EFFECTS OF HERRMANN'S WHOLE-BRAIN MODEL ON RETENTION AND ACADEMIC PERFORMANCE AMONG SECONDARY SCHOOL PHYSICS STUDENTS IN ZARIA EDUCATION ZONE, KADUNA, NIGERIA.

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P16EDSC8093
BSc Ed (Physics) A. B. U. Zaria (2015)

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

DECEMBER, 2021

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A DISSERTATION SUMBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY,IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A MASTER'S DEGREE IN SCIENCE EDUCATION,

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

DECEMBER, 2021

DECLARATION

I Yusuf MUSA (P16EDSC8093) hereby declare that this dissertation entitled "**Effects of Herrmann's Whole-Brain Model on Retention and Academic Performance among Secondary School Physics Students in Zaria Education Zone Kaduna, Nigeria**." has been carried out by me, in the Department of Science Education, Faculty of Education, Ahmadu Bello University, Zaria. Under the supervision of Prof. M. M. Atadoga and Dr. M. K. Falalu. The information derived from the literature has been duly acknowledged.

This dissertation has not been presented in any previous application for any degree in any university.

_____ _____

Yusuf MUSA Date

CERTIFICATION

This dissertation entitled "**Effects of Herrmann's Whole-Brain Model on Retention and Academic Performance among Secondary School Physics Students in Zaria Education Zone Kaduna, Nigeria**" by Yusuf MUSA meets the regulations governing the award of the Masters Degree in Science Education, in Ahmadu Bello University, Zaria and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This research work is dedicated to my father Mal. Musa Aliyu, my mother Mal. Rabi Musa, my wife Mrs. Rashida Yusuf, my daughters Aisha Yusuf and Maryam Yusuf, and my sons Muhammad Yusuf and Aliyu Yusuf.

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LIST OF ABBREVIATIONS

T/L System:	Thinking/Learning System
4MAT:	Four Mode Application Technique
HWBM:	Herrmann's Whole Brain Model
WAEC:	West African Examination Council
NECO:	National Examination Council
SSII:	Senior Secondary II
WPT:	Wave Performance Test
FI:	Facility Index
DI:	Discriminating Index

OPERATIONAL DEFINITION OF THE KEY TERMS

Herrmann's Whole Brain Model: This is a Brain-compatible model that defines learning styles as a function of brain chambers (Parts) and put emphasis on learning with whole brain.

Academic Performance: This refers to the scores that students obtained in the cause of evaluation at the end of a program, an instruction or task.

Retention: This refers to the ability of students to store/ keep information in the cognitive structure for a given period after given instruction and retrieve/recall at a later time when needed.

ABSTRACT

This study examined the effects of Herrmann's Whole-Brain Model on Retention and Academic Performance among Secondary School Physics Students in Zaria Education Zone Kaduna, Nigeria. The study was guided by four research objectives, four research questions and four null hypotheses. Pretest, posttest and post-posttest quasi-experimental design was employed for the purpose of the study. The population of this study comprised all public co-educational secondary school Physics students two (SSII) in Zaria education zone, Kaduna state with the total population of 1,422 out of which two schools with 228 SS II Physics students were sampled using simple random sampling technique. A validated and reliable instrument, Wave Performance Test (WPT) with reliability coefficient of 0.762 developed by the researcher was used for generating data. Research Questions raised were answered using means and standard deviations while the null hypotheses were tested using t-test statistical tool at 0.05 level of significance. The results showed a significant difference in performance in favour of students exposed to the Herrmann's Whole-Brain Model ($P=0.00$ at $\alpha \leq 0.05$). The results also revealed no significant difference in performance of male and female students exposed to HWBM ($P=0.37$ at $\alpha \leq 0.05$). The result further revealed that the students exposed to HWBM had better retention compared to their counterpart who were taught using lecture method ($P=0.00$ at $\alpha \leq 0.05$). However, the difference in retention of male and female students exposed to HWBM was not statistically significant ($P=0.34$ at $\alpha \leq 0.05$). The study concluded that the HWBM is effective in the teaching and learning of Wave concepts in senior secondary schools and it is gender friendly. Based on the findings, the following recommendations were made among others: Teachers should employ HWBM in the teaching of Wave concepts in senior secondary schools to enhance students' retention and academic performance. Workshops and seminars for Physics teachers should be organized by the Ministry of Education for each education zone in Kaduna state on the use of HWBM.

CHAPTER ONE

THE PROBLEM

1.1 Introduction

The purpose of education is to teach learners to become more efficient thinkers, making smart social, emotional, and academic decisions (Brown, 2012). The major aim of teaching science in schools is to facilitate students' acquisition of science process skills and to promote the understanding of concepts being taught with a view to applying them to real life situations (Afolabi & Akinbobola, 2012). The study of science has been of great importance internationally for sustainable and socio-economic development as well as technological advancement of a nation like Nigeria.

According to Isa (2018), nations can be classified accurately into developed, developing and underdeveloped by the number of scientists each nation could produce. This could be the reason why scientific and technological breakthrough is usually the goal of any nation like Nigeria. Every nation particularly Nigeria has specified certain goals/objectives which can be achieved by using education as a tool for national development. National Policy on Education (FME, 2014) spells out the way by which those specified goals and objectives can be attained through education. Some goals and objectives are projected in the teaching and learning of science. Some of the science subjects in the policy include Physics.

Physics is among the major pillars of science and a core science in Nigerian senior secondary schools. Physics deals with the study of laws that determine the structure of the universe with reference to the matter and energy in the universe (Ike, 2002). Falalu (2014) opined that political, economic, social and military strength depend on

technological strength and quality of science teaching. These show that Physics plays very important roles in equipping students with the necessary scientific skills for a progressive society and forms bedrock for scientific knowledge because many of the tools on scientific and technological advancement depends on direct product of Physics. Hence, Physics must be taught in a way students will perceive and understand it, retain what is learnt and reflect higher scores for meaningful application. Despite the importance of Physics to individuals and national development, academic performance of students in the subject is not encouraging as is manifested in both internal and external examination within and outside the country and poster low patronage of the subject (Olusola & Omotade, 2014).

Academic performance refers to the scores that students obtain in the cause of evaluation at the end of a program or an instruction. Academic performance is how well an individual is able to demonstrate desired abilities. Usman (2000) defined Academic performance as the extent to which students have learnt, acquired certain information and mastered skills usually as a result of planned instruction or training. The quality of scores on the part of students' academic performance in science is influenced by a number of factors which raise it or improve it to the desired level or standard. Performance measures the behaviors or an aspect of a feat that can be observed at a specific period (Sunday & Kola 2014). Academic performance occupies a very important place in continuing higher education as well as in the selection and placement in any organization and institution. The success of any educational program depends largely on level of success in students' performance recorded (Ezeaghasi, 2017). However, several factors have been attributed to poor academic performance among Nigerian secondary schools' students in science (Physics inclusive). Afolabi and Akinbobola *(2012)* and Okoronka and Wada (2014) opined that poor academic performance in our schools queries the methodology of

instruction. Hence, the use of instructional Strategy is found to be significantly effective on academic performance in science. In an effort to attend optimal academic performance of the students, researchers such as Clark (2016), Ezeaghasi (2017) and Sontillano (2018) advocate the use of brain-compatible models one of which Herrmann's Whole Brain Model (HWBM).

Herrmann (2000) classified learning styles based on the functions controlled by each chamber of the brain and identified four divisions within the brain, each of which was associated with a certain learning style which is now known as Herrmann's Whole-Brain Model (Bawaneh et al., 2010; Bawaneh et al., 2012). This model emphasized on the use of the four learning styles in each lesson so as to provide equal learning opportunity for all learners. Since, the product of schools (educated people) are expected to shape the destiny of the society and they can only do this, if they are able to retain what they have been taught in school, this study is interested in finding out the effect of HWBM on students' retention in Physics.

Retention as one of the important variable of this study is defined by Yero (2011) as the ability of a learner to recall, remember and recollect a body of knowledge after passing through instruction. Retention according to Bunkure (2012), is the ability to retain and consequently remember things experienced or learned by an individual at a time. The theories of forgetting make it clear that forgetting takes place as a result of passage of time. As such, the students' retention ability should be strengthened through memorization, practice and activity based learning as comprises in HWBM. As such, this study is interested in verifying the effect of HWBM on students' academic performance in Physics.

Related literature confirmed that Physics is not being taught the way it should in Nigerian secondary schools (Afolabi & Akinbobola, 2012 & Godwin & Okoronka 2015). This may be the reason why poor performance in Physics has persisted over the years. In the word of Josiah (2012), Physics results in most certified examinations like the West African Senior School Certificate Examination (WASSCE) have not been satisfactory and this have been attributed to many factors which include utilization of inappropriate teaching methods in schools. Therefore, there is need for an innovative strategies that will enhance students' academic performance, retention and acquisition of requisite skills in Physics. There are several documentations about retention and academic performance in science and mathematics among secondary school students with respect to gender in connection with various instructional strategies which are conflicting and inconclusive. As such, this study is interested in verifying the effect of HWBM on gender.

