent form after going through the information, if you volunteer to participate in the study.

Purpose of the Research: The main focus of this research is to determine the effects of analogies and metaphors on senior secondary school students' achievement in genetics, as part of efforts geared towards promoting meaningful learning of Biology.

Procedure: The participants will be required to attend series of class lessons on genetics, which is one of the major topics in the Biology syllabus. The lessons will take place during the regular class periods allocated for Biology in the selected schools time tables. Participating students will be exposed to two novel teaching strategies and the lessons would last for four (4) weeks only.

Confidentiality: All information provided will be treated with utmost confidentiality and used for the purpose of research only.

Risks: No risk is envisaged to your person during the research, as the main focus of the research is to teach genetics during the regular classroom.

Benefits: The research is envisaged to bring to you meaningful learning of genetics concepts. It would also assist you to generate analogies and metaphors in other topics in Biology or other subjects thereby, bringing about better understanding of abstract science concepts.

Right of Volunteers: Your participation in this research is voluntary. Hence, if you decide not to take part or stop your participation in the research at any time, you will not lose anything. You also have the privilege of contacting the researcher on 08037645104 or the Department of

Science Education, University of Ilorin, Ilorin, Nigeria in case you have any question related to the research.

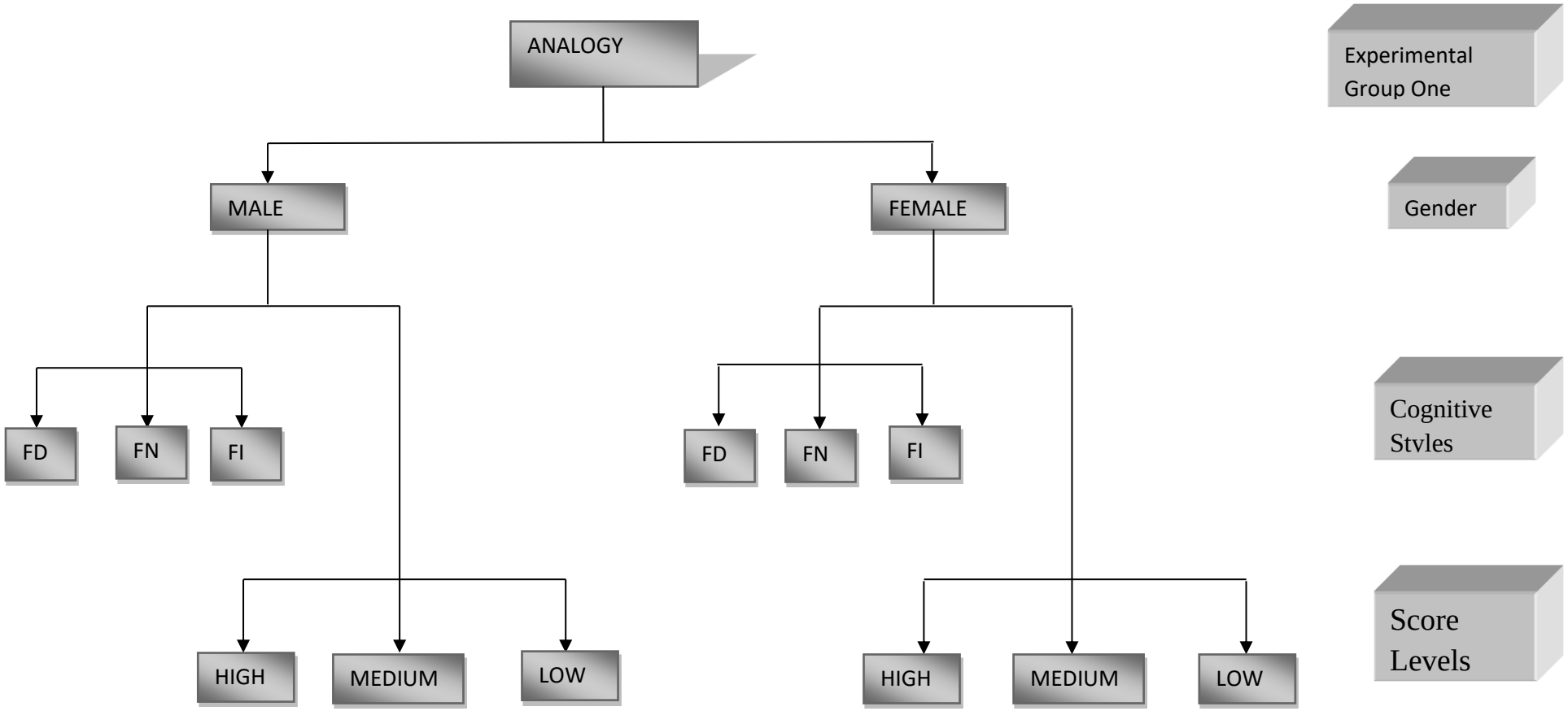
Respondent Agreement: I hereby voluntarily consent to participate in the research. I know that I may refuse to participate or stop my participation in the research at any time. In addition, I know that if I have any question about the research or my right as a student participant, I may contact the Department of Science Education, University of Ilorin or call the researcher on the following mobile number: 08053272058, 08037645104

Student	Signature	Date
Parents/ Guardian	Signature	Date
Researcher	Signature	Date

APPENDIX III

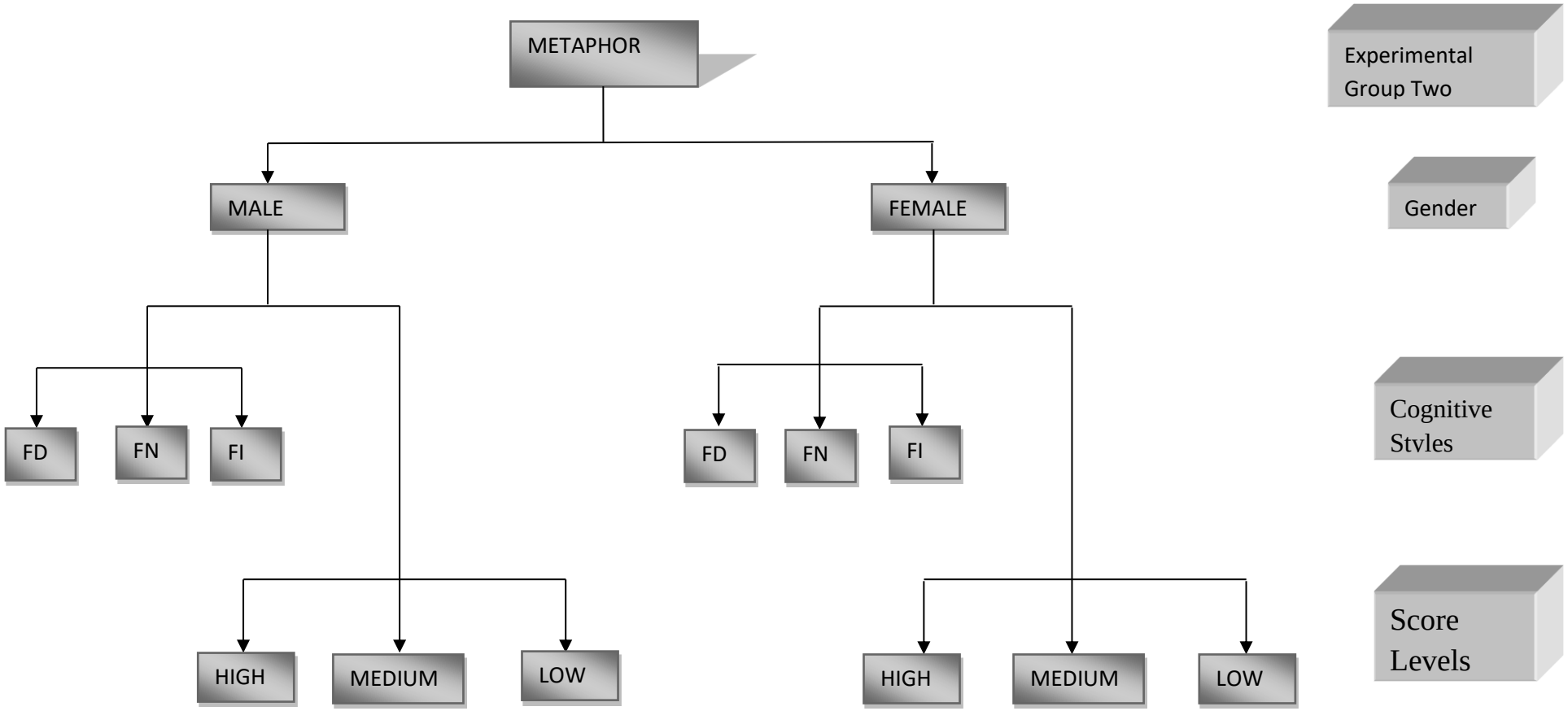
SCHEMATIC DIAGRAM OF THE RESEARCH DESIGN

Key: FD- Field-Dependent; FN-Field-Neutral; and FI- Field-Independent



APPENDIX IV

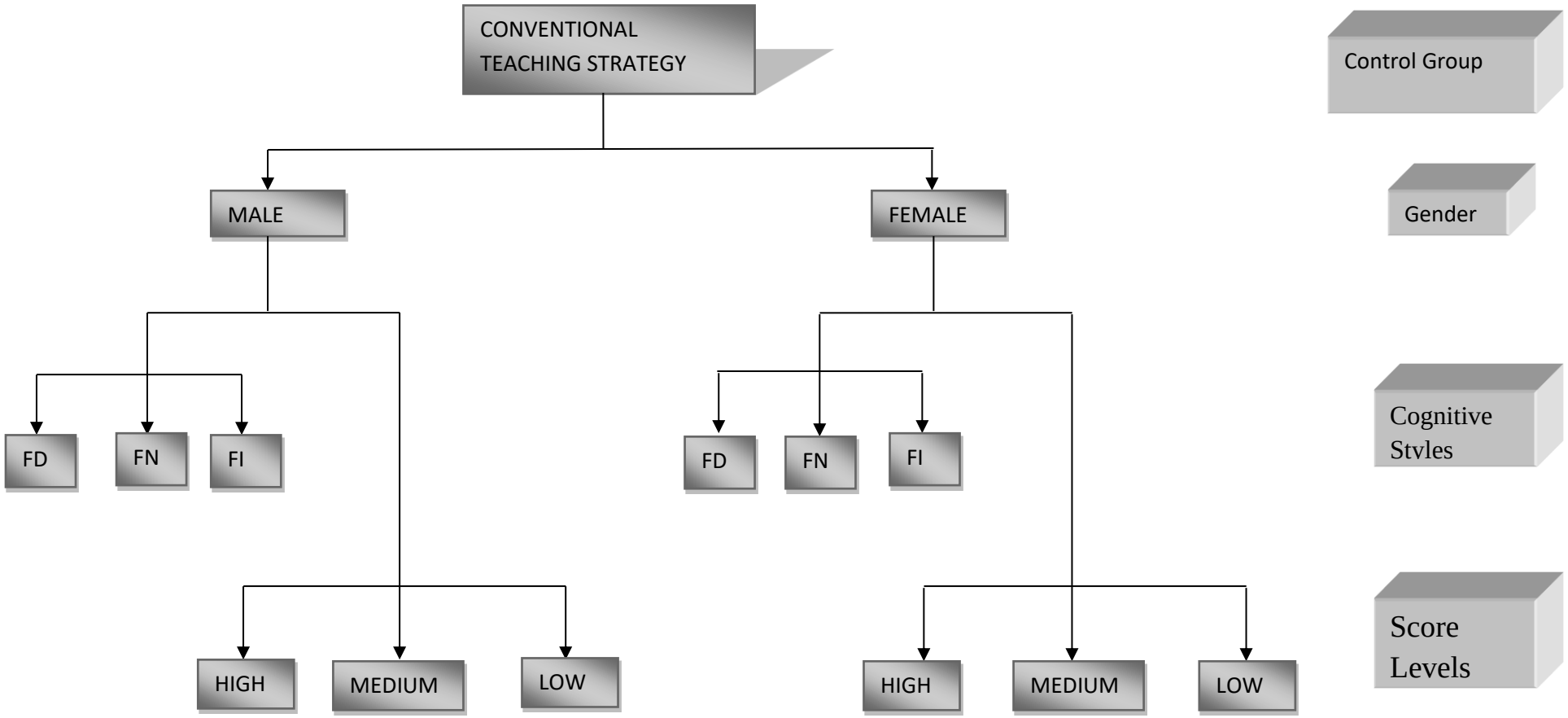
SCHEMATIC DIAGRAM OF THE RESEARCH DESIGN



Key: FD- Field-Dependent; FN-Field-Neutral; and FI- Field-Independent

APPENDIX V

SCHEMATIC DIAGRAM OF THE RESEARCH DESIGN



APPENDIX VI

Group Embedded Figure Test

Name: …….

Class: ……. **Gender: *Male*( ) *Female* ( )**

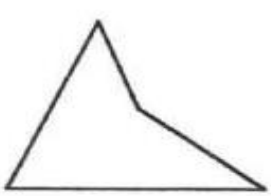
Date: ……...

Instruction: This is a test of your ability to find a simple form where it is hidden within a complex pattern.

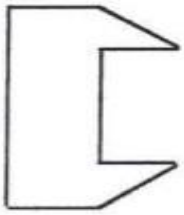
The results of this test will not affect your subject assessment in any way

Time allowed: 20 minutes

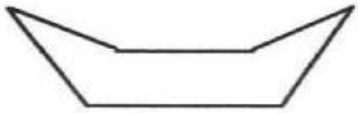
Study the shapes below and locate them in the embedded figure



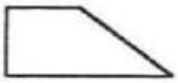
A



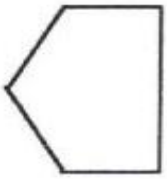
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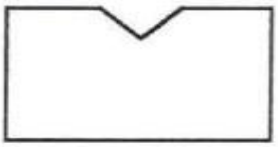
C



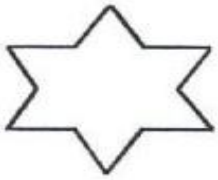
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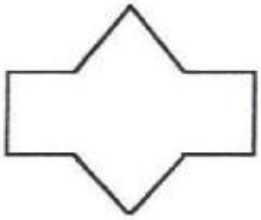
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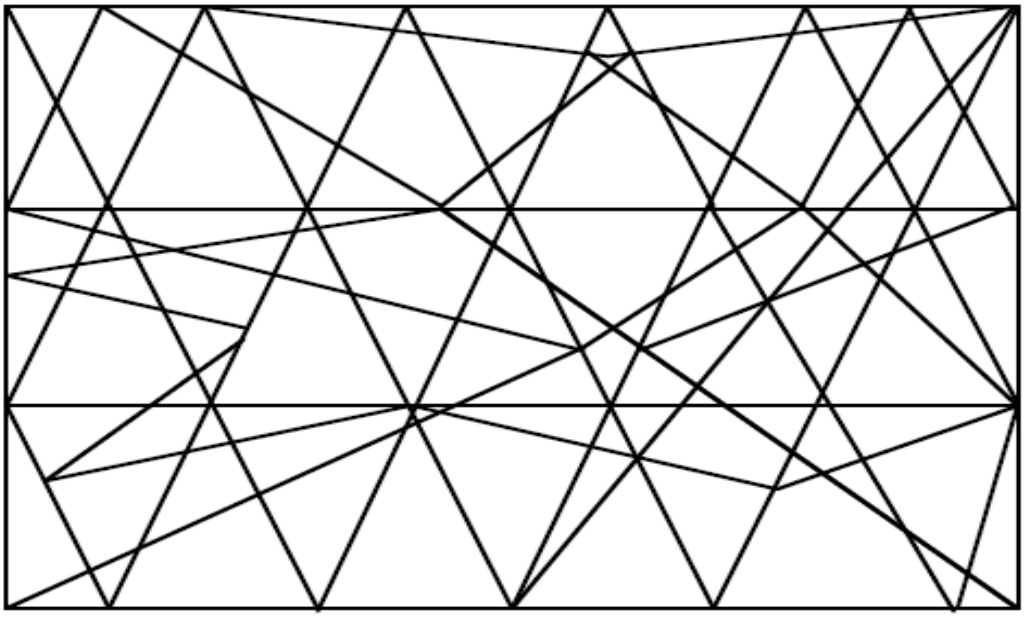