Gender has been identified as one of the predictor variables that may be factored into students' academic performance and retention. The ABC of women's right and gender equality (2000) defines gender as the socially constructed differences and relations between males and females. According to Filgona and Sababa (2017), gender is the range of physical, biological, mental and behavioural characteristics pertaining to and differentiating between the feminine and masculine (female and male) population. Gender, as a concept, becomes a topic of discussion and captured the interest of educators in Nigeria, due the socio-cultural differences manifested between male and female in which some vocations and professions have been voluntarily surrendered to men while others have been surrendered to women. Difference in treatment through education created and sustained gender gap, which also became visible in the science related disciplines. Several studies have documented gender sensitivity in the favour of male students while others reported females' superiority and others still, zero disparity.

Khairulanuar et al. (2010) found gender differences in favour of male students. Afolabi & Akinbobola (2012) reported that gender has no significant effect on students' academic performance. Filgona & Sababa (2017) reported gender sensitivity in favour of female students. Hence, reports on gender and students' academic performance are conflicting and inconclusive. As such, the researcher investigates if HWBM is gender-friendly. In view of the relationship among students' academic performance, retention ability, gender and teaching strategy, the researcher investigated the effects of HWBM on retention and academic performance among Secondary School Physics students in Zaria Education Zone Kaduna State, Nigeria.

1.1.1 Theoretical frame work

The learning theory most compatible with HWBM is constructivism (Sorensen & Murchu, 2006). Constructivist learning theory is based on the assumption that learners construct their own knowledge as they attempt to make sense of their experiences. HWBM is based on Piaget's developmental stage theory and Vygotsky's theory. Piaget's developmental stage theory holds that cognitive development was a progressive reorganization of mental processes resulting from biological maturation and environmental experience. According to Piaget (1970), children construct an understanding of the world around them, experience discrepancies between what they already know and what they discover in their environment, then, adjust their ideas accordingly. This reflects the structure of HWBM as it takes into account the cognitive development of the learner. Vygotsky (1978:57) states that: "Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (inter-psychological) and then inside the child (intra-psychological). This view corresponds to the employment of interactive learning (Group task) and then internal learning (individual task) in HWBM.

Herrmann's Whole Brain Model is also rooted in two instructional design theories that are based on the information provided by current neuroscience research on learning. One theory is Gardner's theory of multiple approaches to learning. Gardner (1983) stated that every individual has different abilities in each area and that incorporating all intelligences in the learning process maximizes learning potential. The second theory is the Kovalik's Integrated Thematic Instructional Design Theory. Kovalik (1994) stated that students need to explore the new and different and to be open to new ideas requiring confidence that one is in a safe environment, one in which mistakes and difficulty in understanding/doing something are considered just part of learning, not an opportunity for sarcasm and put-downs. These theories are based on an understanding that processes in the brain are carried out by neural networks (Sorensen & Murchu, 2006). These theories correspond to the employment of attention getting techniques and multiple learning styles and the class rules in HWBM respectively. Hence, there is hope that the academic performance and retention can be enhanced using HWBM

Based on this theoretical background, this research investigated the effects of HWBM on retention and academic performance among Physics students in Zaria education zone Kaduna state, Nigeria.

1.2 Statement of the Problem

Physics as a core science in senior secondary schools plays important roles in equipping students with the necessary scientific skills for a progressive society and forms the bedrock for scientific knowledge and technology upon which the development of any nation based. Despite the importance of Physics to national development, the subject is dwindling in terms of knowledge retention, academic performance and patronage over the years. It is clear from research findings that the subject has been suffering from low

patronage and poor academic performance in both internal and external examination within and outside the country (Godwin & Okoronka, 2015). Average performance was reported by the WAEC chief Examiner for candidates for Physics in (2015), (2016), (2017), and (2018) where Lack of mastery of subject matter, Lack of understanding of scientific terms, Poor computation and skills were identified as the candidates' weaknesses (https://www.waecgh.org/EXAMS/ChiefExaminersReport.aspx) retrieved on 12th oct, 2020. Based on the above reports, poor academic performance in Physics has been identified over years and may be attributed to the poor retention ability among the students.

Isa (2018) opined that information stored in the long term memory can be described as information retained and could be measured through performance. In other word, learner must retain the learned materials for some moment before he or she can be able to retrieve the information and perform positively in any corresponding evaluation task. Hence, the students' retention ability should be strengthened. As such, this study examined whether retention could be enhance through combined direct instruction, sharing, memorization, practice and immediate feedback as affair in HWBM.

A critical look at the contents of Physics curriculum in Nigeria indicates that the traditional teacher-centered approaches are not relevant and not appropriate to promote efficient learning of the content of the programme (Afolabi & Akinbobola, 2012). The use of inappropriate instructional strategies by teachers in introduction and presentation of learning materials provide learners with less opportunity to process and retain what they sense and experience. In such situation learners assimilate learning materials they are exposed to without understanding the meaning. As a result, retention, retrieval and application to real life situation may not be materialized. Encoding learnt materials in

such way involves a level of processing that is poor and consequently leads to poor retention and difficulty in later retrieval hence, lead to poor academic performance as seen in results of standardized examinations like WAEC and NECO (Godwin, 2014).

In an effort to check this problem, Several attempts had been made by researchers such as Yero (2011) and Akingbade and Omotade (2013) to investigate the effectiveness of teaching methods on academic performance in science and findings revealed that innovative methods such as Guided Discovery, Inquiry, Science Process Approach, Problem Solving, and Cooperative Learning Strategy are effectively enhancing students' academic performance in Physics at Secondary School level: Yet the problems persist. Therefore, there is need for some models that will not only maximize meaningful understanding of concepts in Physics but also provide teachers and students the opportunity to interact with their environment and utilize their brains appropriately. HWBM with its unique approach that combines direct instruction, sharing and immediate feedback may put an end to these problems. This is what motivated the researcher to investigate the effects of HWBM on retention and academic performance among Secondary School Physics students in Zaria education zone Kaduna state, Nigeria.

1.3 Objectives of the Study

The objectives of the study are to:

a) determine effects of Herrmann's Whole-Brain Model on academic performance among Physics students in Zaria education zone Kaduna state, Nigeria;
b) investigate effects of Herrmann's Whole-Brain Model on retention ability among Physics students in Zaria education zone Kaduna state, Nigeria; and
c) determine effects of Herrmann's Whole-Brain Model on academic performance of male and female Physics students in Zaria education zone Kaduna state, Nigeria;

d) find effects of Herrmann's Whole-Brain Model on retention ability of male and female Physics students in Zaria education zone Kaduna state, Nigeria;

1.4 Research Questions

The following research questions guided the study;

a) What is the difference between the mean scores of students taught wave concepts using Herrmann's Whole-Brain Model and those taught the same concepts using the lecture method?

b) What is the difference between the retention levels of the students taught wave concepts using Herrmann's Whole-Brain Model and those taught the same concepts using lecture method?

c) What is the difference between the mean performance scores of male and female students taught wave concepts using Herrmann's Whole-Brain Model?

d) What is the difference between the retention levels of male and female students taught wave concepts using Herrmann's Whole-Brain Model?

1.5 Null Hypotheses

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

$H0_1$: There is no significant difference between the academic performance of students taught wave concepts using Herrmann's Whole-Brain Model and those taught the same concepts using the lecture method.

$H0_2$: There is no significant difference between the retention levels of students taught wave concepts using Herrmann's Whole-Brain Model and those taught same using lecture method.

$H0_3$: There is no significant difference between the mean performance scores of male and female students taught wave concepts using Herrmann's Whole-Brain Model.

$H0_4$: There is no significant difference between the retention levels of male and female students taught wave concepts using Herrmann's Whole-Brain Model

1.6 Significance of the Study

The study investigates the effects of Herrmann's Whole-Brain Model on retention and academic performance among secondary school Physics students in Zaria education zone, Kaduna state. However, the findings of this study would hopefully benefit the following;

Secondary School Physics Students: The findings of this study would help the secondary school Physics students to identify the learning strategy that enhances academic performance in Physics. It is also hoped that the use of Herrmann's Whole-Brain Model for teaching Physics in senior secondary schools would enhance their academic performance and retention of learned concept as well.

Secondary School Physics Teachers: The findings of this study would be beneficial to secondary school Physics teachers by helping them to use learning strategies which is in line with the psychological, physiological and sociological interest of the learners and with high learners' participation. Information from this study would help Physics Teachers to improve upon their teaching activities through the use of HWBM as effective instructional strategy in their field. Physics teachers would benefit from the finding as it discourages them from using lecture method which is stressful and boring.

Curriculum Planners: The findings would be relevant to curriculum planners and other educational agencies as to emphasize those strategies that facilitate meaningful learning. The Curriculum Developers and Authors who develop syllabuses or syllabi and recommend effective methods of instruction would incorporate the teaching strategy as reflected in this study, and also the findings of this study would be used to clarify, and modify the existing claims on abstract nature of science (Physics inclusive).

Professional Bodies: The finding would be useful to professional bodies and associations like Science Teachers' Association of Nigeria (STAN) Mathematics Association of Nigeria (MAN) in their workshops and conferences to make emphasis on new and effective instructional models such as HWBM. Professional bodies such as Nigerian Educational Research and Development Council (NERDC) that carry out seminars, workshops, and research activities might find the results of this study useful and incorporate them into their Instructional Packages.

Fellow Researchers: The findings would be useful to fellow researchers as a source of reference for related studies in various geographical areas. The limitations of this study can also be used by fellow researchers as a source of problems for further studies and consequently become the roots of new related researches.

1.7 Scope of the Study

This study investigates the effects of HWBM on retention and academic performance among Senior Secondary School Physics students in Zaria education zone, Kaduna state, Nigeria. HWBM was adapted for the purpose of this study. The use of HWBM was justified by its unique characteristics. HWBM is essentially designed to accommodate brain functionality and respond to students' preferred thinking/learning styles. The research was limited to only public Secondary Schools offering Physics in the zone. The use of public Secondary Schools rests on the fact that but resources and services are distributed equally among the schools. Senior Secondary II (SSII) students was used for the purpose of this research due to the fact that students at this level were neither introductory SSI students nor final year SSIII students who involved in final year examination. Co-educational schools in the zone were used for this study in other to report gender related issues. Wave concepts drawn from SSII syllabus were used as content for teaching the experimental and control groups. The concepts of waves that

were treated in this study were; wave, type and characteristics of waves, electromagnetic spectra, applications of electromagnetic spectra, wave equations and their applications. The use of these concepts was based on the fact that Physics curriculum emphasizes its teaching at SSII level and that most of the concepts of wave are abstract in nature having limited instructional facilities. WAEC chief examiner reported that these concepts appeared annually in the SSCE and are perceived by students as difficult concepts that contribute to their failure (WAEC in Bello, 2015).

1.8 Basic Assumptions

The study is based on the following assumptions that:

a) The schools selected for this study have professionally trained and qualified Physics teachers.

b) The schools selected for this study have valid and reliable equipment and materials for teaching and learning of Physics.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This chapter reviews the literature on Effects of Herrmann's Whole-Brain Model on Retention and Academic Performance among Secondary School Physics Students in Zaria Education Zone Kaduna State, Nigeria. The review is focused on the following sub-headings:

2.2 Physics as a Teaching Subject in Nigerian Secondary Schools

2.3 Science Teaching Methods in Nigerian Secondary Schools

2.4 Herrmann's Whole Brain Model

2.5 Retention in Physics

2.6 Academic Performance in Physics

2.7 Retention and Academic Performance

2.8 Gender and Academic Performance in Physics

2.9 Overview of Similar Studies

2.10 Implication of the Related Literature Reviewed to the present Studies

2.2 Physics as a Teaching Subject in Nigerian Secondary Schools

Physics is one of the science teaching subject in Nigerian secondary schools. Physics is an aspect of science that helps to explain cause- effect relationships of matter and energy, and their application to natural phenomena (Atadoga, 2001). Physics is identified as the most utilized basic science subjects in most technology and technology- related profession. Physics concepts and techniques underpin the understanding of other disciplines (Olonade in Akingbade, & Omotade, 2013). Physics occupies very wide area in science and technology as it comprises numerous field of studies such as mechanics,

electricity, heat, wave, optics, cryogenics, astrophysics, plasma Physics, nuclear Physics, and solid state Physics. Physics is a cross-cutting discipline that has applications in many sectors of economic development, including health, agriculture, water energy and information technology (Josiah, 2012). Physics, as a science subject, has been acknowledged as a pre-requisite for the study of several courses in universities (Bello, 2015).

The development of any nation, which depends on science and technology, hinges on Physics education. Physics is not only crucial to science and technology but also a strength to politics, economics, security and other social issues as the political, economic, social and military strength depend on technological strength and quality of science teaching (Falalu, 2014). This merely indicates that the enormous role Physics plays in the technological growth of any nation must not be undermined. It is germane to say that the technological growth of a nation leads to its social and economic development. The importance of Physics for the development of a nation is, therefore, glaring (Akingbade & Omotade, 2013).

However, despite the recognition given to Physics as the bedrock of science and technology, gaps still exist between curriculum planners' intention and what goes on in the classroom (Folashade & Akinbobola, 2009). In an effort to address these gaps, among others, Folashade and Akinbobola (2009) reported the superiority of Problem-based learning technique over lecture method in Physics. Afolabi and Akinbobola (2012) concluded that action learning strategy enhances students' achievement in Physics more than problem-based learning strategy, Akingbade and Omotade (2013) concluded that "application of Metacognitive strategies" has significant impact on the reading and students' academic performance in Physics. Bello (2015) reported the superiority of

Computer-Aided Instruction over lecture method. These show that the success of Physics teaching in Nigeria secondary schools hinges on teaching method adopted by Physics teachers. Science educators advocate the use learners-centered instructional approaches in teaching and learning of science. However, there are various teaching methods at disposal of science in Nigeria secondary schools as discussed in this chapter.

2.3 Science Teaching Methods in Nigerian Secondary Schools

Teaching is a process of imparting knowledge or idea that involves some activities on the part of the teacher and learner. The main purposes of teaching include the imparting of knowledge, skills and attitude and shaping the learning domains of the learners to manifest relatively permanent change in behaviour of the learner. Method can be defined as the way, approach or procedure of doing something. Teaching method may be described as various ways in which information is presented to the students specifying the nature of the activities in which the teacher and the learner will be involved during the teaching and learning processes. According to Joshi (2008), the term "teaching method" refers to the ways, approaches, procedures and kinds of activities which teachers and students engage in the interactive process with a view to inducing, inspiring and facilitating learning for the purpose of accomplishing a set of instructional objectives. Hence, the prime functions of a teacher is to build up the services of intellectual capital through the utilization of appropriately selected curriculum materials, content and corresponding learning experiences, motivational strategies, and application of instructional theories in the teaching and learning process with the aim of attaining certain instructional objectives. There are different methods of teaching at the disposal of science education which include; lecture method, demonstration method, cooperative method, discussion method, field trip (excursion) method, problem-solving method and

discovery method. Hence, it is the responsibility of the teacher in the light of the topic to be treated to choose appropriate methods based on the needs of the students in other to enhance teaching and learning.

Lecture method is a teacher-centered method in which the new material is presented and explained by the teacher while the students are less active in the teaching and learning process. In this method of teaching, the teacher do most of class-room activities and the students are given less opportunity to participate in the teaching and learning process. However, a critical look at the contents of Physics curriculum in Nigeria indicates that the traditional teacher-centered approaches are not relevant and not appropriate to promote efficient learning of the content of the programme (Afolabi & Akinbobola, 2012).

Another method of teaching which is more innovative than lecture method is demonstration Method. Demonstration Method of teaching and learning is a method in which teachers dramatize topics to be taught by either the use of items or recorded materials, while students are made to practice the skills demonstrated in readiness for the time they will be asked to display their level of efficiency in the performance of those skills (Musa, 2015). This method enable the students to visualize the material being taught or demonstrated by the teacher. Unlike lecture method of teaching which demand just oral presentation of information to students without an active involvement of the students, Demonstration Method explains steps of an operation or principles and shows how a process, procedure or an experiment is to be carried out; what to do, and why it should be done that way. The demonstration can be carried out by the teacher alone, the teacher and the learner, the learner who is knowledgeable in the activity or by an invited guest. The guiding principle is that the purpose of the demonstration must be clear to all participants and the process must involve the learners as much as possible. However,

demonstration Method doesn't allow science students to enjoy the honey taste of science concepts such as wave and vibration due to the absent of real situation. Technology brings about new innovations such as computer that may serve as means of solving educational problems as it ease and fasten instructional task.

According to Atadoga et al. (2016), the world has shifted to the computer era, for that the teaching and learning has to move with the current trend and that is the teaching and learning with the aid of computer. The use of computers in teaching and learning process is termed as computer based-instruction method (Ayuba, 2017). This approach to learning attempt to improve the success of science teaching and learning through taking the advantage of the interactive elements of computer system, along with other electronic devices and the computer's ability to present many different kind of media. This method especially captures the interest of young learners due to the involvement of videos presentations and videos games. Also, tests and exercises are often handled in an interactive manner, and sometimes they can almost be like games depending on the style of the implementation. However, computer based-instruction method requires the basic knowledge of computer for both teachers and the learners, electricity supply as well as availability computer systems which is found insufficient in most Nigerian secondary schools. Science teaching and learning embraces students' team-work otherwise known as Cooperative learning strategy.