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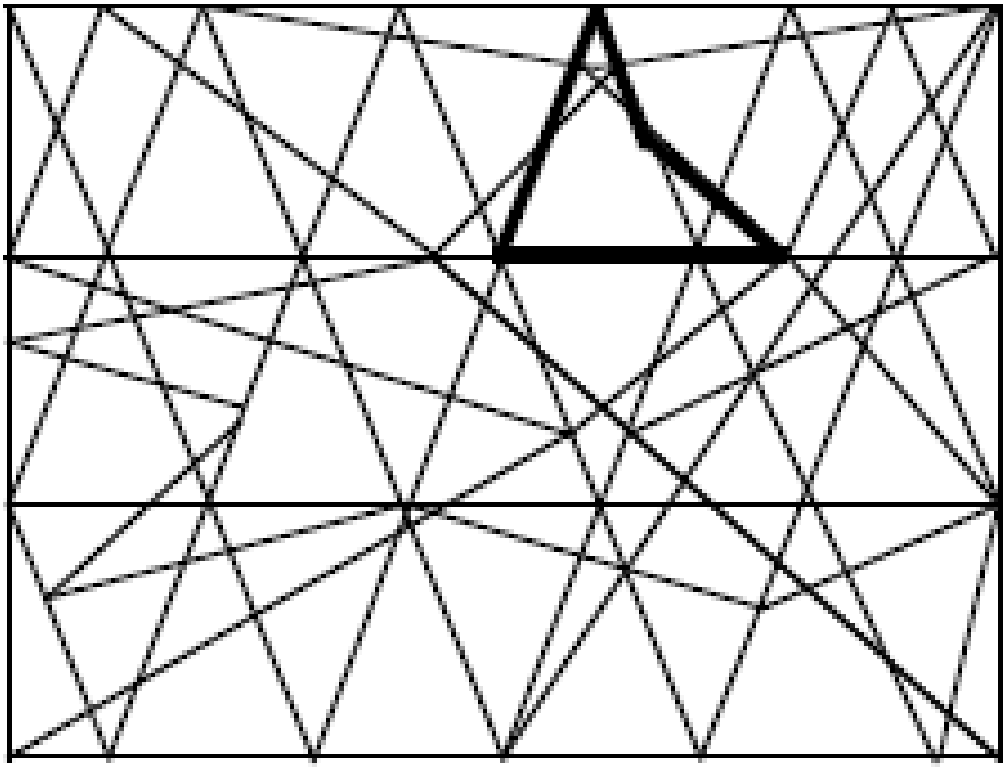