Cooperative learning is a learner-centered and teacher facilitated strategy in which the teacher groups the students, supplies them with instructional materials and instructional guides and allows them to work together as a team with the aim of improving their academic success. According to Sani (2017), cooperative learning strategy is an instructional strategy that involves students working in teams to accomplish a common

goal. In cooperative learning, each member of a team is charged with the responsibility of his or her academic performance as well as helping team-mates to learn better and consequently perform better. However, even with the advent of cooperative Learning Strategy, the success of science teaching and learning remain poor. This may hinges on the fact that individuals differ in their preferred thinking/learning styles.

However, it is evident that these strategies (Demonstration method, cooperative method, discussion method, field trip method, problem-solving method and discovery method) are learners-centered but none of these strategies takes into consideration the structure and function of the brain (Olaoluwa & Ayantoye, 2016). Research evidence suggests the adoption of learner-centered strategy based on the structure and function of brain can improve learners' academic performance. (Olaoluwa & Ayantoye, 2016; & Sontillano, 2018). The current research in neuroscience about how brains naturally learn best lead to the development of various teaching models known as Brain-Compatible Teaching Models such as Caine and Caine's Brain / Mind Learning model, Edwards & Sparapani's Thinking / Learning System, McCharty's Four Mode Application Techniques (4MAT) System and Herrmann's Whole Brain model (HWBM).

2.3.1 Brain / Mind Learning model

Brain / Mind Learning model is a brain-compatible teaching model developed by Caine and Caine (1989). The model emphasizes on three interactive instructional elements emerging out of the brain natural working principles. These three fundamental elements are;

i. **Relaxed Alertness:** This means trying to eliminate fear in learners by creating an optimal emotional and social climate for learning. A challenging learning environment with minimal threats should be provided (Gülpinar, 2005). When a

person is interested in something, he/she is open to learn and vice versa. A relaxed and opened brain learns more easily.

ii. **Orchestrated Immersion:** This refers to a students' concentration on the content they encounter by creating learning environments that fully immerse students in an educational experience.

iii. **Active Processing:** A learner's brain is actively processing. For instance, to make an experience meaningful, memory naturally reacts to new objects incompatible with the previous maps. Thus, brain test the experience that is contrary to the known (Duman, 2010). This can be realized in a classroom setting by allowing the learner to consolidate and internalize information by actively processing it.

2.3.2 Edwards & Sparapani's Thinking / Learning System

The Thinking/Learning System is an instructional paradigm that couples selected levels of Bloom's taxonomy with selected higher-order thinking processes. Thinking/learning system is a thinking skills programme developed by Peter Edwards and Ervin Sparapani in (1994) based on four high-level thinking skills: processing information, creative thinking, critical thinking and decision making. It is a programme which combines high-level thinking strategies and brain learning principles with the aim of realising high-level thinking education. This teaching model was developed by matching the levels in Higher-Order Thinking Skills (HOTS) and Bloom's taxonomies. The system emphasizes brain-compatible learning and strives to teach high-level thinking through activities. The linear and hierarchical structure of the programme is illustrated in Figure 2.1 bellow.

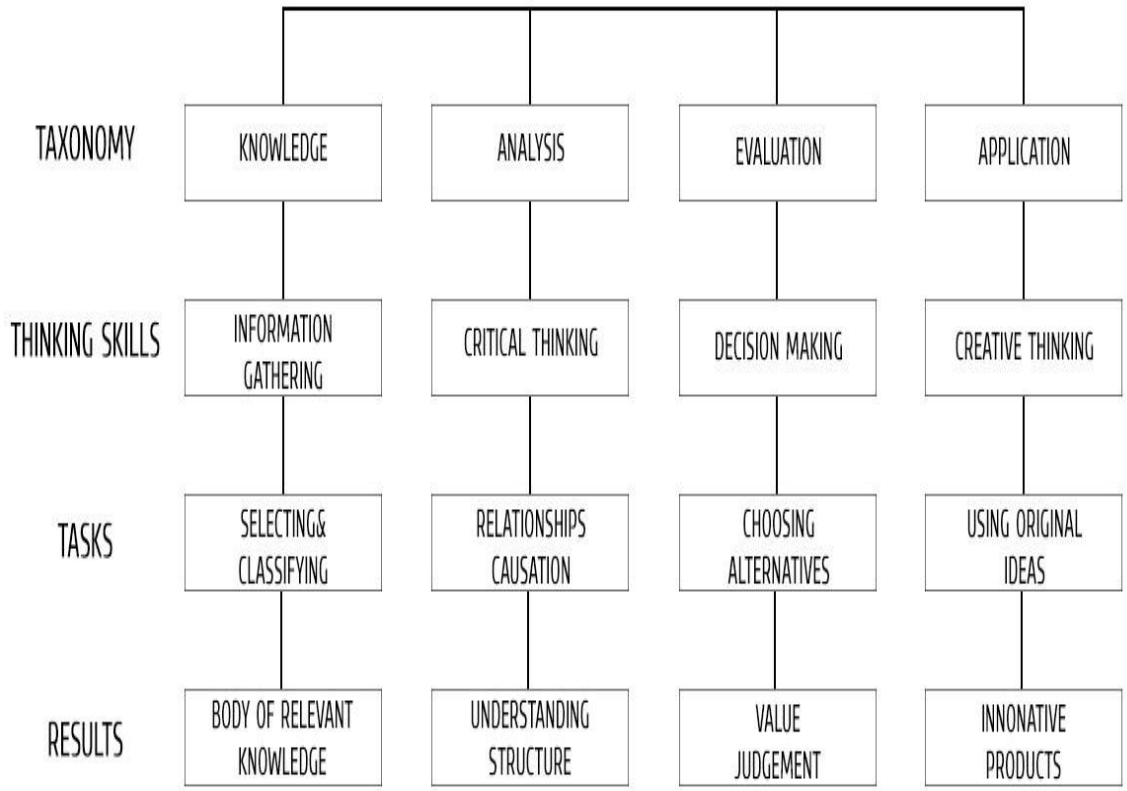


Figure 2.1: Conceptual Framework of the (T/L) System (Edwards & Sparapani, 1994).

In the knowledge/information gathering loop students develop skills to select the information that will serve for the purposes of the activities in the lesson, to categorise them and to associate them with the subject. In the analysis/critical thinking loop, they focus on the importance of and reasons for relationships. The application/creative thinking loop underlines that there is a need to use original ideas and evaluate the sufficiency of the products in order to come up with innovative products. Evaluation/decision making loop, on the other hand, emphasizes the evidence and criteria to select alternatives and to develop standards of judgment.

On one hand, the programme is skill based, on the other hand it is mentioned that high-level thinking skills are linked with the principles of brain/mind based thinking. There is

no grading for the programme and it can be used for all primary school students and adults.

2.3.3 Four Mode Application Techniques (4MAT)

The 4MAT model was originally developed by Bernice McCarthy in 1987 using Kolb's Learning Cycle. It is based on research from many fields, but mainly is a synthesis of findings from the fields of learning styles and right and left brain dominance. 4MAT is a model of instruction that works on the assumption that there is interplay on how learners perceive and how they process what they perceive. The way learners perceive and process information describes their learning style. There are four types of learners in regard to different learning style which are; imaginative learners, analytic learners, common sense learners and dynamic learners (McCarthy, 1990).

4MAT has a distinction from other learning styles theories; it takes into account all learning styles in one cycle of learning process, which involves all learners' difference (McCarthy, 1987). The learner has to travel the cycle with a spin to fully engage in the activities of the four diverse learners. The learning process cycle of 4MAT System is illustrated in figure 2 below.

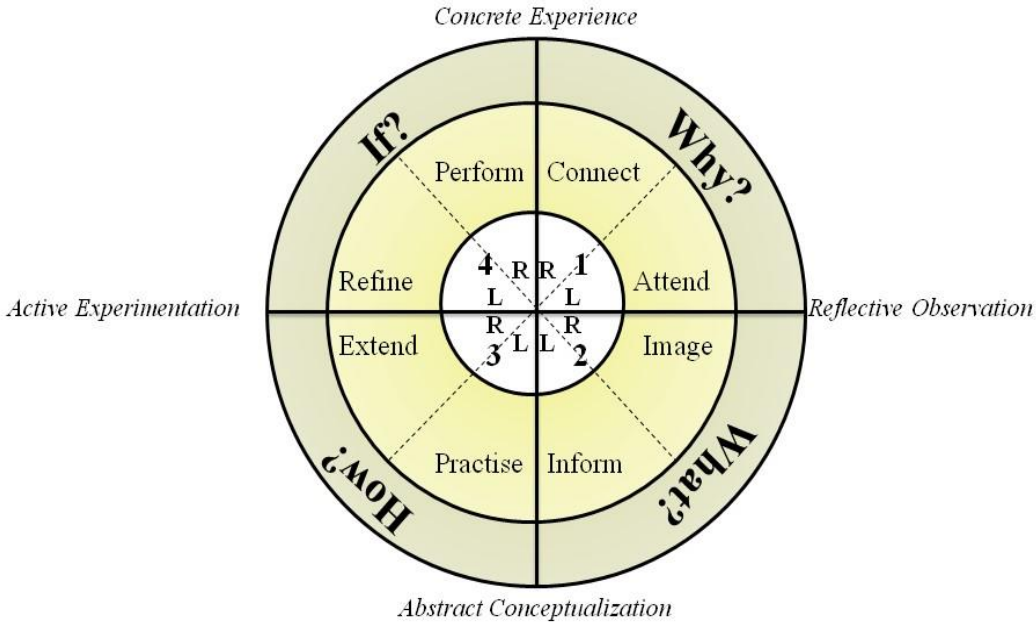


Figure 2.2: The 4MAT Teaching Model (Bülbül & Özsoy, 2015).

The system offers a model for planning instruction that takes into account the four learning styles of students which benefits teachers by giving them a framework to design learning activities (McCarthy, 1990). In the 4Mat System, teachers sequentially design lessons focusing on four issues:

1. Personal Connections -- How can I help students to make connections between the content and their immediate lives?
2. Concept Development -- How can students integrate this information and see how it fits within the overall course?
3. Practical Applications – What can students do in the learning environment using the information to see it at work?
4. Creative Integration – How can students apply this information in original and more complex ways?

2.4 Herrmann's Whole Brain Model

Herrmann (1988) proposes that the brain is divided into an upper part and a lower part based on learning characteristics, both of which are further subdivided into right and left

portions. The upper part deals with abstract and conceptual concepts while the lower part deals with emotional and intrinsic ideas. The left-upper part deals with logic and quantity whereas the left-lower parts deal with sequence and organization. On the other hand, the right-upper part deals with conceptual and visual notions, whereas the right-lower part deals with interpersonal and emotional concepts (Bawaneh et al., 2012).

Herrmann (2000) classified learning styles based on the functions controlled by each chamber of the brain and identified four divisions within the brain, each of which was associated with a certain learning style. (Bawaneh et al., 2010), as shown in Figure 2.3 below.

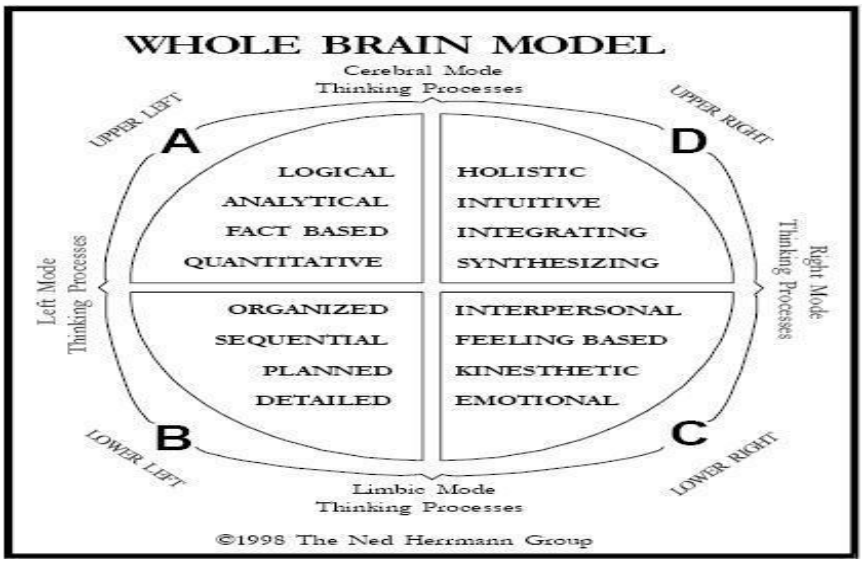


Figure 2.3: Brain Division by Herrmann's Taxonomy (Herrmann, 2000).

According to Herrmann in Bawaneh et al. (2011),

> *The upper left quarter (QA) represents external learning, which is logical, rational, realistic, analytical, critical, deductive, quantitative, and verbal. Learners within this category traditionally learn best through lectures, textbooks, and teachers who serve as knowledge dispensers and answerers of questions. The lower left quarter (QB) refers to procedural learning. Procedural learners are characterized as being sequential, structured, organized, regulated, individualized, and needing verification. Their preferred learning style is the procedural, step-by-step approach, in which practice, repetition, hands-on activities, abstract cognition, and commonsense are most emphasized. The lower right quarter (QC)*

> *describes interactive learning, in which interrelations and kinesthetic work are emphasized. Interactive learners are sensory, cooperative, emotional, intuitive and explorative. Their ideal learning environment is created by experience, feedback, listening, physical experimentation, and shared thinking. The upper right quarter (QD), which represents internal learning, incorporates much of what is required for comprehensive, creative, imaginative, conceptual, and inductive ways of learning. The ideal learning context for an internal learner is characterized by insightfulness, idea construction, and concept understanding that occur instantly, totally, comprehensively and intuitively. (P 3&4)*

Hence, HWBM stresses on providing equal learning opportunities for different learners, where each of the four learning styles (A, B, C, and D) fulfilled in a single lesson, so that a student's preferable learning style will be utilized in one quarter of the classroom time, while the remaining three quarter of total classroom time assigned will be for learning with other learning styles.

Out of the above models discussed, HWBM is the only model that takes into account the functions of the four divisions of the brain in relation to the four learning styles. Hence, give room for educators to make one to one mapping between the four brain divisions and the four learning styles for effective and efficient lesson design. According to Bawaneh et al. (2012), HWBM is essentially designed to accommodate brain functionality and respond to student's preferred thinking and learning styles. As such, HWBM model may be suitable to any age level and any group of students in any place. Based on the above justification, Herrmann’s Whole Brain Model (HWBM) was adopted for this study.

2.5 Retention in Physics

Retention as one of the important variables of the study, refers to the ability of a learner to recall, remember and recollect a body of knowledge after passing through instruction (Yero 2011). In other word, retention refers to what is learned minus what has been forgotten. The theories of forgetting make it clear that forgetting takes place as a result of

passage of time. As such, the students' retention ability should be strengthened through memorization, practice and activity based learning. Knowledge is acquired through perception and perception takes place through the senses. Knowledge develops if the information perceived is retained in the mind. But if the information is destroyed or fades away quickly then knowledge cannot develop. Thus, retention is the preservation factor of the mind (Godwin, 2014). As such, this study was interested in verifying the effect of HWBM on students' retention ability in Physics.

2.6 Academic Performance in Physics

Academic performance refers to the quality of results of students that is reflected in their examination scores. Academic performance is how well an individual is able to demonstrate desired abilities. The quality of scores on the part of students' academic performance in science is influenced by a number of factors which improve it to the desired level or standard. Performance measures the behaviours or an aspect of a feat that can be observed at a specific period (Sunday & Kola 2014). Josiah (2012) opined that performance of students in Physics in most certified examinations bodies like the West African Examination council (WAEC), National Examination Council (NECO) have not been satisfactory and these have been attributed to many factors which include utilization of inappropriate teaching methods in schools. Usman (2000) revealed that low academic performance among students in Science (Physics inclusive) to be as a result of use of teacher-centered method which lead to poor academic performance, retention and acquisition of requisite skills. There are several documentations about academic performances in science education among secondary school students in connection with various instructional strategies. Hence, this study was interested in verifying the effect of HWBM on retention and academic performance among Physics students in Zaria education zone Kaduna state, Nigeria.

2.7 Retention and Academic Performance

Isa (2018) revealed that information stored in the long term memory can be described as information retained and could be measured through performance. In other word, learner must retain the learned materials for some moment before he or she can be able to retrieve the information and perform positively in any corresponding evaluation task. Hence, the students' retention ability should be strengthened. As such, this study examined whether retention could be enhance through combined direct instruction, sharing, memorization, practice and immediate feedback as contained in HWBM.

2.8 Gender and Academic Performance in Physics

According to Filgona and Sababa (2017), gender is the range of physical, biological, mental and behavioural characteristics pertaining to and differentiating between the feminine and masculine (female and male) population. In other word, gender does not refers to only sex difference between male and female but the entire physical, biological, mental and behavioural characteristics that differentiate between male and female. Gender has been identified as one of the predictor variable that may be factored in students' academic performance as well as retention and captured the interest of educators in Nigeria, especially now that gender equity is being emphasized in many quotas. Gender, as a concept, becomes a topic of discussion and captures the interest of educators in Nigeria, due the socio-cultural differences manifested between male and female in which some vocations and professions have been voluntarily surrendered to men while others have been surrendered to women. Difference in treatment through education creates and sustaines gender gap, which also becomes visible in the science related disciplines.

Several studies have documented gender sensitivity in the favour of male students while others reported females' superiority and others still, zero disparity. Filgona and Sababa, (2017) investigated the Effect of Gender on Senior Secondary School Students' Academic Achievement in Geography when Mastery Learning Strategy and Conventional Method are used for instruction. The study revealed that Female students exposed to learning Geography through Mastery Learning Strategy performed better than their Male counterparts.Contrarily, Khairulanuar et al. (2010) found gender differences in favour of male students. On the other hand, Afolabi and Akinbobola, (2012) the effect of action learning strategy on students' academic achievement in Nigerian senior secondary school Physics. The findings showed that gender has no significant effect on the academic performance of Physics students taught with action learning and problem-based learning strategies. Hence, studies on gender and students' academic performance are conflicting and inconclusive. As such, the researcher was interested to find out if HWBM is gender friendly or bias.