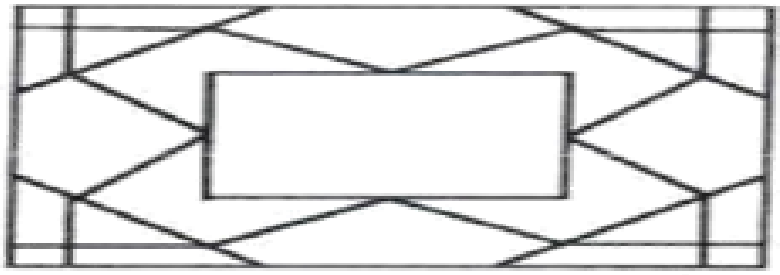
H

Example



Find shape A

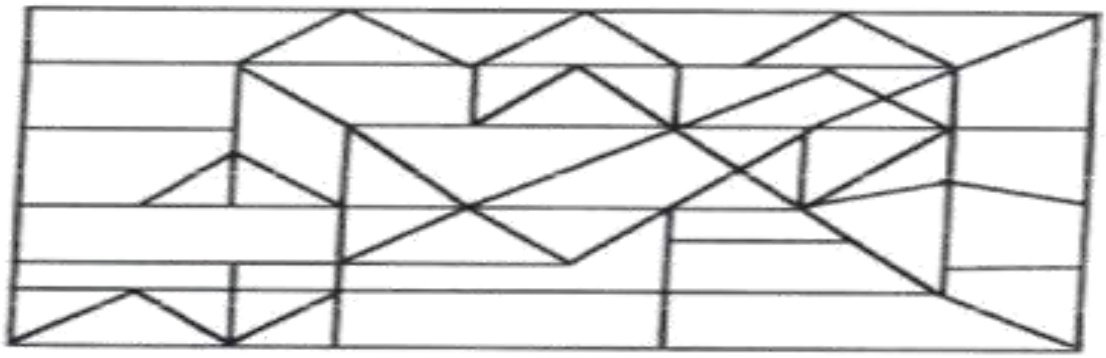




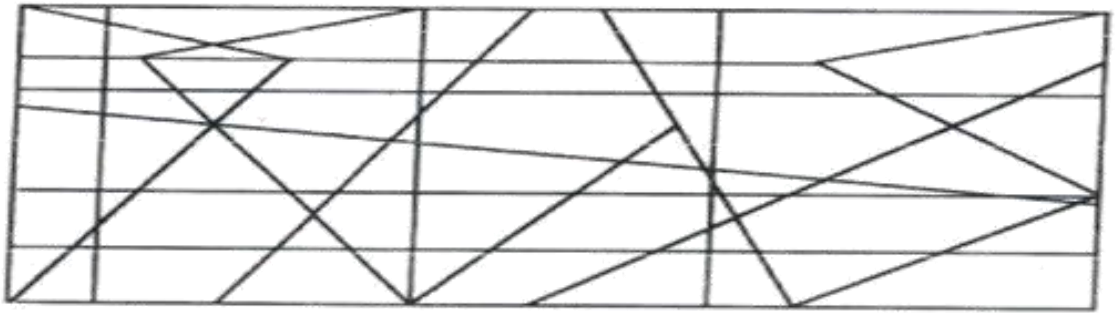
Find shape B



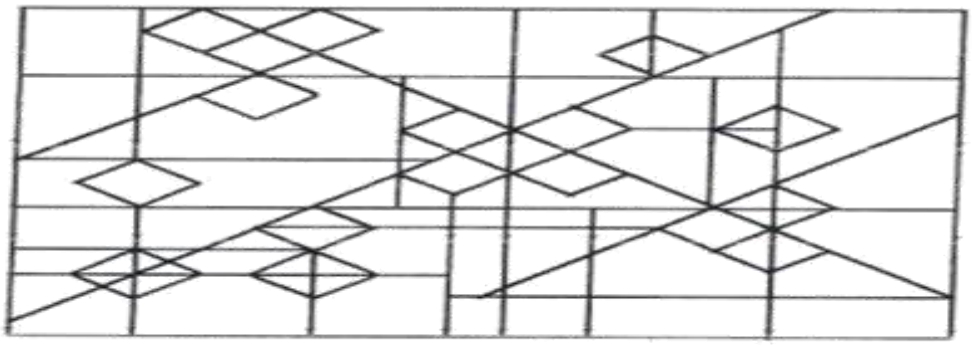
Find shape D



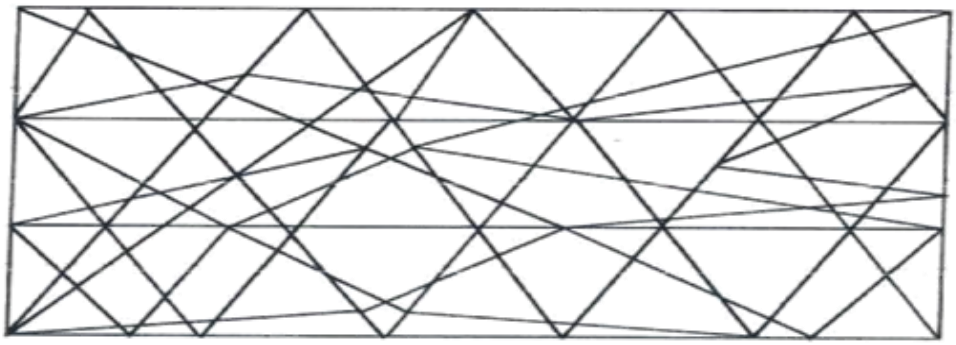
Find shape H



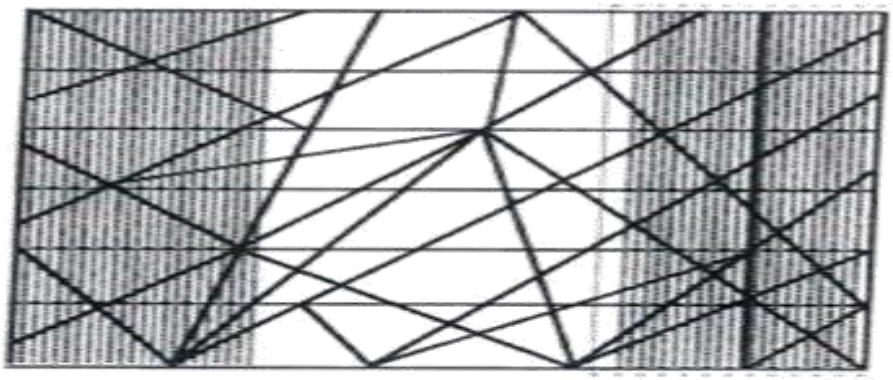
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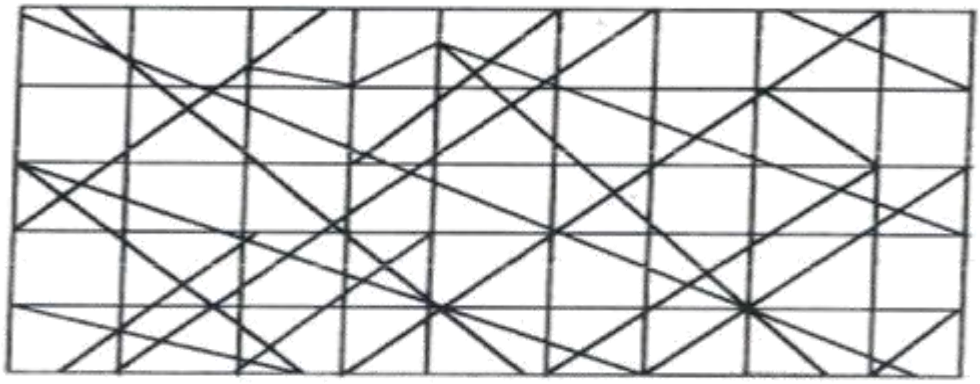
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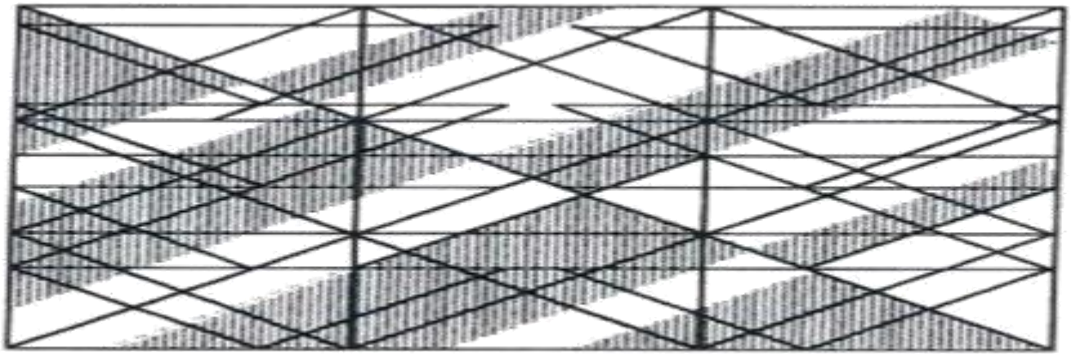
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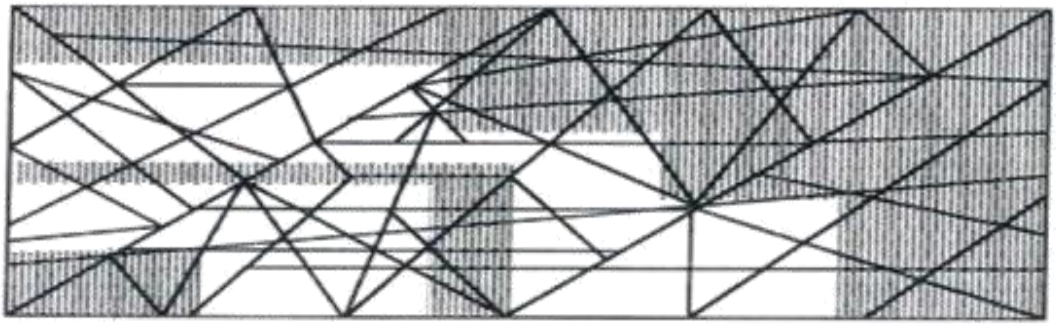
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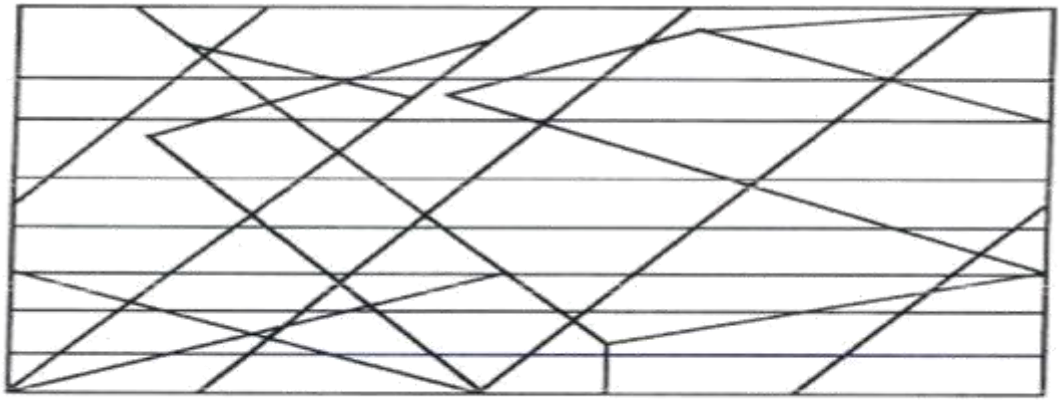
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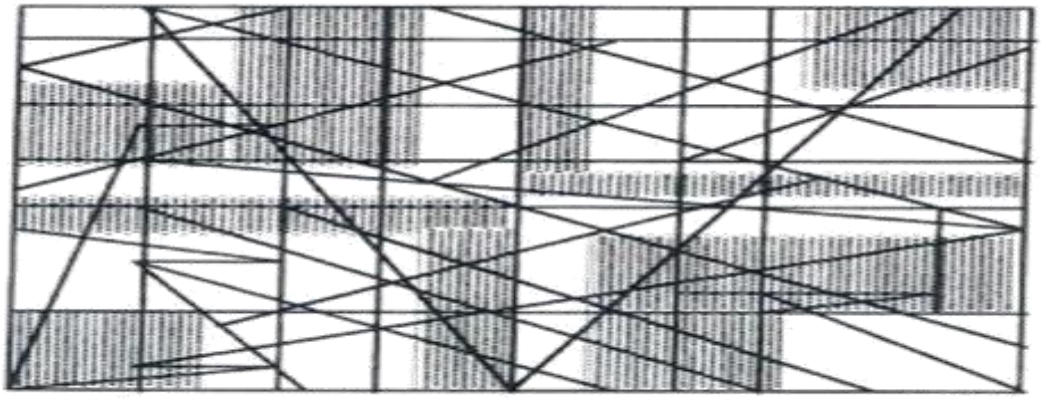
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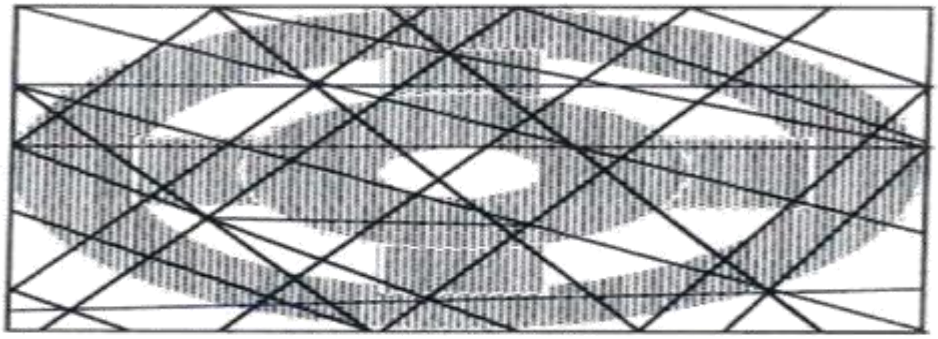
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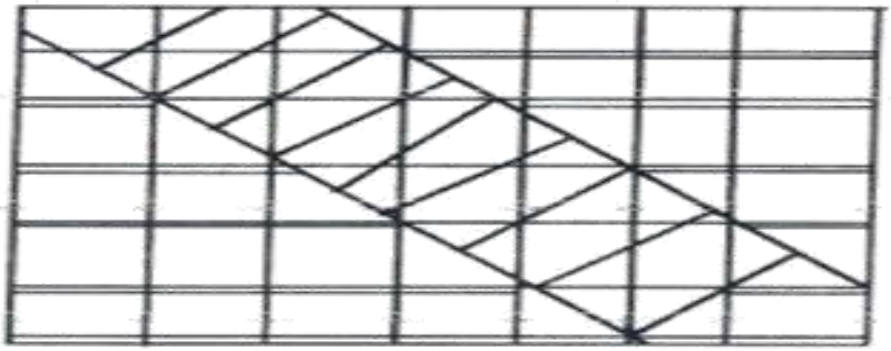
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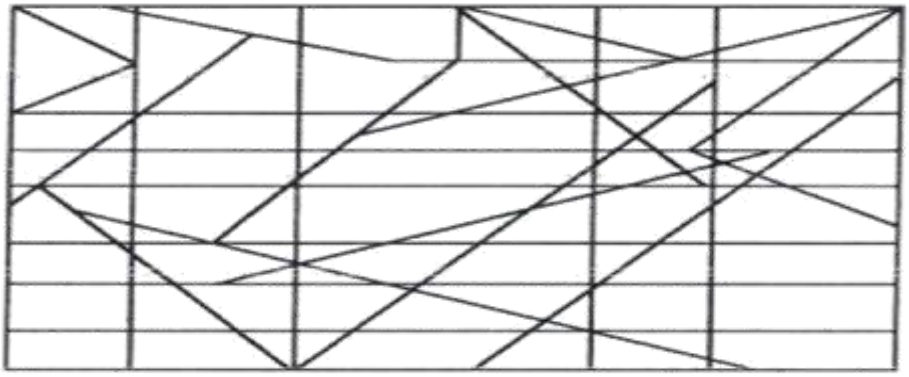
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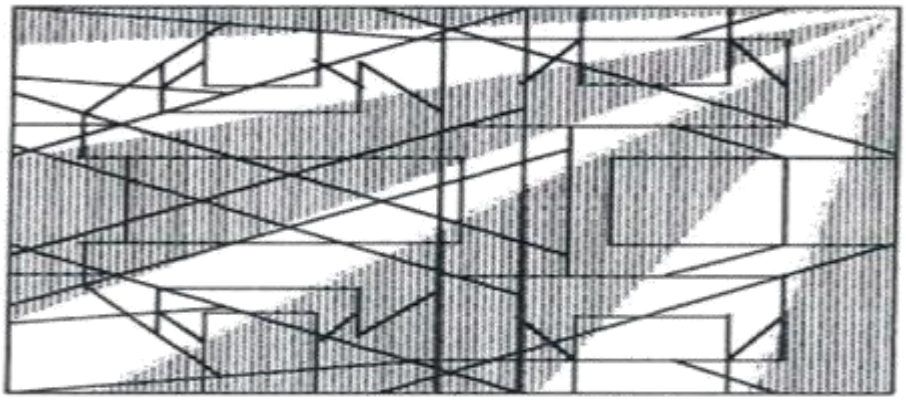
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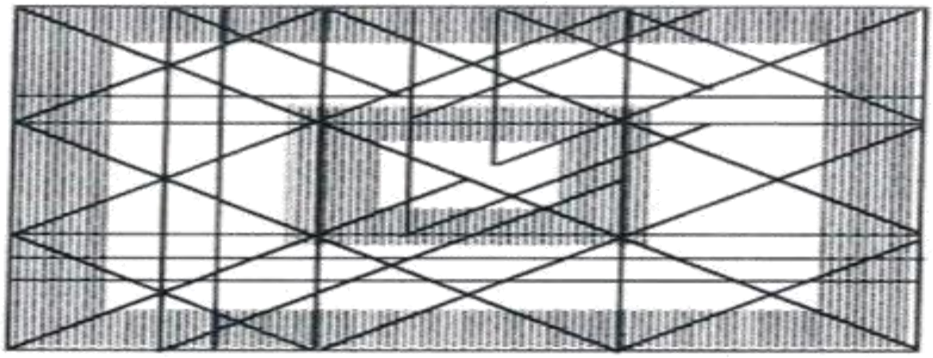
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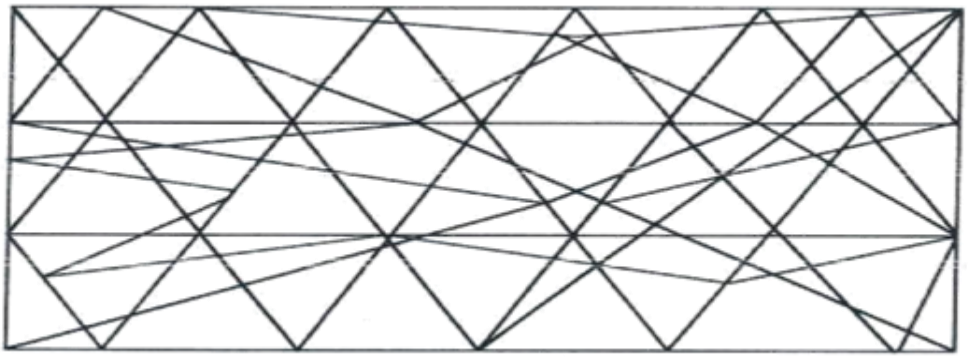
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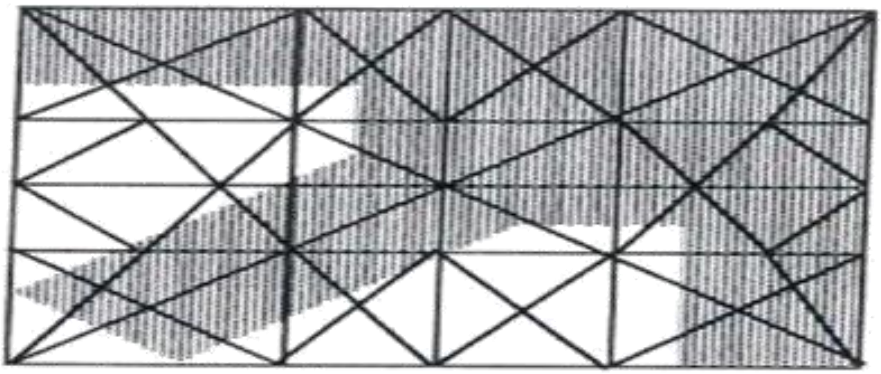
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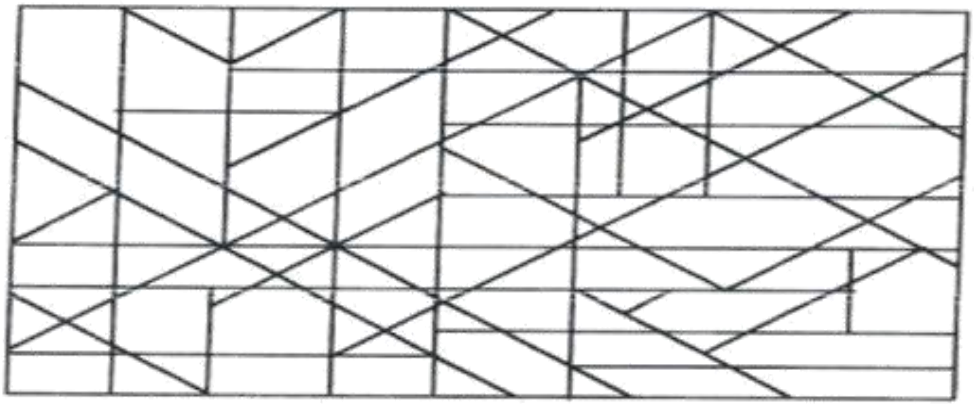
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APPENDIX VII

Item Analysis Table of GAT

S/N	Item Difficulty(p) $P = {}^{R}/_{T} * 100$	Discrimination Index $D = Ru - R_L/{}^{1}/_{2}T$	Decision
1	77	0.46	Retained
2	85	0.24	Retained
3	87	0.43	Retained
4	17	0.18	Deleted
5	80	0.24	Retained
6	60	0.39	Retained
7	97	0.12	Deleted
8	65	0.34	Retained
9	41	0.40	Retained
10	66	0.37	Retained
11	65	0.49	Retained
12	60	0.33	Retained
13	39	0.42	Retained
14	53	0.49	Retained
15	80	0.24	Retained
16	70	0.27	Retained
17	74	0.27	Retained
18	44	0.35	Retained
19	61	0.39	Retained
20	77	0.46	Retained
21	76	0.33	Retained
22	84	0.25	Retained
23	65	0.49	Retained
24	18	0.10	Deleted
25	56	0.42	Retained
26	66	0.30	Retained
27	59	0.42	Retained
28	67	0.31	Retained
29	73	0.36	Retained
30	65	0.43	Retained
31	71	0.33	Retained
32	85	0.24	Retained
33	71	0.36	Retained
34	74	0.36	Retained
35	52	0.36	Retained
36	88	0.21	Retained
37	53	0.43	Retained
38	65	0.36	Retained
39	39	0.43	Retained
40	52	0.43	Retained
41	44	0.52	Retained
42	85	0.27	Retained
43	70	0.33	Retained

44	80	0.43	Retained
45	65	0.43	Retained
46	88	0.20	Retained
47	70	0.42	Retained
48	61	0.36	Retained
49	50	0.39	Retained
50	80	0.42	Retained
51	70	0.33	Retained
52	89	0.21	Retained
53	79	0.42	Retained

APPENDIX VIII

DEPARTMENT OF SCIENCE EDUCATION
FACULTY OF EDUCATION
UNIVERSITY OF ILORIN, ILORIN, NIGERIA
Comparative Effects of Figures of Comparison on Senior School Biology Students' Achievement in Genetics in Ilorin, Nigeria

Dear Students,

These test items are prepared solely to investigate the effects of analogies and metaphors on senior secondary school students' achievement in genetics in Ilorin, Nigeria. The main focus of the test items are basic genetic terms, transmission of characters and Mendel's experiment in genetics. The instrument is divided into two sections, which are as follows:

SECTION A

Personal data of respondents

Name of School: ……
Respondent's Gender: ……..

SECTION B

Genetics Achievement Test (GAT)

This section contains of multiple-choice items on genetics prepared by the researcher following the formats of NECO and WAEC past questions. It is made up of 50 items, each containing four options A-D from which the respondents are expected to pick the right option. You are to attempt all items and each of the items carries equal mark.

1. Which of the following is the carrier of hereditary materials?
   A. centriole B. cytoplasm C. nucleolus D. chromosome
2. Which of the following statements is correct about the structure of a chromosome? A chromosome consists of:
   A. two chromatids joined at the centromere
   B. two chromatids joined at the spindle
   C. two chromatids threads joined at the centriole
   D. thread-like structures not joined together
3. Which of the following statements best explains the meaning of homologous chromosomes?
   A. product of division of chromosomes
   B. two identical chromosomes from each parent
   C.chromosomes arranged on spindle fiber during cell division
   D.chromosomes arranged on the equatorial plate of the cell
4. The outward appearance of an organism is referred to as ……
   A. phenotype B. genotype C. dominance D. recessiveness
5. The genetic make-up of an organism is described as its …….
   A. phenotype B. genotype C. character D. allele
6. In an individual who is heterozygous for a particular character, the hereditary factor that is always expressed is described as …….
   A. allele B. sickle-cell gene C. dominant gene D. chromosome
7. The gene affecting the same trait and are located at the same position on the homologous chromosomes are called ……
   A. autosomes B. alleles C. lociD. chromatid
8. Character which fails to express itself in the first filial generation but emerges in the second is ……
   A. heterozygous B. homozygous C. dominant D. recessive

9. If a black guinea pig of genotype BB, is crossed with a white guinea pig of genotype bb, what will be the phenotype of the F1 generation?
   A. half of the offspring would be black while the other half would be white
   B. all the offspring would be black
   C. all the offspring would be grey
   D. one-third of the offspring would be black white two-third would be white
10. Which of the following diseases is not hereditary?
   A. Albinism B. Scabies C.Haemophilia D. Colour blindness
11. A sudden loss of black pigment from the skin of an African can be attributed to:
   A. Blending of black and white genes B. Recombination of genes
   C. Loss of epidermis D. Mutation in the skin cells
12. In Mendel's experiments, it was discovered that the F1 generation of a cross between brown cock and a white hen were all brown because the gene for the:
   A. Brown colour was recessive B. White colour was dominant
   C. Brown colour was dominant D. White colour did not combine
13. The presence of the rhesus antigen on a Red blood cell is determined by ……
   A.Rhesus blood group B.Dominant allele C.Recessive allele D. A, B and C
14. Which of the following traits in humans can be affected by environmental factors?
   A. Skin colour B. Eye colour C. Baldness D. Tongue rolling
15. Heterozygous tall plants were crossed with pure breeding dwarf plants of the same species. What will be the approximate percentage distribution of the offspring?
   A. 100% tall, 0% dwarf B. 75% tall, 25% dwarf C. 50% tall, 50% dwarf
   D. 25% tall, 75% dwarf
16. If the pink colour of a petal is dominant over white, what would be the colour of the flower of the F1 generation when a pure pink flowered plant is crossed with a white flowered plant?
   A. Purple B. Pink C. White D. Yellow
17. If two parents are sickle cell carriers then their genotypes would be:
   A. HbAHbA and HbSHbS B. HbSHbS and HbSHbS
   C. HbAHbS and HbAHbS D. HbAHbA and HbAHbA
18. Which of the following is used to find out which plant is homozygous dominant or heterozygous?
   A. Backcross B. Test cross C. XY chromosome D. A and B
19. Which of the following is a major cause of variation among organisms?
   A.InbreedingB.Test cross C. Sexual reproduction D. Gene dominance
20. An Albino man marries a normal woman (homozygous for skin pigmentation). What is the probability that the people could have an albino child?
   A. 0% B. 0.5% C. 25% D. 60%
21. In a living cell, factors which are responsible for inheritance are located on the ……
   A. nuclear membrane B.nucleolus C.chromosomes D. nucleoplasm
22. Which of the following represents Mendel's second law of inheritance? The factors of two pairs of contrasting characters are …….
   A. dependent on each other B. on homologous chromosomes
   C. allelomorphic D. inherited independently of each other
23. In a cross involving a heterozygous red-flowered plant (Rr) and a white flowered-plant (rr). What is the probability that the offspring will be Rr?
   A. 1 B. 1⁄2 C.1⁄4 D. 3⁄4
24. If a baby is a female, her mother's ovum must have been fertilized by a sperm carrying the chromosome ……

A. X B. XY C.XX D. YY

25. Which of the following results of the cross between YyxYy is correct?
A. 2Yy : 2yyB. 1YY : 1Yy : 2yy C. 2Yy : 1yy : 1YY D. 1YY : 2Yy : 1yy

26. A yellow maize is planted and all the fruits obtained are of yellow seeds. When they are cross-bred, yellow seeds and white seeds are obtained in a ratio 3:1. The yellow seeds are said to be …….
A. non-heritable B. sex-linked C. a recessive traitD. a dominant trait

27. The heritable characters that are determined by a gene located only on the X – chromosome is …….
A. recessive B. sex-linked C. homozygous D. dominant

28. The crossing of individuals of the same species with different genetic characters is ….
A. cross breeding B. polygenic inheritance C. non-disjunction D. inbreeding

29. Mr. Andrew, his wife and child belong to blood groups A, B, and O respectively. The genotypes of both parents are:
A.I^AI^O and I^BI^B B. I^AI^A and I^BI^B C. I^AI^B and I^AI^O D. I^AI^O and I^BI^O

30. The illustration below shows a monohybrid cross for plant height where T is the allele for tallness and t for shortness, which of the following statement is not true. Plant TT x tt, with offspring Tt.
A. Both parents are homozygote B. The offspring are tall
C. All the offspring are heterozygote D. The parents are hybrid

31. The tendency of two or more genes to segregate together in a cross is known as ……
A.Co-dominance B.Incomplete dominance C. Polygenic-inheritance D.Sex-linkage

32. A pair of contrasting genes on the chromosome for expressing a pair of contrasting character is referred to as ……..
A. Hybrids B. Alleles C.Locus D. Traits

33. The hereditary material in eukaryotic cells is known as:
A. ADP B. CNS C. RNA D. DNA

34. The ratio of carrier to normal in the F1 generation derived from a parental cross of two carriers of sickle cell genes is:
A. 3:1 B. 1:3 C. 2:1 D. 1:2

35. If parents' blood groups AB and OO produce six children:
A. Three of them will have group B B. All offsprings will have group O
C. Two of them will have group A D. Four of them will have group A

36. When two heterozygous mates, the dominant trait will appear in:
A. The F1 generation only B. F2 generation only
C. Both F1 and F2 generations D. F1 generation if the gene is strong

37. Which of the following is true of the children of a haemophilic man who marries a woman that is not haemophilic and does not carry the trait?
A. All the daughters will be carriersB. All their daughters will be haemophilic
C. All their sons will be carrier D.All their sons will be haemophilic

38. Sex linked genes are located on:
A. Y-chromosomes B. X and Y-chromosomes C. Homologous chromosomes D. X-chromosomes

39. Which of the following is the best explanation for a child who is phenotypically short and born of two tall parents?
A. The father possess a gene for shortnessB. the mother possesses gene for shortness
C. Nature makes the child short D. Both parent posses' genes for shortness

40. The genotypic ratio of the offspring of the cross between two heterozygous round seed is:
A. 1:2 B. 1:2:1 C. 1:1:1:1 D. 3:1

41. Genetic constitution could be described as:
    A. Sex linkage B. Incomplete dominance C. Test cross D. Heterozygosity
42. Incomplete dominance could be described as …….
    A. Ability of two contrasting allele to interact and produce a homozygous phenotype of one of the parent
    B. Ability of two different alleles to interact and produce a heterozygous phenotype that is different from the two homozygous phenotypes
    C. Ability to produce a heterozygous phenotype of the dominant trait in the parent
    D. A and B
43. The following are the reasons for Mendel's choice of Pea plant, EXCEPT
    A. Short life span B. they have several of their traits exist in one or two forms
    C. the plant could Self pollinate itself D. Very common to buy
44. In determining the sex of a baby, a male baby is formed if:
    A. A sperm with X chromosome combined with an egg with X chromosome
    B. A sperm with Y chromosome combined with an egg with X chromosome
    C. If X chromosome in egg combines with both X and Y chromosomes in sperm
    D. A sperm with Y chromosome combined with an egg having Y chromosome
45. The following are characters that could be transmitted in human beings, EXCEPT:
    A. Intelligence B. Body structure C.Human height D. Structure of the seed
46. The F_1 of a cross between a tall and a dwarf plant was tall. The F_1 was advanced to F_2. How many of 120 F_2 plants will be dwarf?
    A. 30 B. 60 C. 90 D. 120
47. If the pink colour of a petal is dominant over white, what would be the colour of the flower of the F1 generation when a pure pink flowered plant is crossed with a white flowered plant?
    A. Purple B. Pink C. White D. Yellow
48. What characteristic is described in the statement "The dog's coat is brown"?
    A. Pedigree B. Genotype C. Phenotype D. Dominance
49. What term describes a gene with two dominant alleles that are expressed at the same time?
    A. Polygenic B. Mutational C. Codominant D. Incomplete Dominant
50. Which of the following statements best describes law of segregation?
    A. The two alleles for a gene separate when gametes are formed
    B. A species can have a variety of different alleles that code for a single characteristic
    C. The alleles of different genes separate independently from each other during the process of gamete formation
    D. Populations of a single species divided geographically will change over time to form Two separate species.

APPENDIX VIII

MARKING SCHEME

1.	D	28.	A
2.	A	29.	D
3.	B	30.	D
4.	A	31.	D
5.	B	32.	D
6.	C	33.	D
7.	B	34.	B
8.	D	35.	D
9.	B	36.	C
10.	D	37.	A
11.	B	35.	A
12.	C	36.	C
13.	A	37.	A
14.	C	38.	B
15.	C	39.	D
16.	B	40.	B
17.	C	41.	C
18.	B	42.	B
19.	D	43.	D
20.	C	44.	B
21.	A	45.	D
22.	C	46.	A
23.	D	47.	B
24.	B	48.	C
25.	A	49.	C
26.	D	50.	C
27.	D		

APPENDIX IX

LESSON PLAN FOR ANALOGY INSTRUCTIONAL STRATEGY

FIRST WEEK: INTRODUCTION TO GENETICS

Week: One

Name: SULAIMAN, Musa Mohammed

Matriculation Number: 98/25OC250

School:

Class: S.S. Three

Subject: Biology

Topic: Introduction to Genetics

Date:

Duration: 80 Minutes

Period of Lesson:

Instructional Materials: A chart showing picture of a family

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

1. Define Genetics
2. List the names of scientists that have contributed to the field of genetics.
3. Define Heredity and Variation
4. Give examples of transmittable characters in human beings
5. Give examples of transmittable characters in plants
6. Describe how characters get transmitted and behave from generation to generation
7. Define some key terms used in genetics such as gene, chromosomes, genotype, phenotype and so forth

Previous Knowledge: students are already familiar with cell structures and have been exposed to cell division

Stage	Teacher's Activities	Students' Activities	Duration
Introduction	The teacher displays the picture of a typical family and asks the students to closely look at the picture and comments	The students identify that some members of the family look alike while others look different	5 minutes

Presentation Stage 1	From the discussion with the students the teacher explains to the students that the similarities and differences noticed were as a result of the characteristics inherited by the offspring from their parents (genetics), then proceed to informing the students that the branch of biology that deals with study of inheritance and variability is called Genetics	The students listen to the teacher	3 Minutes
Stage 2	The teacher asks the students to name some prominent scientists in the field of genetics and after their responses listed out the names of some prominent biologists who had contributed to the study of genetics to include: 1. Gregor Mendel (1822-1884) often referred to as the father of genetics. His experiments served as the foundation for more studies in the field of genetics 2. Thomas Hunt Morgan (1866-1945) who was the pioneer in the use of fruit flies in the study of genetics 3. Calvin Bridges (1889-1938) also worked on fruit flies and discovered that female flies had two X chromosomes and a Y chromosome others are scientists like De Vries in Holland, Correns in Germany and Von Tschermak in Austria who discovered the phenomenon of regular, predictable ratios of the types of offspring produced by mating pure breeding parents	The students respond to the teachers' question	3 minutes
Stage 3	The teacher formally defines the term genetics as the scientific study of heredity and variation among living things. The teacher explains this by using the analogy ***Genetics is like a blue print of life***	The students ask the teacher to explain how Genetics is likened to the blue print and were informed that ***Blue prints are detailed set of action to be accomplished***	2 minutes
Stage 4	The teacher defines the terms Heredity and Variation Heredity is the transmission of inherited characters from parents to offspring via the genes while variation is the difference between individual plant or animal of the same species or the difference which exists between parents and offspring as well as among offspring. This is responsible for the similarities and the differences in organism. Variation can be defined as the differences in structure, characters and behaviour of individuals of the same species such that no two	The students also look for similar analogies that could be used to explain the concept of hereditary variation	5 minute

	individuals are exactly alike. It arises because apart from the case of identical twins, no two offspring inherit exactly the same set of characteristics from their parents ***Hereditary Variation is like an individual having different denominations of money in his/her pocket.*** An individual having these monies definitely is holding money but they are quite different both in physical structure and what they could buy		
Stage 5	The teacher lists some characters that can be transmitted in both human beings and plants Characters that can be transmitted in human beings 1. Tongue rolling 2. Colour of skin, hair and eye 3. Size of nose, head and ear 4. Height of human 5. Colour blindness 6. Intelligence and so forth The teacher further lists some examples of characters that can be transmitted in plants 1. Taste of fruit 2. Life span 3. Size of fruit, leaves, flowers 4. Shape of leaf, flower and fruits among others	The students are to list some of the characters that can be transmitted in plants and human beings	5 minutes
Stage 6	The teacher explains how characters get transmitted and behave from generation to generation Characters controlled by genes are the only ones that can be transmitted. Diploid organisms have two sets of chromosomes referred to as homologues and as such organisms have two copies of each gene, with each copy occupying identical locations or loci on the homologous chromosomes. Diploid organisms produces gametes (male = sperm; female = egg cells or ova) by meiosis. During meiosis, the number of chromosome is halved and hence the cells become haploid, containing only one copy of each gene. During sexual reproduction, the two gametes fuse to form a zygote. Each zygote is diploid as it	The students jot down some of the facts as explained by the teacher	6 minutes

	has a copy of each gene from each parent. Characters determined by genes are therefore transmitted from parents to offspring via gametes		
Stage 7	The teacher highlights key genetic terms and defines them appropriately for the students **Diploid:** This occurs when an organism has two sets of chromosome in the body cell. Diploid number is double the haploid number. It is represented by 2n. ***Analogically, this is like an individual having two pairs of shoes which are similar in design and maker, with each of the pair representing a chromosome*** **Haploid:** having a set of chromosomes that consists of one chromosome from each of the homologous pairs in a diploid organism or when an organism has one set of chromosome in the gamete. It is represented by small letter (n) **Chromosome:** distinct body in the nucleus that appears during cell division and contains the genes. ***These are rod like or thread like bodies found in the nucleus of a cell and houses the genes*** **Gene:** This is the unit responsible for transmitting hereditary traits which is a segment of the DNA molecule that codes for the synthesis of a particular protein. ***A gene is like a single page instruction book telling the body what to do.*** **Characters:** These are recognizable inheritable attributes possesed by an organism **Traits:** One or two or more possible forms of a character; a recognizable feature of an organism **Gamete:** This is a mature sex cell that takes part in reproduction and is of two types vis-à-vis the male gamete or spermatozoan (in animal) or pollen grain (in plants) and the female gamete (egg or ovum in animals) and ovules (in plants) **Locus:** This is the site for the location of a gene in a chromosome. Analogically, this is viewed as the address of the gene. ***For instance, it is like the address of the gene on a chromosome*** **Allele:*An allele is like a two page instruction book telling the body what to do***. These are the different forms of the same gene. This could be imagined as a pair of shoe in the shoebox on a shoe rack **Dominant Allele:*This is like the bully that has power and control over the other one***. Dominant traits mask the recessive traits	The students also generate other analogical terms that can be used to describe each of the genetic terminologies defined by the teacher	7 minutes

	Recessive Allele: An allele whose phenotypic expression is completely masked in heterozygotes by the presence of a dominant allele. ***This is the kid being bullied and has less power or control over the other one*** **Homozygote:** A diploid individual whose two copies of a gene are the same. In essence an individual carrying identical alleles on both homologous chromosome is said to be homozygous for the gene. ***It could be likened to identical twins*** **Heterozygote:** A diploid individual carrying two different alleles of a gene on its homologous chromosome or having different alleles for a given character at the corresponding sites on homologous chromosomes. ***This could also be viewed as fraternal twins who do not look alike*** **Genotype:** Sum total of genes present in the cells of an organism. ***This is explained analogically as the recipes for making a cake. For instance, it is like all the recipes required by the baker to make a cake*** **Phenotype:** the observable expression of the characters of an organism resulting from the interaction between the genes and the environment. ***This is like the cake produced from the recipes that are gathered together by the cake designer*** **Hybrid**: this is an offspring from a cross between parents that are genetically different but of the same species. ***This is likened to the term crossbred between two organisms of the same species***		
Recapitulation	The teacher and the students go over the lesson by laying emphasis on the major points of discussion. The teacher informs the students that they share close resemblance with their family members because they tend to share some traits with them. 1. The branch of Biology that deals with inheritance and variability is termed genetics 2. Genetics is the study of heredity and variation 3. Gregor Mendel, Thomas Morgan and so forth are some of the great scientists that have played prominent role in the field of genetics 4. Only characters controlled by genes are transmittable from generation to generation	The students listen to the teacher's explanation	4 minutes

Evaluation	The teacher evaluates the lesson to determine whether or not the objectives of the lesson have been achieved by asking the following questions 1. Define the term genetics? 2. List three people that have contributed immensely to the development of genetics as a field in Biology 3. List five transmittable characters in human beings and plants 4. Differentiate between genotype and phenotype 5. What organelle is responsible for the transmission of character from parents to offspring	The students respond to the teacher's questions	2 minutes
Assignment	The teacher gives out the following assignment 1. Differentiate between monohybrid and dihybrid inheritance	The students write down the assignment.	2 minutes

DATE:

WEEK: Two

CLASS: S. S. 3.