2.9 Overview of Similar Studies

This study aimed at investigating the effects of Herrmann Whole-Brain model on retention and academic performance among secondary school Physics students in Zaria education zone Kaduna, Nigeria. However, there are various empirical studies conducted in Nigeria or elsewhere in the world which are either directly or indirectly similar or related to this study. Hence, the researcher looked at some of these studies one after the other as follows:

Ozden and Gultekin (2008) investigated the effects of brain-based learning in a 5th grade Science course on academic achievement and retention of previously acquired knowledge. This experimental study, which was designed as pre- and post-test control

group model, was conducted in 2004-2005 academic year at Kütahya Abdurrahman Paşa Primary School in Kütahya, Turkey. Two classes, namely 5-A and 5-B, were determined as experimental and control groups respectively. The participants of this study were 22 fifth graders from each group. The study lasted 11 days for a total of 18 class hours. During the research process, the experimental group was administered a brain-based learning approach, while the control group was administered a traditional teaching approach. Analysis of post-test and retention level tests revealed a significant difference between the groups favoring brain-based learning. The study is similar to the present study as it examined the effect of Brain-Based Learning strategy on knowledge retention in science using lecture method as control. However, the study was conducted in Kütahya, Turkey while the present study was conducted in Kaduna, Nigeria. Also, the study used relatively small population leaving moderate population as a gap which the present study addressed.

Serap and Melek (2009) determined the effect of learning organized instruction which designed according to the brain based learning on achievement, retention, attitude and the learning process. The study was conducted in Gazi University, Ankara, Turkey. Control grouped pre-test post- test experimental design has been applied in the research with 40 participants in each group and qualitative data related to the learning process has been reached with an interview technique. The research revealed that brain based learning environment has a positive effect on the higher level learning, retention of the learning and the attitude toward course of the university students. The study is similar to the present study as it examined the effect of Brain-Based Learning strategy on knowledge retention in science using lecture method as control. However, the study was conducted in Gazi University, Ankara, Turkey while the present study was conducted in Kaduna,

Nigeria. Also, the study used relatively small population leaving larger population as a gap which the present study addressed.

Alao and Abubakar (2010) investigated gender enrolment gap and academic performance of college Physics students. A sample of eighteen female and eighteen male students were purposively selected as sample from the department of Physics/Computer science education of Federal college of Education (Technical), Omoku in Rivers state in the 2007/2008 academic session. The cumulative grade point average (CGPA) of the sample was analysed using mean, standard deviation and percentages. Four hypotheses formulated were tested using t-test. It was revealed that there was no statistical significant difference in academic performance between female and male students. Based on this, it was recommended that teachers in the department of Physics/Computer should still improve on their pedagogy skills so as to be able to impact on the students, stressing the importance of Physics in Technology, giving them the necessary motivation to learn especially in their introductory courses. The study is similar to the present study as it compered gender and academic performance of physics students. However, the study was conducted at post-secondary school level in Rivers state while the present study was conducted at secondary school level in Kaduna state. The study also concentrated on academic performance leaving other dependent variables such as retention unaddressed which the present study addressed.

Duman (2010) investigated the effects of Brain-Based Learning (BBL) on the academic achievement of students with different learning styles in Muğla/Turkey. The study group consists of students from the Department of Social Sciences Teacher Education in the Faculty of Education at Muğla University (N=68). In the study, a pre-test-post-test experimental design was used. Data were collected by using academic achievement tests

and the Kolb's Experiential Learning Style questionnaire. The findings of the study revealed that the BBL approach was more effective in increasing students' achievement than the traditional approach and no significant difference was observed among the achievement levels of the experimental group students with different learning styles. The study is similar to the present one as it measured the effects of Brain-Based Learning verses traditional lecture method using quasi – experimental design. However, the study was limited to university level in turkey leaving a gap at secondary school level which the present study bridged.

Bawaneh et al. (2011) investigated the effect of Herrmann Whole-Brain Teaching Method over conventional teaching method on eight graders in their understanding of simple electric circuits in Jordan. Participants (N= 273 students; M=139, F=134) were randomly selected from Bani Kenanah region-North of Jordan and randomly assigned to both teaching methods (Hermann Whole-Brain Teaching Method =135, Conventional Teaching Method =138). A multiple choice concept test was developed measuring misconceptions commonly held by eight grade students on simple electric circuits. The mean score of the experimental group and that of the control group was 10.96 and 8.31 respectively. The data generated were analyzed using t-test, ANCOVA and Post Hoc analysis at 0.05 level of significance. The results showed that Hermann Whole-Brain Teaching Method was more successful than the conventional teaching method in fostering students' understanding of simple electric circuits. However, there was no significant differences attributed to gender or interaction between methods and gender on student' understanding of simple electric circuits. The results suggest that curriculum developers and textbook authors are advised to take into account students' learning styles and characteristics of brain parts as illustrated by Hermann Whole-Brain Model in the curricula and textbooks they develop. Teachers are also recommended to focus on

individual differences among students and respond to their learning styles during science lessons. Like the present study, the study measured the effects of Herrmann's Whole-Brain Teaching Method (HWBTM) verses lecture method. However, the study left some variables such as retention and academic performance unaddressed which the present study addressed. Also the study was conducted in Jordan while the present study was conducted in Zaria education zone, Kaduna state Nigeria.

Awolola (2011) investigated the effect of Brain-Based Learning strategy on the achievement regarding the learning of Mathematics of 522 Senior Secondary School Students in Oyo State, Nigeria. The study also examined moderator effect of cognitive style on independent variable (instructional strategy) and dependent variable (mathematics achievement). The study adopted a pretest-posttest non-equivalent control group design in a quasi – experimental setting. The study adopted a pretest-posttest non-equivalent control group design in a quasi – experimental setting. The ANCOVA statistic was used to analyze the data collected from the study. The result showed that Brain-Based Instructional strategy enhanced students' achievement in mathematics more than the conventional lecture method. Similar to the present, the study measured the effects of Brain-Based Learning verses lecture method using quasi – experimental design. However, in the study ANCOVA statistic was used while t-test independent was used for the present study. Also the study was limited to senior secondary school mathematics students in Oyo state leaving senior secondary school Physics students in the state and other States untouched. This is another significant gap that the present study filled.

Bawaneh et al. (2012) investigated the effect of Herrmann Whole Brain Teaching Method (HWBTM) to enhance eighth grade students' motivation towards science learning in Jordan. The randomly selected sample (N=357) including students within the Bani,

Kananah Directorate of Education Jordan. One hundred eighty-three (Male = 98, Female = 85) students were instructed using HWBTM whereas hundred seventy-four (Male = 82, Female = 92) students were taught how to use the Conventional Teaching Method (CTM). Two instruments were developed: 1) Thinking Preference Questionnaire to classify participants based on their preferred thinking styles; and 2) Student's Motivation towards Science Learning Questionnaire. Data were analyzed using a 2-way ANCOVA and Post Hoc with split file techniques and a significance threshold (α) of 0.05 using the SPSS software package. The results showed that HWBTM surpassed the CTM in enhancing students' motivation towards science learning. The results showed that there are no statistical significant differences amongst the students' preferred thinking styles across HWBTM on students' motivation towards science learning and there are differences across CTM. The results also showed that the main effect of students' gender on the post test score of students' motivation towards science learning were not found statistically significant. Like the present study, the study measured the effects of Herrmann Whole Brain Teaching Method (HWBTM) verses lecture method. In contrary to the present study, the study was limited to students' motivation leaving other variables such as retention and academic performance unaddressed which the present study addressed. Also the study was conducted in Jordan while the present study was conducted in Zaria education zone, Kaduna state Nigeria.

Haghighi (2012) investigated the effects of brain-based learning in sophomore students majoring in Aircraft Repair & Maintenance on academic achievement and retention. This experimental study, which was designed as pre- and post-test control group model, was conducted at Civil Aviation Technology College in Tehran, Iran. The study lasted 16 weeks for a total of 63 class hours. During the research process, the experimental group was administered a Brain-Based Learning Approach, while the control group was administered

a traditional teaching method. Analysis of post-test achievement and retention tests revealed a significant difference between the groups favouring Brain-Based Learning. The study is similar to the present study as it investigated the effects of Brain-Based Learning verses traditional teaching method using Control Grouped pre-test post- test quasi – experimental design. Similar to the present study, the study investigated the effects of Brain-Based Learning approach on retention. However, the study was conducted in Tehran, Iran while the present study was conducted in Nigeria. Also, the study was conducted at Aviation Technology College while the present study was conducted at senior secondary school level.