SUBJECT: Biology

TOPIC: Genetics

SUB-TOPIC: Mendel's work in Genetics,

PERIOD:

DURATION: 40 minutes

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

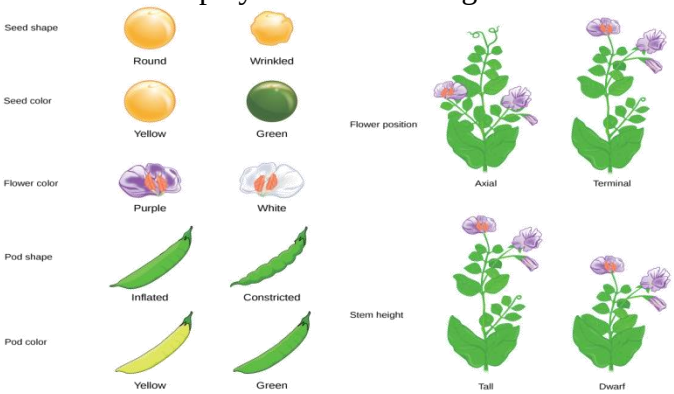
1. Describe Mendel's experiments in Genetics
2. State Mendel's Laws of Genetics
3. Explain Dihybrid and Monohybrid Inheritance
4. Make genetic crossings for Dihybrid and Monohybrid Inheritance
5. Describe the structure of the chromosome and DNA
6. Explain the relationship that exists between the chromosome, gene, and DNA
7. Describe Test cross and Back cross
8. Explain amendments to Mendelian genetics

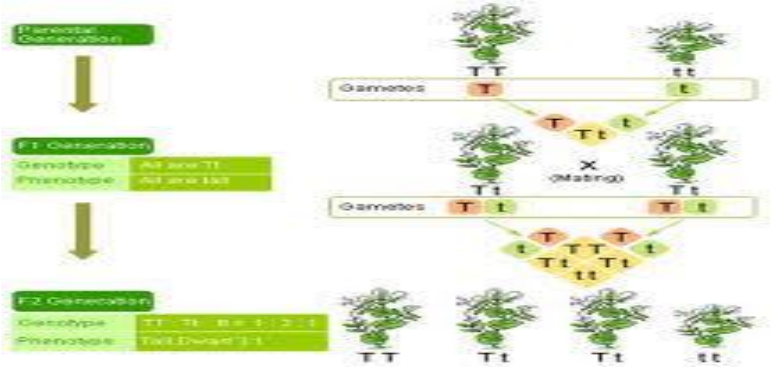
REFERENCE TEXT: Michael, M. C. (2015). *Essential Biology for Senior Secondary Schools.6th Edition*. Tonad Publishers Limited.

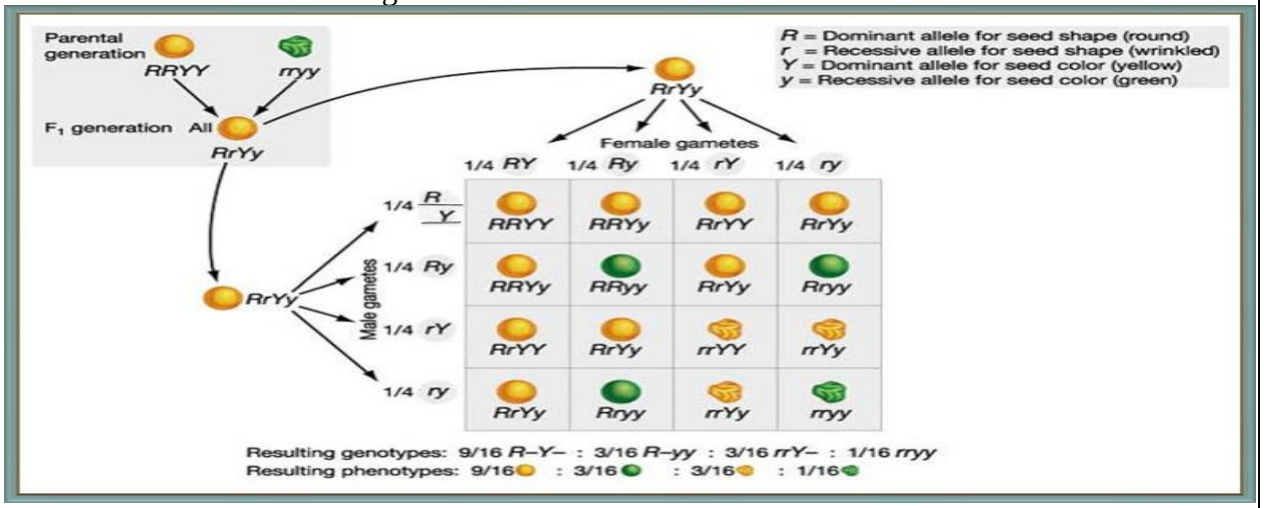
Idodo-Umeh, G. (2011). *College Biology*.Benin City: IdodoUmeh Publishers Ltd

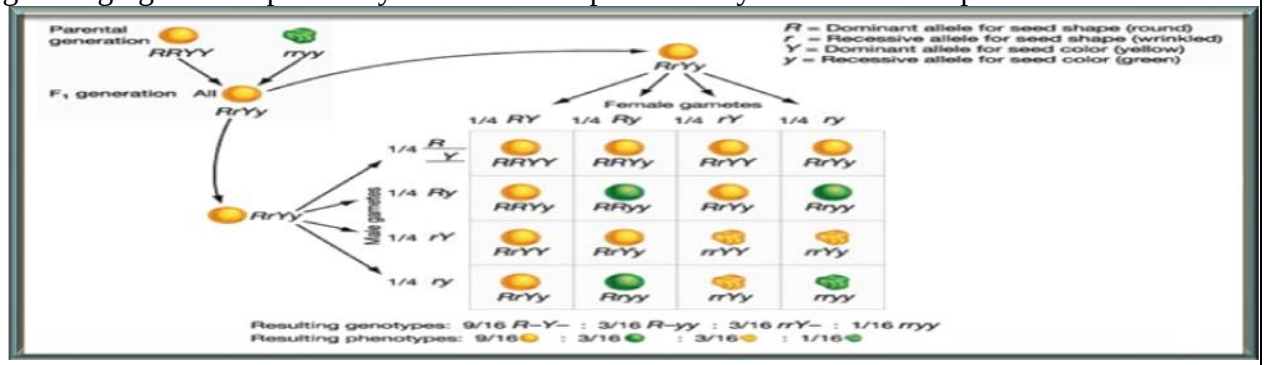
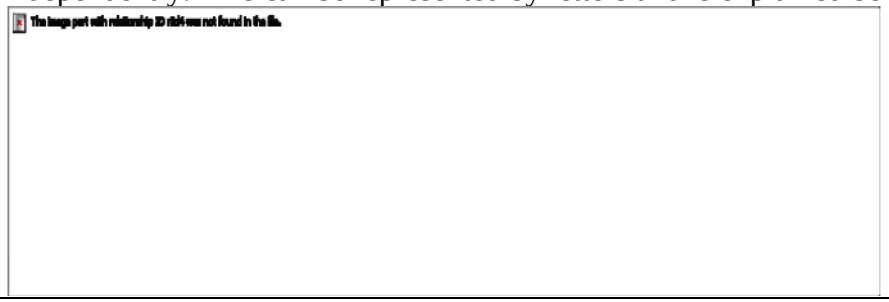
TEACHING AIDS:

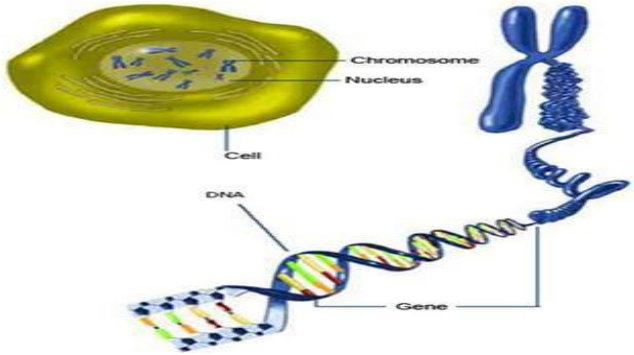
PREVIOUS KNOWLEDGE: The students have been taught sexual reproduction and transmission of characters in human.

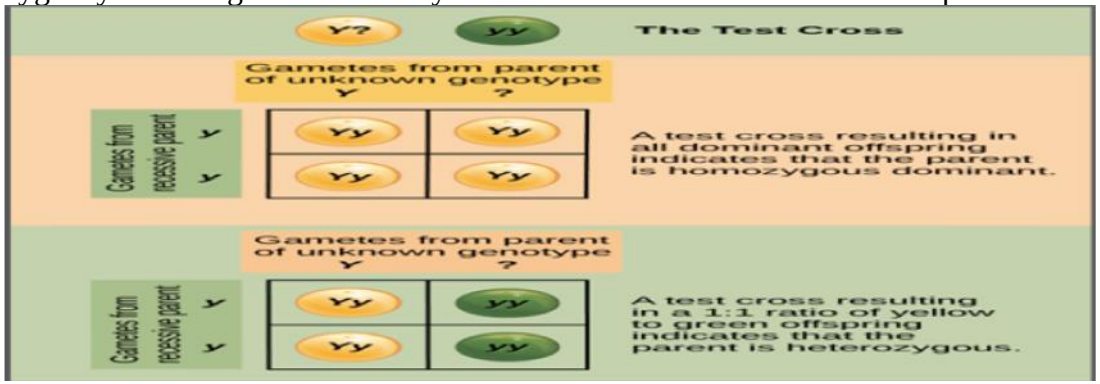
Stage	Teacher's Activities	Students' Activities	Duration
Introduction	The teacher introduces the topic by explaining Mendel's role. Mendel is often regarded as the father of genetics because his work forms the basis on which the foundation is set for heredity and variation.	The students write down the days' topic	2 minutes
Presentation Stage 1	The teacher describes Mendel's experiments Mendel carried out several experiments on how hereditary characters are transmitted from generation to generation. He carried out the experiment using Garden pea (*Pisum sativum).* Mendel chose Garden pea because of the following reasons: The teacher explains why pea plants were chosen by Mendel for his research work. Mendel chose to use pea plants because several of the traits in the plant exist in one or two forms. For instance, the seeds are either round or wrinkled, the stems are either tall or short, the pods are either smooth or rough, and flowers are either axial or terminal. Aside this, the plants also have very short life span and could self-pollinate itself. The teacher then displays a chart showing some of the stated features that made the pea plant distinct. 	The students carefully observe the chart displayed by the teacher	5 minutes
Stage 2	The teacher describes Mendel's experiments Mendel adopted the use of two methods in the course of his experiments. These methods were monohybrid and dihybrid inheritance. Monohybrid is the act of crossbreeding organisms with a single distinct characteristic, for example crossing an organism that is tall with another that is short. While, dihybrid inheritance deals with the act of crossing organisms with two distinct characters	The students listen with rapt attention to the teacher	15 minutes

	He planted tall plants for several generations and discovered that the plants were all tall plants. He did the same with short plants. This set of organisms that have been found of producing only tall and short plants respectively overtime were referred to as pure trait. Pure trait is also known as homozygous trait. He proceeded to plant tall plants and short plants. By the time the flowers were produced, the pollen grains of the tall plants tagged male were collected and pollinated with the stigma of the short plants tagged female. He also collected the pollen grains of the short plant and placed them on the stigma of the tall plant and then covered the artificially pollinated flowers with small paper bags to prevent natural pollination by insects. Mendel observed that the offspring, the first filial generation F_1 all resembled one parent and did not show any sign of the other plant. However, when he crossed the F1 plants, the F_2 generation he got were made up of tall and short plants in a ratio of 3:1. He then called this stage the Second Filial generation F2 The outcome of this experiment led to Mendel's first law of genetics  Mendel's conclusion Results obtained from the experiments enabled Mendel to propose some major theories about inheritance 1. Since the link between the parents and the offspring is the gamete, each characteristic must be represented in the gamete by something that causes its expression in the offspring. This according to Mendel is referred to as factor or germinal unit		

	2. Mendel also concluded from the offspring he got from the first filial generation that a pair of contrasting characteristics overshadowed the other. He called the characters that were shown as dominant and the ones that were not visible as recessive.		
Stage 3	The teacher explains to the students that from the conclusions, Mendel postulated two laws known as Mendel's first and second laws of genetics. Mendel's first law The law is also called law of segregation of gene (Law of purity of gamete), it states that genes are responsible for the development of the individual and they are transmitted independently from one generation to another without undergoing any alteration. ***This is explained using the analogy of throwing a linked dice that alleles are passed randomly by chance through gametes from parents to offspring just as an individual playing a dice game is having equal chances of throwing any of the numbers on a dice. i.e there is 50:50 chance***	The students listen attentively to the teacher and also jot down important points	4 minutes
Stage 4	The teacher further describes Dihybrid Inheritance, which led to Mendel's second law of Genetics. This is the crossing of organisms with two contrasting characters. For example, Mendel carried out various experiments in which he crossed plants which differed in two pairs of contrasting characters such as seed shape and seed colour. This he called dihybrid inheritance, from where he formulated the second law of genetics  **Figure 4 Dihybrid Cross**	The students study the chart displayed by the teacher to illustrate dihybrid cross	5 minutes

Stage 5	The teacher states Mendel's second law of Genetics (Law of Independent Assortment of Genes) The law states that each character behaves as a separate unit and it is inherited independently of each other. For example, during gamete formation, the alleles of each gene segregate independently. For instance, they will not influence one another (i. e. mix and match with alleles for other characters). Invariably, the law holds that during gamete formation, the allele of each gene segregates independently. This can be represented by letters and is explained below  ***Analogically, this can be likened with passing instructional manuals to the children independently of one another from the list of numerous manuals that could be used to build different machines***	The students also generate analogies that can be used to explain the law	5 Minutes
Step 5	The teacher states Mendel's second law of Genetics (law of independent assortment of genes) The law states that each character behaves as a separate unit and is inherited independently of each other. For example, during gamete formation, the alleles of each gene segregate independently. They will not influence one another (i. e. mix and match with alleles for other characters). Invariably, the law holds that during gamete formation, the allele of each gene segregates independently. This can be represented by letters and is explained below 	The students list some of the analogies generated	4 Minutes

	The law refers to the fact that organisms contain different kinds of genes. For instance we have genes for skin colour, shape of the ears, nose and so forth that will eventually separate and recombine independently or unconnected with other genes.		
Step 6	The teacher describes the structures of the Chromosome and DNA Chromosomes are rod like or thread like bodies found in the nucleus of the cell. They appear at the beginning of cell division as cell division progresses Chromosomes are located in sex organs of the body, and all organisms of the same species have the same number of chromosomes in each body cell. In human beings, there are naturally 46 chromosomes which occur as 23 pairs. Each chromosome of a pair occupies the same position as and is similar in shape and size to the other. Each pair is therefore called homologous chromosome. There are basically two types of chromosomes namely: i. Sex chromosome ii. autosomes Each chromosome is made up of protein units with a strand of DNA round them. Along its length are genes which are actually DNA segments.		5 minutes
Step 7	The teacher discusses the relationship that exist between the cell, chromosome, gene, and DNA To illustrate the relationship between the cell, chromosome and DNA, the teacher displays a pictorial analogy of the link  ***Using the cell city analogy, the cell is regarded as a city. In the city, we have the city hall which represents the nucleus of the cell and controls most of the cells activity by sending out information that it needs to function. The DNA represents a single house on a street, while the gene would equal a whole street of houses, and the chromosome is all the streets in a neighborhood which are found in the city.***	The students listen to the teacher and write down the basic relationship which exists among the nucleus, chromosomes, genes, and DNA	6 minutes

Step 8	The teacher explains the concepts of test cross and back cross Test cross is the act of breeding dominant phenotype with its recessive phenotype in order to determine the zygosity of the dominant phenotype Zygosity is the degree of similarity between two alleles that determines a particular trait.  Back cross is defined as the act of breeding an F1 hybrid with one of the two parents. Breeding an F1 with the homozygous dominant, produces a 100% dominant phenotype, while if the F1 is breed with a recessive phenotype, the offspring produces 50% dominant and 50% recessive phenotype ***Analogically the concept of test cross could be likened to mating one's Alsatian dog with another Alsatian dog in the neighbourhood that is not related to the dog in order to determine its zygosity while Back cross is likened to allowing one's Alsatian dog to mate the mother***		
Evaluation	The teacher evaluates the lesson by asking the students the following questions. 1. Describe Mendel's experiments in Genetics 2. State the two Mendel's laws of genetics 3. Distinguish between Monohybrid and Dihybrid inheritance 4. Differentiate between test cross and back cross	The students respond to the teacher's question appropriately	4 Minutes
Assignment	The teacher gives out assignments to the students as follows: 1. Using annotated diagram, show the relationship existing between the cell nucleus, chromosomes, genes and the DNA	The students write down the assignment question	2 Minutes

DATE:

WEEK: Three

CLASS: S. S. 3.

SUBJECT: Biology

TOPIC: Genetics

SUB-TOPIC: Beyond Mendelian Heredity (Polygenic Inheritance, Co dominance, Incomplete Dominance) and Sex Determination in Human.

PERIOD:

DURATION: 40 minutes

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

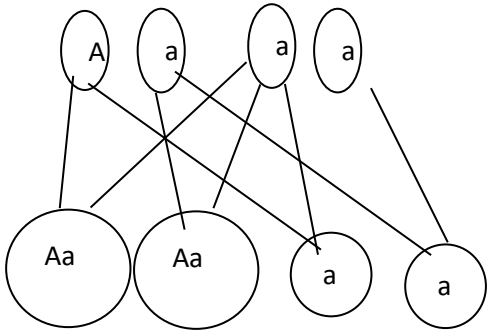
1. Describe Polygenic inheritance
2. Describe Incomplete dominance
3. Describe Co dominance
4. Describe how sex is determined in Human beings
5. Define probability in Genetics
6. Explain how probability can be applied to the formation of gametes
7. Describe application of probability to the formation of offspring in Humans

REFERENCE TEXT: Michael, M. C. (2015). *Essential Biology for Senior Secondary Schools*.6th Edition. Tonad Publishers Limited.

TEACHING AIDS:

PREVIOUS KNOWLEDGE: The students have been taught Mendel's laws and transmission of characters in human.

Stage	Teacher's Activities	Students' Activities	Duration
Introduction	The teacher asks the students to explain dominant traits and recessive traits	The students gave different definitions for the concepts	2 minutes
Presentation Stage 1	The teacher introduces the days topics and explain the concepts of polygenic inheritance, incomplete dominance, and co-dominance Polygenic Inheritance: When several genes affect a character, it is called a polygenic character. For instance, several characters in human being such as eye colour, height, skin colour and so forth are polygenic in nature The teacher defines the concept "incomplete dominance" this is ability of two contrasting alleles to interact and produce a heterozygous phenotype that is different from the two homozygous phenotypes. Example is found in four 'o' clock plant and Mirabilis Jalapa. ***Analogically this is likened to the mixing of white paint with red paint to produce pink coloured paint.*** The teacher also defines Co dominance as a condition in which both alleles for the same gene are fully expressed. For instance a person having an allele I^A and I^B will have both alleles being expressed as I^AI^B which means that both alleles are fully expressed and neither of the allele is dominant over the other. ***Analogically, this can be likened to trade by batter between two traders in which both trader exchange goods in equal value without any of the trader exploiting each other.***	The students were asked to generate different analogy that can be used to explain the concepts	5 minutes
Step 2	The teacher explains sex determination in human beings. In human beings, there are 23 pairs of homologous chromosomes in each body cell. Of these, 22 pairs are called autosomes and have no direct effect on the sex of the individual. One pair is directly concerned with sex determination. This one pair is referred to as sex chromosomes. In the male, the two sex chromosomes in each body cell are called X and Y-chromosomes. Each male gamete carries either an X or a Y chromosome. In the female, all the cells of the body contain one X chromosome each. At fertilization, the combination of an egg with a sperm carrying either an X or a Y chromosome occurs by chance. The chances of an egg combining with either of the two types of sperms are equal. When a sperm with an X chromosome combines with an egg having X chromosome, the zygote has two X chromosomes and forms a female baby. But if a sperm with a Y chromosome fuses with an egg, the zygote has X and Y-chromosomes and form a male baby.		

Step 3	The teacher defines probability in Genetics Probability is a branch of Mathematics, which can be applied to those events that depend entirely on chance. Probability is usually expressed in units ranging from 0-1. Mendel's works are based on probability.		
Step 4	The teacher explains the application of probability to the formation of gametes. Suppose an organism has a genotype AA, what kind of gametes will it produce and in what proportion? Since only one of the pairs of chromosome get segregated during meiosis, the probable gamete produced from the AA parent is A ½ and ½ A. If the parent is heterozygous (A) (a), the probable gamete will be ½ A and ½ a.		
Step 5	The teacher explains the application of probability to the formation of offspring in Humans. Suppose a male carrier of the albino gene marries a female albino, what is the probability of them having an albino child. The male is heterozygous (Aa), and the female is homozygous recessive (aa) Parents Aa aa Gamete Offspring 		
Evaluation	The probability is that ½ of the offspring will be albino while ½ of them will be heterozygous The teacher asks the students the following questions. Describe Incomplete dominance Describe how sex is determined in Human beings Define probability in Genetics		
Summary	The teacher briefly goes over the topic by answering the questions above with the students.		

Assignment	What is the probability that an individual with genotype Tt will produce a gamete with T gene?		

APPENDIX X

LESSON PLAN FOR METAPHOR INSTRUCTIONAL STRATEGY

FIRST WEEK: INTRODUCTION TO GENETICS

Week: One

Name: SULAIMAN, Musa Mohammed

Matriculation Number: 98/25OC250

School:

Class: S.S. Three

Subject: Biology

Topic: Introduction to Genetics

Date:

Duration: 80 Minutes

Period of Lesson:

Instructional Materials: A chart showing picture of a family

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

1. Define Genetics
2. List the names of scientists that have contributed to the field of genetics.
3. Define Heredity and Variation
4. Give examples of transmittable characters in human beings
5. Give examples of transmittable characters in plants
6. Describe how characters get transmitted and behave from generation to generation
7. Define some key terms used in genetics

Previous Knowledge: students are already familiar with cell structures and have been exposed to cell division

Stage	Teacher's Activities	Students' Activities	Duration
Introduction	The teacher displays the picture of a typical family and asked the students to closely look at the picture and comments	The students identify that some members of the family look alike while others look different	5 minutes

Presentation Stage 1	From the discussion with the students based on their observations on the displayed chart, the teacher formally introduces the topic for the day by explaining to the students that similarities and differences exist between living things and that this is brought about by the characteristics inherited by the offspring from their parents The teacher then proceeds in informing the students that the branch of biology that deals with the study of inheritance and variability is genetics. The state of being different from one another is known as variability, while the transmission of characteristics from parents to offspring is known as heredity.	The students listen to the teacher	3 Minutes
Stage 2	The teacher asks the students to name some prominent scientist in the field of genetics and after their responses listed out the names of some prominent biologists who had contributed to the study of genetics to include: 1. Gregor Mendel (1822-1884) often referred to as the father of genetics. His experiments served as the foundation for more studies in the field of genetics 2. Thomas Hunt Morgan (1866-1945) who was the pioneer in the use of fruit flies in the study of genetics 3. Calvin Bridges (1889-1938) also worked on fruit flies and discovered that female flies had two X chromosomes and a Y chromosome others are scientists like De Vries in Holland, Correns in Germany and Von Tschermak in Austria who discovered the phenomenon of regular, predictable ratios of the types of offspring produced by mating pure breeding parents	The students respond to the teachers' question	3 minutes
Stage 3	The teacher formally defines the term genetics as the scientific study of heredity and variation among living things. The teacher explains this by using the Metaphor ***Genetics is the study of biological communication between generations using the hereditary factors.***	The students were able to relate communication between them and their peers with how information are passed across generation via genes	2 minutes
Stage 4	The teacher defines the terms Heredity and Variation Heredity is the transmission of inherited characters from parents to offspring via the genes while variation is the difference between individual plant or animal of	The students also try to look for similar analogies that could be used to	5 minute

	the same species or the difference which exists between parents and offspring as well as among offspring. Variation can be defined as the differences in structure, characters and behavior of individuals of the same species such that no two individuals are exactly alike. This is responsible for the similarities and the differences in organism. Heredity variation arises because apart from the case of identical twins, no two offspring inherit exactly the same set of characteristics from their parents ***Hereditary Variation is explained with the metaphor "Mathew had different denominations of money in his pocket.*** An individual having these monies definitely is holding money but they are quite different both in physical structure and what they could buy	explain the concept of hereditary variation	
Stage 5	The teacher listed some characters that can be transmitted in both human beings and plants Characters that can be transmitted in human beings 1. Tongue rolling 2. Colour of skin, hair and eye 3. Size of nose, head and ear 4. Height of human 5. Colour blindness 6. Intelligence and so forth The teacher further listed some examples of characters that can be transmitted in plants 1. Taste of fruit 2. Life span 3. Size of fruit, leaves, flowers 4. Shape of leaf, flower and fruits among others	The students are also asked to list some of the characters that can be transmitted in plants and human beings	5 minutes
Stage 6	The teacher explain how characters get transmitted and behave from generation to generation Characters controlled by genes are the only ones that can be transmitted. Diploid organisms have two sets of chromosomes referred to as homologues and as such organisms have two copies of each gene, with each copy occupying identical locations or loci on the homologous chromosomes.	The students jot down some of the facts as explained by the teacher	6 minutes

	Diploid organisms produces gametes (male = sperm; female = egg cells or ova) by meiosis. During meiosis, the number of chromosome is halved and hence the cells become haploid, containing only one copy of each gene. During sexual reproduction, the two gametes fuse to form a zygote. Each zygote is diploid as it has a copy of each gene from each parent. Characters determined by genes are therefore transmitted from parents to offspring via gametes		
Stage 7	The teacher highlights key genetic terms and defines them appropriately for the students **Diploid:** This occurs when an organism has two sets of chromosome in the body cell. Diploid number is double the haploid number. It is represented by 2n. ***Metaphor: Amina has two pairs of shoes which are similar in design and maker with each of the pair representing a chromosome*** **Haploid:** having a set of chromosomes that consist of one chromosome from each of the homologous pairs in a diploid organism or when an organism has one set of chromosome in the gamete. It is represented by small letter (n) ***Metaphor: Segun wore a pair of shoe with different designs to the school*** **Chromosome:** distinct body in the nucleus that appears during cell division and contains the genes and is responsible for the transmission of characters from generation to generation ***Metaphor:*** This is a rod like or thread like body in the nucleus of a cell that houses the genes. ***The chromosome is the city auditor that stores all the records of the city and passes them on as the city grow*** **Gene:** this is the unit responsible for transmitting hereditary traits which is a segment of the DNA molecule that codes for the synthesis of a particular protein. ***Metaphor:A gene is a single note in a music which can be played in different variation or harmony but still end up providing a tune that is the same.*** **Characters or Traits:** These are the inheritable attributes possess by an organism **Gamete:** this is a mature sex cell that takes part in reproduction and is of two types vis-à-vis the male gamete or spermatozoan (in animal) or pollen grain (in plants) and the female gamete (egg or ovum in animals) and ovules (in plants) **Locus:** this is the site for the location of a gene in a chromosome.	The students also generate other analogical terms that can be used to describe each of the genetic terminologies defined by the teacher	7 minutes

	Metaphor: this is the address of the gene on a chromosome **Allele:** These are the different forms of the same gene. ***Metaphor:an allele is a two page instruction book telling the body what to do.*** **Dominant Allele:** this is like the bully that has power and control over the other one. Dominant traits mask the recessive traits **Recessive Allele:** An allele whose phenotypic expression is completely masked in heterozygotes by the presence of a dominant allele. ***Metaphor:Amina performed excellently well that the jurors failed to appreciate the effort put up by Jide in his presentation. In other word, Amina's success over shadowed Jides effort in an event, thereby masking Jide's effort*** Allele is the version of the instructional manual an individual has. It has two versions which mean you always have two copies. If the copies are the same (homozygous) if different (heterozygous) **Homozygote:** A diploid individual whose two copies of a gene are the same. In essence an individual carrying identical alleles on both homologous chromosome is said to be homozygous for the gene. ***Metaphor: John and Joseph are identical twins*** **Heterozygote:** A diploid individual carrying two different alleles of a gene on its homologous chromosome or having different alleles for a given character at the corresponding sites on homologous chromosomes. ***Metaphor:The boys are fraternal twins and do not look alike*** **Genotype:** Sum total of genes present in the cells of an organism. This is explained analogically as the recipes for making a cake. ***Metaphor:*** Genotypes is explained as the genetic make-up or constitution of an individual or the genetic complement of an individual (Genetic coding) ***This is the actual text within the manual and the phenotype is the physical machine that the manual helps to build*** **Phenotype:** the observable expression of the characters of an organism resulting from the interaction between the genes and the environment. ***Metaphor: This is the machine manufacture from the instructional manualorthe cake produced from the recipes gathered by the cake designer***		

	Hybrid: This is an offspring from a cross between two organisms of the same species ***Metaphor: Leon Balogun is an half cast***		
Recapitulation	The teacher and the students go over the lesson by laying emphasis on the major points of discussion. The teacher informs the students that they share close resemblance with their family members because they tend to share some traits with them. 1. The branch of Biology that deals with inheritance and variability is termed genetics 2. Genetics is the study of heredity and variation 3. Gregor Mendel, Thomas Morgan and so forth are some of the great scientists that have played prominent role in the field of genetics 4. Only characters controlled by genes are transmittable from generation to generation	The students listen to the teacher's explanation	4 minutes
Evaluation	The teacher evaluates the lesson to determine whether or not the objectives of the lesson have been achieved by asking the following questions 1. Define the term genetics? 2. List three people that have contributed immensely to the development of genetics as a field in Biology 3. List five transmittable characters in human beings and plants 4. Differentiate between genotype and phenotype 5. What organelle is responsible for the transmission of character from parents to offspring	The students respond to the teacher's questions	2 minutes
Assignment	The teacher gives out the following assignment 1. Differentiate between monohybrid and dihybrid inheritance	The students write down the assignment	2 minutes

DATE:

WEEK: Two

CLASS: S. S. 3.