Uyangör (2012) examine the influence of the 4MAT teaching model which depends on learning styles that have been generated by the help of the relationship between the brain and learning; and focuses on the learning loop as a centre upon students' level of mathematics course achievement; and the level of attitudes towards mathematics in the unit of the Hoop and Circle. An experimental pattern model with a pre-test, post-test control group has been used in this research. The sample of this study comprised 81 students from the 7th grade at Public School in Balıkesir during the 2009-2010 academic session. The findings of this study implied that 4MAT method of instruction was more efficient than the traditional method. The study is similar to the present study as it examine the influence of Brain-Based Learning verses traditional teaching method using pre-test post- test Control Group design. However, the study was conducted in Balıkesir, Turkey in the field of mathematics while the present study was conducted in Nigeria in the field of Physics. Also, the study concentrated on achievement and attitudes leaving a gap for other variables such as retention and academic performance which the present study addressed.

Akyürek and Afacan (2013) examined the effect of Brain-Based Learning Approach on attitudes and motivation levels in 8th grade students' science classes in Kirsehir/Turkey.

Pre/post-test control group research model was used in the study. The research was conducted with one experimental group and two control groups in 2011-2012 academic years. Totally 57 students, 19 in experimental group, 19 in each control groups participated in the research. The study took place during the teaching of 'cell division and heredity' with the science class. In the experimental group, students were taught according to the current science and technology curriculum. As a result, using Brain-Based Learning Approach the experimental group's success was found to be significant differences in favour of the experimental group. Brain-Based Learning Approach used in the experimental group's achievement test scores of control groups' achievement was determined to be statistically significant difference in favour of the experimental group. The study is similar to the present study as it examined the effects of Brain-Based Learning Approach. However, the study was limited to Kirsehir/Turkey and concentrated on attitudes and motivation leaving a gap for other variables such as retention and academic performance which the present study addressed.

Ozlem (2014) investigated the advantages of brain based learning in ELT classes. The participants consisted of 90 university students at Dokuz Eylul University in the city of Izmirin, Turkey. Their ages ranged from 19-22. The participants were pretested, treated and post-tested using questioner. The results obtained from the pretest and post-test were analysed in an effort to explore whether brain-based learning intervention exerts impact on the improvement of participants in listening, reading and speaking of English language. The results obtained from the data analysis shows significant improvement of participants in listening, reading and speaking of English language. The paper proposes that the role of brain based learning help students and colleagues to study their lessons more effectively and help them to be more successful. Hope this study will help new colleagues to prepare useful lesson plans. The study is similar to the present study as it

examined the impacts of Brain-Based Learning strategy. However, the study was conducted in Dokuz Eylul University in the city of Izmirin, Turkey while the present study was conducted in Kaduna, Nigeria. Also, the study concentrated on Students' attitudes and perceptions leaving other variable such as retention and academic performance as a gap which the present study addressed.

Thomas and Swamy (2014) investigated the impact of brain-based teaching approach (BBTA) on the academic achievement of the secondary school students in relation to their issues related to stress. The study adopted quasi- experimental design. The sample constitutes 87 secondary school students of a private aided school in Bangalore city. The sample was grouped statistically into experimental group and control group. The researcher taught the experimental group whereas the control group by the class teacher. The researcher based on the three techniques of BBTA taught the lessons: techniques are namely Relaxed Alertness (RA), Orchestrated Immersion (OI) and Active Processing (AP). The null hypotheses were tested using t-test statistical tool at 0.05 level of significance. The findings revealed significant difference in the mean scores of the experimental and control group in favour of the experimental group. The result of the comparison of boys and girls on their academic scores showed that girls possessed higher mean scores than the boys. The findings led to the conclusion that the brain based teaching approach used in the experimental group gave better impact on their academic achievement. The study is similar to the present study as it examined the effect of Brain-Based Learning strategy on academic achievement of the secondary school students. However, the study was conducted in Bangalore city, Karnataka, India while the present study was conducted in Kaduna, Nigeria. Also, the study concentrated on academic achievement leaving other variables such as retention as a gap which the present study addressed.

Bülbül and Özsoy (2015) determine the effect of the 4MAT teaching model on students in fine arts high school two dimensional art studio classes. This study was designed as a model case sample (purposeful sampling method) and it was conducted in a two dimensional art studio class in a fine arts high school. The study case consisted of eight 9th graders. After 14-week of practice process, the students' perceptions and reactions about the model were assessed. The data were collected by the researchers by a semi-structured interview and an open- ended questionnaire after the interview. Content analysis method was used to analyze the data. The finding of the study revealed that the 4MAT teaching model had a positive effect on the students' perceptions and reactions toward 4MAT teaching model. The study is similar to the present study as it examined the effects of Brain-Based Learning Approach. However, the study was limited to Turkey in the field of fine arts leaving a gap for other subjects such as Physics. Also, the study concentrated on students' perceptions and reactions leaving a gap for other variables such as retention and academic performance which the present study addressed.

Melani (2015) investigated the influence of Whole Brain Teaching (WBT) method in improving students English vocabulary mastery at the seventh grade students in Agung, Sumber. The methodology of the research is quantitative and used pre- experimental one group pre-test and post-test design. The population was 60 students out of which 33 students were sampled. The researcher used t-test statistical tool with the aid of SPSS version 16. The findings of study revealed that the usage of whole brain teaching method improved students English vocabulary mastery at the seventh grade students in Agung, Sumber. Cirebon, Indonesia. Based on the findings, the reseacher concluded that there is positive and significant influence of using whole brain teaching method on the students' mastery in learning English vocabulary. Similar to the present study, the study investigated the impact of Whole Brain Teaching verses lecture method adopting quasi-

experimental design using t-test statistical tool to test the null hypotheses in the study. However, the study was conducted in Indonesia and found Whole Brain Teaching worthy. Since Whole Brain Teaching is found worthy in Indonesia, there is need for such study in Nigeria especially in Zaria education zone, Kaduna state.

Edward (2016) worked on a topic English as a Foreign Language through Whole Brain Teaching (WBT) in primary school in Tarragona, Spain. The study measured the changes in the English command of the learners and the changes in their motivation. The study was conducted in Escola Joan Ardvol School with the total population of 450 students. The study was a quasi-experimental designed with a control group. Two groups were selected using random sampling. The experimental group received it through Whole Brain Teaching techniques while the control group received it through lecture method. The study used Mann Whitney U-test and Linear Regressions for data analysis. The findings of this study implied that Whole Brain Teaching had much more effect on students' English command and motivation compared to lecture method. However, the study was limited to Tarragona. Since WBT is found worthy in Tarragona, Spain there is need for such study in Nigeria particularly Zaria education zone. The study concentrated on motivation while other variables such as retention and academic performance are left behind. Also, the study concentrated on English language leaving other subjects such as Physics as a gap. Hence, there is need to establish relationship between HWBM and retention and academic performance in Physics concept in Nigeria. The present study attempted fill these gaps.

Mahnaz and Mahbobeh (2016) investigated the effects of brain-based training on learning and retention of life skills in adolescents. This experimental study was designed as a pre-post-test with a control group model and was conducted at the Center for Intellectual

Development of Children and Adolescents in Iran/Isfahan in the academic year of 2014-2015. Two groups were selected each of 10 participants using random cluster sampling. During the research process, the experimental group received a brain-based training package (in 10 sessions) while the control group continued with their regular training. Results: Multivariate analysis of covariance (MANCOVA) was used to compare the pre-test and posttest results. A significant difference was observed between the two groups of this study in learning ($F= 22.906$, $P<0.01$) and retention ($F=34.744$, $P<0.01$). Conclusion: The findings of this study imply that brain-based training had much more effect on students' learning and retention compared to traditional training. The study is similar to the present study as it examined the effect of Brain-Based Learning strategy on knowledge retention in science using lecture method as control. However, the study was conducted in Isfahan, Iran while the present study was conducted in Kaduna, Nigeria. Also, the study used relatively small population leaving larger population as a gap which the present study addressed.

Clark (2016) examined the relationship between different levels of exposure to Whole Brain Teaching (WBT) techniques and the mean difference in Academic Self-Concept (ASC), as measured by the general-school, mathematics, and reading sub-scores on the Self-Description Questionnaire I, between treatment conditions. Self-concept theory as posited by Shavelson et al. and the Marsh/Shavelson revision, the skill development approach to self-concept enhancement, and the reciprocal effect model provide the theoretical foundations of this dissertation. A one-way multivariate analysis of variance (MANOVA) was used to determine if the mean ASC scores differed among 191 second and third grade students exposed to three levels of the WBT factor. Results of the three-group MANOVA failed to support use of WBT techniques to improve ASC. Reconfiguration of the quasi-independent variable into two groups revealed that general-

school ASC scores were significantly lower in the group exposed to limited to no WBT techniques. Assessing students at risk for educational problems may reveal more convincing evidence for WBT as an effective ASC intervention. The implications for social change include encouraging WBT practitioners to make more empirically sound claims and decisions regarding their practice, thereby allowing students an educational experience grounded in scientific findings, rather than subjective assumptions. The study is similar to the present study as it examined the effects of Whole Brain Teaching. However, the study was limited to California, USA and concentrated on academic self-concept leaving a gap for other variables such as retention and academic performance which the present study addressed.