SUBJECT: Biology

TOPIC: Genetics

SUB-TOPIC: Mendel's work in Genetics,

PERIOD:

DURATION: 40 minutes

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

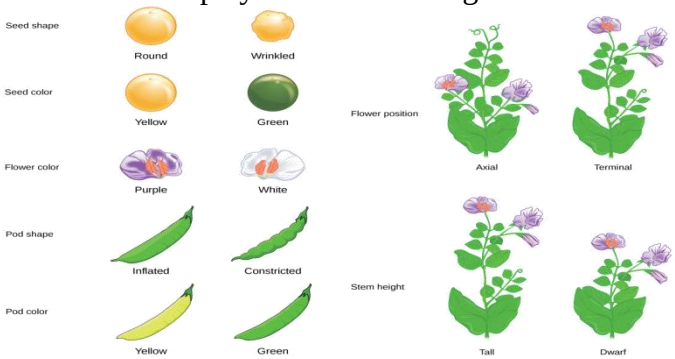
1. Describe Mendel's experiments in Genetics
2. State Mendel's Laws of Genetics
3. Explain Dihybrid and Monohybrid Inheritance
4. Make genetic crossings for Dihybrid and Monohybrid Inheritance
5. Describe the structure of the chromosome and DNA
6. Explain the relationship that exists between the chromosome, gene, and DNA
7. Describe Test cross and Back cross
8. Explain amendments to Mendelian genetics

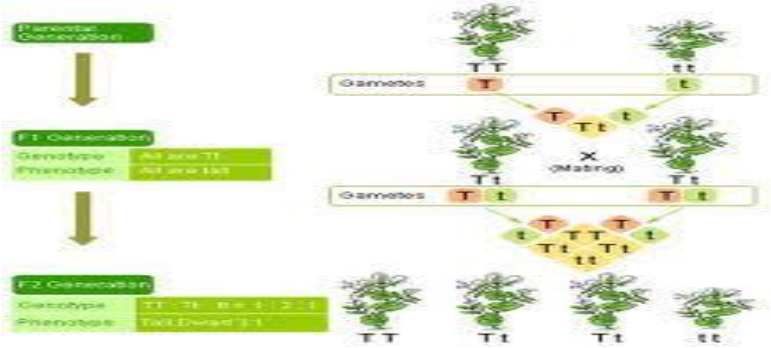
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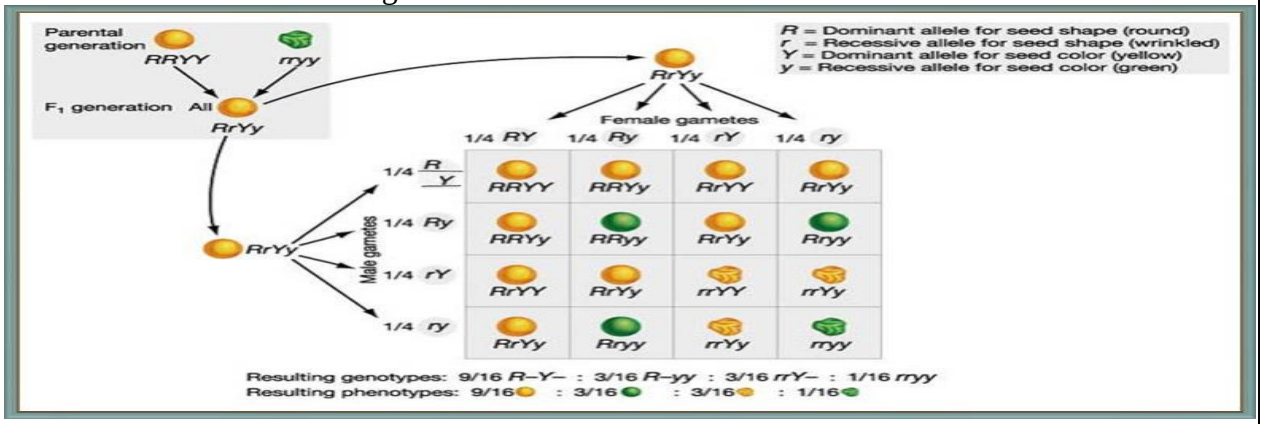
Idodo-Umeh, G. (2011). *College Biology*.Benin City: IdodoUmeh Publishers Ltd

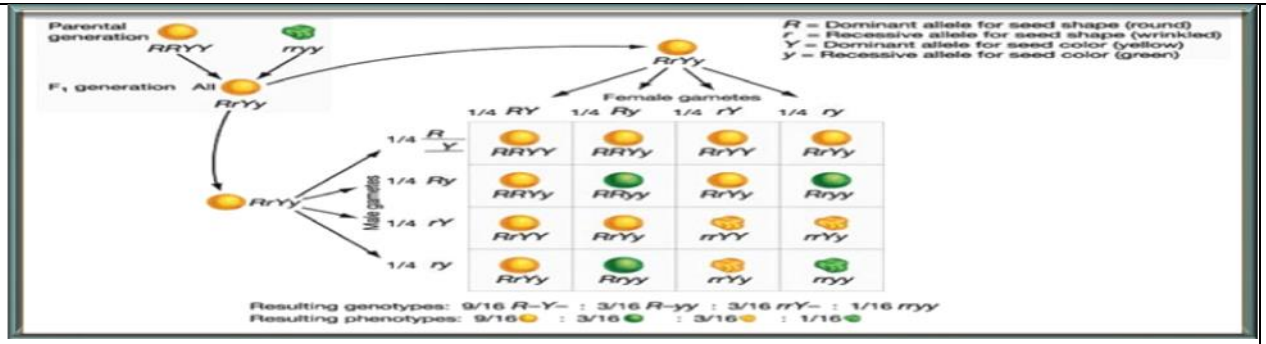
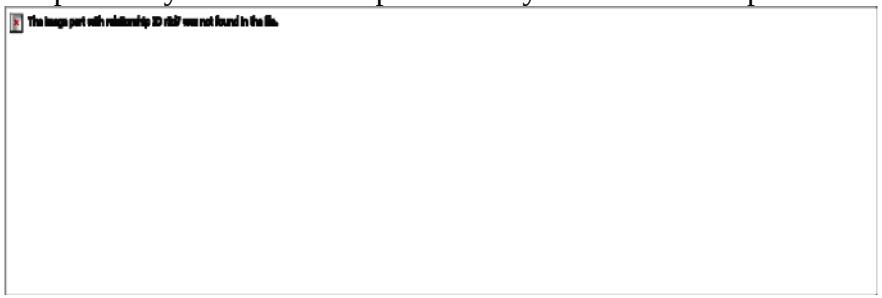
TEACHING AIDS:

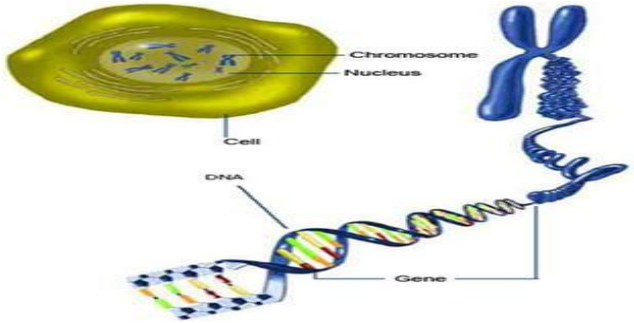
PREVIOUS KNOWLEDGE: The students have been taught sexual reproduction and transmission of characters in human.

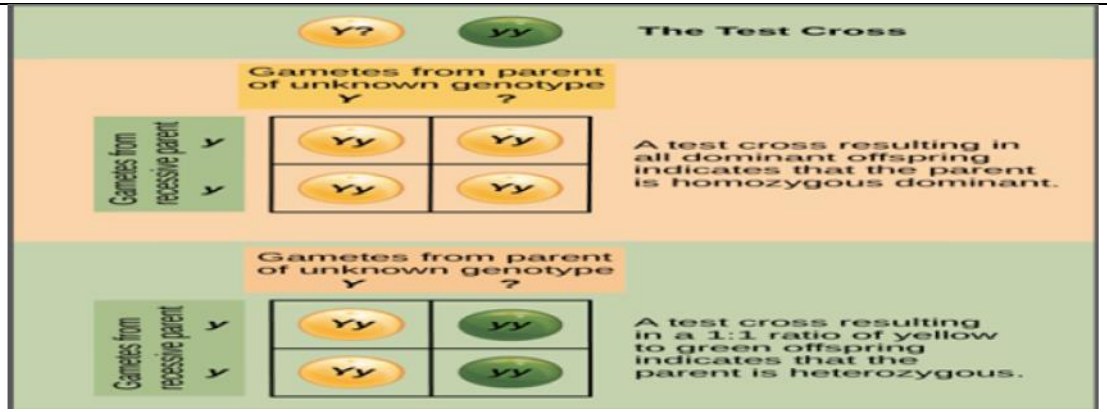
Stage	Teacher's Activities	Students' Activities	Duration
Introduction	The teacher introduces the topic by explaining Mendel's role. Mendel is often regarded as the father of genetics because his work forms the basis on which the foundation is set for heredity and variation.	The students write down the days' topic	2 minutes
Presentation Stage 1	The teacher describes Mendel's experiments Mendel carried out several experiments on how hereditary characters are transmitted from generation to generation. He carried out the experiment using Garden pea (*Pisum sativum).* Mendel chose Garden pea because of the following reasons: The teacher explains why pea plants were chosen by Mendel for his research work. Mendel chose to use pea plants because several of the traits in the plant exist in one or two forms. For instance, the seeds are either round or wrinkled, the stems are either tall or short, the pods are either smooth or rough, and flowers are either axial or terminal. Aside this, the plants also have very short life span and could self-pollinate itself. The teacher then displays a chart showing some of the stated features that made the pea plant distinct. 	The students carefully observe the chart displayed by the teacher	5 minutes
Stage 2	The teacher describes Mendel's experiments Mendel adopted the use of two methods in the course of his experiments. These methods were monohybrid and dihybrid inheritance. Monohybrid is the act of crossbreeding organisms with a single distinct characteristic, for example crossing an organism that is tall with another that is short. While, dihybrid inheritance deals with the act of crossing organisms with two distinct characters He planted tall plants for several generations and discovered that the plants were all tall plants. He did the same with short plants. This set of organisms that have been found of producing	The students listen with rapt attention to the teacher	15 minutes

	only tall and short plants respectively overtime were referred to as pure trait. Pure trait is also known as homozygous trait. He proceeded to plant tall plants and short plants. By the time the flowers were produced, the pollen grains of the tall plants tagged male were collected and pollinated with the stigma of the short plants tagged female. He also collected the pollen grains of the short plant and placed them on the stigma of the tall plant and then covered the artificially pollinated flowers with small paper bags to prevent natural pollination by insects. Mendel observed that the offspring, the first filial generation F_1 all resembled one parent and did not show any sign of the other plant. However, when he crossed the F1 plants, the F_2 generation he got were made up of tall and short plants in a ratio of 3:1. He then called this stage the Second Filial generation F2 The outcome of this experiment led to Mendel's first law of genetics  Mendel's conclusion Results obtained from the experiments enabled Mendel to propose some major theories about inheritance 3. Since the link between the parents and the offspring is the gamete, each characteristic must be represented in the gamete by something that causes its expression in the offspring. This according to Mendel is referred to as factor or germinal unit 4. Mendel also concluded from the offspring he got from the first filial generation that a pair of contrasting characteristics overshadowed the other. He called the characters that were shown as dominant and the ones that were not visible as recessive.		
Stage 3	The teacher explains to the students that from the conclusions, Mendel postulated two laws known as Mendel's first and second laws of genetics.	The students listenattentively to	4 minutes

	Mendel's first law The law is also called law of segregation of gene (Law of purity of gamete), it states that genes are responsible for the development of the individual and they are transmitted independently from one generation to another without undergoing any alteration. The law ensures that each allele always has an equal chance of being passed from generation to generation irrespective of whether the allele is dominant or recessive ***Metaphorically, Amina and Jide in a dice game has equal chances of throwing either numbers that are similar or different from the dices that are not mandated to turn in any specified number***	the teacher and also jot down important points	
Stage 4	The teacher further described Dihybrid Inheritance, which led to Mendel's second law of Genetics. This is the crossing of organisms with two contrasting characters. For example, Mendel carried out various experiments in which he crossed plants which differed in two pairs of contrasting characters such as seed shape and seed colour. This he called dihybrid inheritance, from where he formulated the second law of genetics  **Figure 5 Dihybrid Cross**	The students study the chart displayed by the teacher to illustrate dihybrid cross	5 minutes
Stage 5	The teacher states Mendel's second law of Genetics (Law of Independent Assortment of Genes) The law states that each character behaves as a separate unit and it is inherited independently of each other. For example, during gamete formation, the alleles of each gene segregate independently. For instance, they will not influence one another (i. e. mix and match with alleles for other characters). Invariably, the law holds that during gamete formation, the allele of each gene segregates independently. This can be represented by letters and is explained below	The students also generate metaphors that can be used to explain the law	5 Minutes

	 ***Metaphor: The Chief Executive passed instructional manuals to the different units in the organisation independently of one another from the list of numerous manuals that could be used to build different machines***		
Step 5	The teacher states Mendel's second law of Genetics (law of independent assortment of genes) The law states that each character behaves as a separate unit and is inherited independently of each other. For example, during gamete formation, the alleles of each gene segregate independently. They will not influence one another (i. e. mix and match with alleles for other characters). Invariably, the law holds that during gamete formation, the allele of each gene segregates independently. This can be represented by letters and is explained below  The law refers to the fact that organisms contain different kinds of genes. For instance we have genes for skin colour, shape of the ears, nose and so forth that will eventually separate and recombine independently or unconnected with other genes.	The students listsome of the metaphors generated	4 Minutes
Step 6	The teacher describes the structures of the Chromosome and DNA Chromosomes are rod like or thread like bodies found in the nucleus of the cell. They appear at the beginning of cell division as cell division progresses		5 minutes

	Chromosomes are located in sex organs of the body, and all organisms of the same species have the same number of chromosomes in each body cell. In human beings, there are naturally 46 chromosomes which occur as 23 pairs. Each chromosome of a pair occupies the same position as and is similar in shape and size to the other. Each pair is therefore called homologous chromosome. There are basically two types of chromosomes namely: iii. Sex chromosome iv. autosomes Each chromosome is made up of protein units with a strand of DNA round them. Along its length are genes which are actually DNA segments.		
Step 7	The teacher discusses the relationship that exist between the cell, chromosome, gene, and DNA To illustrate the relationship between the cell, chromosome and DNA, the teacher displays a pictorial analogy of the link  ***Using the cell city metaphor, the cell is regarded as a city. In the city, we have the city hall which represents the nucleus of the cell and controls most of the cells activity by sending out information that it needs to function. The DNA represents a single house on a street, while the gene would equal a whole street of houses, and the chromosome is all the streets in a neighborhood which are found in the city.***	The students listen to the teacher and write down the basic relationship which exists among the nucleus, chromosomes, genes, and DNA	6 minutes
Step 8	The teacher explains the concepts of test cross and back cross Test cross is the act of breeding dominant phenotype with its recessive phenotype in order to determine the zygosity of the dominant phenotype Zygosity is the degree of similarity between two alleles that determines a particular trait.		

	 Back cross is defined as the act of breeding an F1 hybrid with one of the two parents. Breeding an F1 with the homozygous dominant, produces a 100% dominant phenotype, while if the F1 is breed with a recessive phenotype, the offspring produces 50% dominant and 50% recessive phenotype ***Metaphorically the concept of test cross could be likened to mating one's Alsatian dog mating with another Alsatian dog in the neighbourhood that is not related to the dog in order to determine its zygosity while Back cross is like allowing one's Alsatian dog to mate the mother***		
Evaluation	The teacher evaluates the lesson by asking the students the following questions. 5. Describe Mendel's experiments in Genetics 6. State the two Mendel's laws of genetics 7. Distinguish between Monohybrid and Dihybrid inheritance 8. Differentiate between test cross and back cross	The students respond to the teacher's question appropriately	4 Minutes
Assignment	The teacher gives out assignments to the students as follows: 2. Using annotated diagram, show the relationship existing between the cell nucleus, chromosomes, genes and the DNA	The students write down the assignment question	2 Minutes

DATE:

WEEK: Three

CLASS: S. S. 3.

SUBJECT: Biology

TOPIC: Genetics

SUB-TOPIC: Beyond Mendelian Heredity (Polygenic Inheritance, Co-dominance, Incomplete Dominance) and Sex Determination in Human.

PERIOD:

DURATION: 40 minutes

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

1. Describe Polygenic inheritance
2. Describe Incomplete dominance
3. Describe Co-dominance
4. Describe how sex is determined in Human beings
5. Define probability in Genetics
6. Explain how probability can be applied to the formation of gametes
7. Describe application of probability to the formation of offspring in Humans

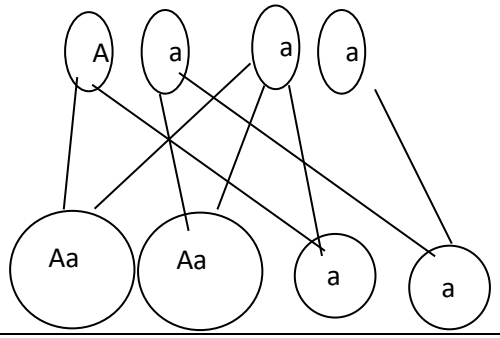
REFERENCE TEXT: Michael, M. C. (2015). *Essential Biology for Senior Secondary Schools*.6th Edition. Tonad Publishers Limited.

TEACHING AIDS:

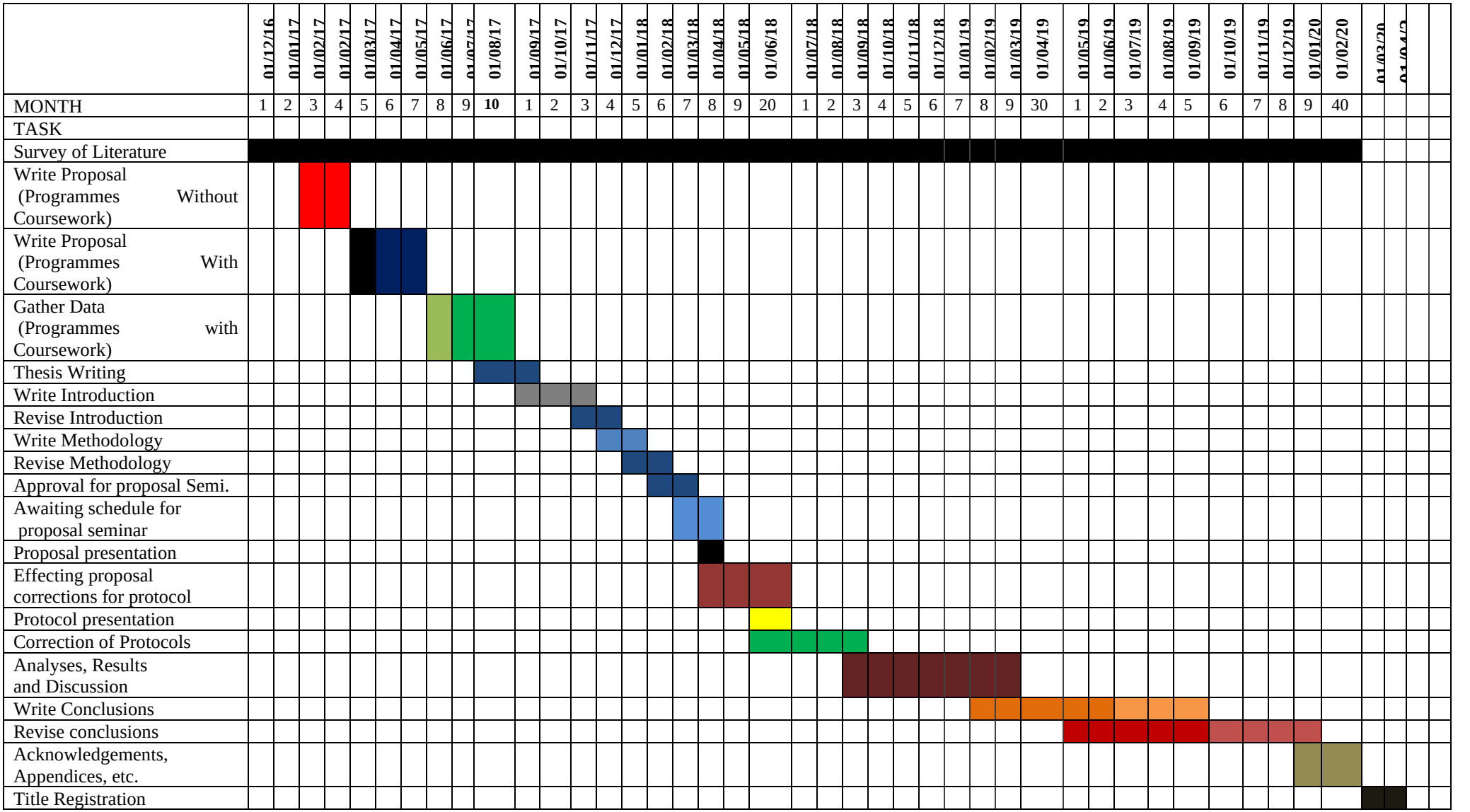
PREVIOUS KNOWLEDGE: The students have been taught Mendel's laws and transmission of characters in human.

Stage	Teacher's Activities	Students' Activities	Duration
Introduction	The teacher asks the students to explain dominant traits and recessive traits	The students gave different definitions for the concepts	2 minutes

Presentation Stage 1	The teacher introduces the days topics and explain the concepts of polygenic inheritance, incomplete dominance, and co-dominance Polygenic Inheritance: When several genes affect a character, it is called a polygenic character. For instance, several characters in human being such as eye colour, height, skin colour and so forth are polygenic in nature The teacher defines the concept "incomplete dominance" this is ability of two contrasting alleles to interact and produce a heterozygous phenotype that is different from the two homozygous phenotypes. Example is found in four 'o' clock plant and Mirabilis Jalapa. ***Metaphor: Segun and Amina mixed two primary colours to get a secondary colour.*** The teacher also defines Co dominance as a condition in which both alleles for the same gene are fully expressed. For instance a person having an allele I^A and I^B will have both alleles being expressed as I^AI^B which means that both alleles are fully expressed and neither of the allele is dominant over the other. ***Metaphor: the farmer and the fisher man conducted trade by batter in which the farmer gave part of his farm produce to the fisher man in exchange for some fishes***	The students were attentive and also generate different metaphors to explain the concepts	5 minutes
Step 2	The teacher explains sex determination in human beings. In human beings, there are 23 pairs of homologous chromosomes in each body cell. Of these, 22 pairs are called autosomes and have no direct effect on the sex of the individual. One pair is directly concerned with sex determination. This one pair is referred to as sex chromosomes. In the male, the two sex chromosomes in each body cell are called X and Y-chromosomes. Each male gamete carries either an X or a Y chromosome. In the female, all the cells of the body contain one X chromosome each. At fertilization, the combination of an egg with a sperm carrying either an X or a Y chromosome occurs by chance. The chances of an egg combining with either of the two types of sperms are equal. When a sperm with an X chromosome combines with an egg having X chromosome, the zygote has two X chromosomes and forms a female baby. But if a sperm with a Y chromosome fuses with an egg, the zygote has X and Y-chromosomes and form a male baby.		
Step 3	The teacher defines probability in Genetics Probability is a branch of Mathematics, which can be applied to those events that depend entirely on chance. Probability is usually expressed in units ranging from 0-1. Mendel's works are based on probability.		

Step 4	The teacher explains the application of probability to the formation of gametes. Suppose an organism has a genotype AA, what kind of gametes will it produce and in what proportion? Since only one of the pairs of chromosome get segregated during meiosis, the probable gamete produced from the AA parent is A ½ and ½ A. If the parent is heterozygous (A) (a), the probable gamete will be ½ A and ½ a.		
Step 5	The teacher explains the application of probability to the formation of offspring in Humans. Suppose a male carrier of the albino gene marries a female albino, what is the probability of them having an albino child. The male is heterozygous (Aa), and the female is homozygous recessive (aa) Parents Aa aa Gamete Offspring 		
Evaluation	The probability is that ½ of the offspring will be albino while ½ of them will be heterozygous The teacher asks the students the following questions. Describe Incomplete dominance Describe how sex is determined in Human beings Define probability in Genetics		
Summary	The teacher briefly goes over the topic by answering the questions above with the students.		
Assignment	What is the probability that an individual with genotype Tt will produce a gamete with T gene?		

APPENDIX XI


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MONTH
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TASK
Survey of Literature
Write Proposal (Programmes Without Coursework)
Write Proposal (Programmes With Coursework)
Gather Data (Programmes with Coursework)
Thesis Writing
Write Introduction
Revise Introduction
Write Methodology
Revise Methodology
Approval for proposal Semi.
Awaiting schedule for proposal seminar
Proposal presentation
Effecting proposal corrections for protocol
Protocol presentation
Correction of Protocols
Analyses, Results and Discussion
Write Conclusions
Revise conclusions
Acknowledgements, Appendices, etc.
Title Registration

APPENDIX XII

Dissemination of Findings

The findings of the study would be disseminated among stakeholders in the field of education using the following avenues.

Journal Publications: The findings of the research would be published in both National and International reputable journal outlets

Conferences:: The researcher would hopefully also attend both National and International conferences organized by educational institutions and professional bodies like Science Association of Nigeria (SAN), Science Teachers Association of Nigeria among others

Seminars: The researcher would organize seminars and workshops for both primary and secondary school teachers in order to sensitize them on the use of analogy and metaphor instructional strategies to bring about meaningful learning.

Blogs: The researcher also intends to make use of the social media by creating a blog site where the findings would be disseminated.

Libraries: The research article would also be produced and donated to various Libraries to serve as reference material for other researchers.

APPENDIX XIII

UNIVERSITY OF ILORIN, ILORIN, NIGERIA

UNIVERSITY ETHICAL REVIEW COMMITTEE

Vice Chancellor: Prof. S.A. Abdulkareem
B.Che, M.ChE, (Detroit); Ph.D. (Louisville),
MNAICh, MNSE, MACS, R.Eng. (COREN).
Registrar: Dr, (Mrs) F.M. Olowoleni
B.Sc (Zaria); MBA, M.Sc. PGDE (Ilorin)

E-mail: P.M.B. 1515, Ilorin
uerc@unilorin.edu.ng
unilorin.uerc@gmail.com
Website: ethicalrview.unilorin.edu.ng
www.unilorin.edu.com

Our Ref: UIL/UERC/98/25OC250

Date: 14th February, 2019

Protocol Identification Code: UERC/EDU/309
UERC Approval Number: UERC/ASN/2019/1592

COMPARATIVE EFFECTS OF INSTRUCTION IN FIGURES OF COMPARISON ON SENIOR SCHOOL STUDENTS' ACHIEVEMENT IN GENETICS IN ILORIN, NIGERIA

Name of applicant/Principal Investigator: **SULAIMAN,** Musa Mohammed.
Address of Applicant: Department Science Education
Faculty of Education,
University of Ilorin, Ilorin.
Type of Review: Full Committee Review...
Date of Approval: 14/02/2019

Notice of Full Committee Approval

I am pleased to inform you that the research described in the submitted proposal has been reviewed by the University Ethical Review Committee (UERC) and given full Committee approval.

This approval dates from 14/02/2019 to 13/02/2022, and there should be no participant accrual or any activity related to this research to be conducted outside these dates.

You are requested to inform the committee at the commencement of the research to enable it appoints its representative who will ensure compliance with the approved protocol. If there is any delay in starting the research, please inform the UERC so that the dates of approval can be adjusted accordingly.

The UERC requires you to comply with all institutional guidelines and regulations and ensure that all adverse events are reported promptly to the UERC. No charges are allowed in the research without prior approval by the UERC. Please note that the UERC reserves the right to conduct monitoring/oversight visit to your research site without prior notification.

Thank You,

Ismaila Isah
For: University Ethical Review Committee

UNIVERSITY ETHICAL REVIEW COMMITTEE
University of Ilorin, Ilorin, Nigeria

"....If it's not ethical, it's not scientific, if it's not scientific it's not ethical"

APPENDIX XIV

UNIVERSITY OF ILORIN, ILORIN, NIGERIA.

POSTGRADUATE SCHOOL

Vice-Chancellor:
Prof. S. A. AbdulKareem
B.ChE (Detroit); Ph.D. (Louisville);
MNAICh; MNSE; MACS; R.Eng (COREN)

Dean:
Prof. S. A. Bolu
B. Agric; M. Sc; Ph.D (Ilorin)
(Animal Nutrition) MNSAP, MASAN RAS.

Zahra Ishowo-Jaji House

PMB 1515, Ilorin, Nigeria.
website: www.unilorin.edu.ng
Tel: +234 903 092 4197
+234 811 114 1632
E-mail:pgschool@unilorin.edu.ng

UIL/PGS/91/42 **20th June, 2019**

SULAIMAN, Musa Mohammed
Matric. No.: 98/25OC250
Department of Science Education
Faculty of Education
University of Ilorin
Ilorin.

Dear **Sulaiman,**

APPROVAL OF DOCTORAL RESEARCH PROTOCOL

I am pleased to inform you that, the Board of Postgraduate School at its 279th Meeting held on Wednesday, 22nd May, 2019 considered and approved your Doctoral Research Protocol titled:

Comparative Effects of Instruction in Figures of Comparison On Senior Schools Students' Achievement in Genetics in Ilorin, Nigeria

You are therefore, to proceed with your Ph.D. programme accordingly, please.

Congratulations.

Yours sincerely,

M.A. Alfanla
Secretary, Postgraduate School

MA/JB

APPENDIX XV

UNIVERSITY OF ILORIN, ILORIN, NIGERIA

POSTGRADUATE SCHOOL

Vice-Chancellor:
Prof. S. A. Abdulkareem
B.ChE (Detroit); Ph.D. (Louisville);
MNAICh; MNSE; MACS; R.Eng (COREN)

Dean:
Prof. R. A. Bello
B.Sc., M.Sc., Ph.D.; Economics (ABU)
MNES; NHEA

P.M.B. 1515, Ilorin, Nigeria
Website: www.unilorin.edu.ng
Tel: +2349030924197
+2348111141632
E-mail: pgschool@unilorin.edu.ng

Date: **26th March, 2021**

UIL/PGS/91/55

SULAIMAN, Musa Mohammed
Matric. No.: 98/25OC250
Department of Science Education
Faculty of Education
University of Ilorin
Ilorin.

Dear **Sulaiman,**

RE: REGISTRATION OF TITLE OF Ph.D. THESIS

The Board of the Postgraduate School, at its 289th Meeting held on Wednesday, 20th January, 2021 considered and approved the registration of the title of your Ph.D. Thesis as follows:

Effects of Teaching-With-Figures of Comparison on Senior School Students' Achievement in Genetics in Ilorin Metropolis, Nigeria

Kindly note that in line with Senate decision, you are expected to defend your Thesis not later than Three (3) months after Registration of the Title of the Ph.D. Thesis, with effect from **Friday, 26th March, 2021**. Failure to defend (your thesis) within the given deadline will amount to fresh presentation of abstract for the Registration of Title.

Please note the above information for due compliance and congratulations on this academic feat.

Yours sincerely,

M.A. Alfanla
Secretary, Postgraduate School

A.A./M.A.

APPENDIX XVI

Budget Proposal

Description of Items	Expected from			Total
	Sponsor	Student	Others	
1.0 Personal Cost/ Allowances				
1.1 Research Assistance (3)		Student		15,000
1.2 Research Information		Student		35,000
Sub-total (not> 20% of Budget)				**50,000**
2.0 Equipment				
2.1 HP Laptop		Student		115,000
2.2 HP Printer		Student		45,000
2.3 Modem		Student		7,500
2.4 Flash Drive		Student		4,000
Sub-total				**171,500**
3.0 Supplies and Consumables				
3.1 Textbooks		Student		45,500
3.2 Printing Papers		Student		167,000
3.3 Monthly Subscription for Data Bundles @ 2,500 per month		Student		75,000
Sub-total				**297,500**
4.0 Data Collection Analysis				
4.1 Test Administration		Student		15,000
4.2 Analysis		Student		45,000
Sub-total				**60,000**
5.0 Travels				
5.1 Researcher		Student		26,000
Sub-total				**26,000**
6.0 Dissemination				
6.1 Conferences		Student		130,000
6.2 Journal Publication		Student		30,000
6.3 Workshops		Student		45,000
Sub-total				**205,000**
7.0 Miscellaneous				
7.1 Miscellaneous		Student		100,000
Sub-total				**100,000**
Grand Total				**910,000**