Olaoluwa and Ayantoye (2016) investigated the impact of Brain-Based Instructional Strategy on academic performance of students who are deaf or hard of hearing (D/HH) in mathematics. A pre-test, post-test, control group quasi-experimental design was adopted with a 2 x 3 x 2 factorial matrix. Forty-one students in each group who are deaf or hard of hearing participated in the study in the ratio of male to female is 7:5. Two intact classes each were randomly assigned to the experimental group (Brain-Based Instructional Strategy-BBIS) and the Control Group respectively. The instruments used were, Mathematics Attitude Questionnaire (r = 0.81), Cognitive Style Test (r = 0.80), and Mathematics Anxiety Rating Scale (r = 0.81). Three research questions guided the study. Data obtained were analyzed using descriptive statistics of mean scores and standard deviations to explain and compare pretest and posttest scores of the experimental and control groups in all the criteria measured. Brain-Based Instructional Strategy was more effective at improving students' attitude to mathematics than the conventional method. The findings of the study also indicated that tension and test-phobia which normally permeates the teaching-learning process of mathematics was highly reduced due to the

optimal use of diverse brain compatible instructional materials among students who are D/HH. The study is similar to the present study as it investigated the effects of Brain-compatible Learning Approach on academic performance verses lecture method. However, the study was limited to deaf or hard of hearing students in the field of mathematics leaving the field of Physics untouched and concentrated on academic performance leaving a gap for other variables such as retention which the present study addressed.

Osama, Fahad and Ayman (2016) examined the effect of 4MAT method on academic achievement and attitudes toward engineering for undergraduate students in Saudi Arabia. Comparison between 4MAT and traditional method in teaching selected units from engineering course had been conducted. The sample of this study included 80 under graduate students in two separate groups. One of the groups was considered as an experimental group in which 4MAT method was applied; and the other was considered as a control group in which the traditional teaching has been delivered. Data was obtained from two scales, engineering attitude scale and knowledge test on foundations of engineering and present worth analysis units. The findings of this study revealed that students who are guided through 4MAT are exposed to a variety of learning experiences and increased chances for academic achievement and attitudes toward engineering. In addition, 4MAT method provides a rational foundation for faculty members, who might have hesitated to bring creativity into the classroom, and to develop activities beyond the traditional lecture. Also, the application of 4MAT in engineering classroom leads to renewed interest for the educational process and a greater commitment to teaching and learning. The study is similar to the present study as it examine the effects of Brain-Based Learning verses traditional teaching method. However, the study was conducted in Saudi Arabia in the field of engineering leaving other field of studies such as Physics. Also, the study concentrated on

academic achievement and attitudes leaving a gap for other variables such as retention which the present study bridged.

Oghyanous (2017) investigated the effect of Brain-Based teaching on the self-efficacy of young EFL learners in Iran. The initial participants of the study were 90 learners within the age range of 13-16 who were selected based on convenience sampling. The 90 young EFL learners were given a Flyers test the scores of which were used to choose 60 homogeneous learners whose scores fell within the range of +/- one standard deviation from the mean. The 60 selected learners were then divided into experimental and control group. A Self-Efficacy Questionnaire for Children (SEQ-C), developed by Muris (2001) was administered to the participants in both groups before and after the treatment after being translated into Persian and piloted for reliability check. To implement brain-based teaching in the experimental group. The researcher taught the lessons based on the three techniques of Brain Based Teaching Approach (BBTA). The three techniques used were Relaxed Alertness (RA), Orchestrated Immersion (OI) and Active Processing (AP) in line with Thomas and Swamy (2014). The results of statistical analyses indicated that Brain-Based Teaching Approach had a significant effect on students' self-efficacy. Similar to the present, the study measured the effects of Brain-Based Learning verses traditional lecture method using quasi – experimental design. Unlike the present study, the study was conducted in Iran. Since BBLA is found worthy in Iran, there is need for such study in Nigeria. The study measured effect of brain-based teaching on self-efficacy leaving a gap for measuring effect of brain-based teaching on other variables such as retention and academic performance in which the present study filled.

Uzezi and Jonah (2017) examined the effect of Brain-Based Learning strategy on students' academic achievement, attitude, motivation and knowledge retention in Electrochemistry. The study used a pretest-posttest quasi-experimental design. A total of

87 SSII students from two intact classes from North-Eastern part of Nigeria. One of the classes served as the experimental group that used Brain-Based Learning (N=40) while the other was control group that used Lecture-Based Teaching method (N=47). The data collected were analyzed with means, independent t-test, and Analysis of Covariate which were used to compare the groups' scores. The findings of the study revealed that the difference between retention test scores was statistically significant in favour of experimental group. The study is similar to the present study as it examined the effect of Brain-Based Learning strategy on knowledge retention in science using lecture method as control. However, the study was conducted in North-Eastern part of Nigeria while the present study was conducted in Kaduna state (North-central). Also, the study used relatively small population leaving larger population as a gap which the present study addressed.

Afolabi and Olajuyigbe (2018) investigated to what extent can constructivist instructional strategies bridge gender gap in physics classroom. The study adopted a quasi-experimental research design with 194 SSII Physics students as participants. Physics Achievement Test (PAT) was used for data collection with reliability coefficient of 0.76. It was discovered from the analysis that using appropriate teaching approaches helped female students to learn and remember facts, apply skills, comprehend concepts, analyses and synthesises principles which are cognitive objectives of physics education. Recommendations and suggestions were proffered. The study is similar to the present study as it worked on gender gap in Physics classroom. However, the study failed to investigate how gender affects retention among Physics students which the present study addressed.

Sontillano (2018) determined the impact of Whole brain teaching (WBT) on academic performance of grade 8 students in Algebra. Quasi- experimental research method, specifically, pretest-posttest with control group using matched- subject design was employed in the study. Two heterogeneous classes were randomly selected and assigned as experimental and control groups. Pretest and posttest were used in measuring the academic performance of the students. The experimental group received instructions using WBT techniques whereas the control group underwent the same pacing and content using conventional teaching techniques. The data gathered was analysed using t-test statistical tool at 0.05 level of significance. Based on the result, the students' academic performance increased significantly after subjecting them to WBT techniques and conventional teaching techniques. However, results of the posttest comparison of both groups showed that there was a statistically significant difference between the academic performance of experimental and control groups in favor of the experimental group. Thus, Whole brain teaching has a positive impact on academic performance of grade 8 students in Algebra. The study is similar to the present study as it investigated the effects of Whole brain teaching (WBT) verses traditional teaching method using Control Grouped pre-test post- test quasi – experimental design. However, the study investigated the effects of Whole brain teaching (WBT) on academic performance leaving a gap for other variables such as retention which the present study addressed. Also, the study was conducted in Philippines while the present study was conducted in Nigeria. Furthermore, the study concentrated on the concept of algebra in mathematics leaving a gap for other subjects such as Physics which the present study addressed.

Nwankwo, Chinyere and Nonye (2019) investigated gender difference in Physics conceptual change and retention scores: a case study of metaconceptual teaching approach (MTA). The study used a quasi-experimental non-randomized non-equivalent

control group research design. Two research questions and two hypotheses guided the study. The sample for the study was sixty-eight SS 2 physics students (30 males & 38 females) drawn through multi-stage sampling approach from 65 public secondary schools in Abakiliki Education Zone of Ebonyi State, Nigeria. The relevant data for the study was collected using a Thermal Concept Evaluation (TCE) adapted from Zadnik and Yeo (2001) which was re-validated by three experts. The reliability of the instrument was established using Kuder-Richardson 20 which yielded a reliability index of 0.69. To answer the research questions, mean and standard deviation were used while the hypotheses were tested at 0.05 alpha level using Analysis of Covariance (ANCOVA). The findings of the study showed no significant gender difference in physics conceptual change and retention scores of students when taught the concepts of heat and temperature using MTA. Based on the findings, recommendations made which included among others, that MTA, being gender-friendly, should be incorporated in teaching of sciences, especially physics, in Nigerian secondary schools by physics teachers. The study is similar to the present study as it examine gender difference and retention in Physics using quasi-experimental design. However, the study was conducted in Abakiliki education zone of Ebonyi state while the present study was conducted in Zaria education zone Kaduna state. Also, the study concentrated on retention leaving a gap for other variables such as academic performance which the present study addressed.

Escultura and Ricafort (2019) determined the effectiveness of Whole Brain Teaching Strategy in learning Wave topics among grade 7 students. The pre-test-post-test quasi-experimental design utilizing Solomon Four Groups was used to carry out this study. The results revealed that the level of performance of the control group and experimental group in the pre-test were the same. There was no significant difference between the pre-test results of the control and experimental group. There were better improvements in the

post-test performance of the students in the experimental groups. There was a significant difference between the performance in the pre-test and post-test results of the two groups of respondents. Experimental group showed a better performance than the control group. There was a significant difference among the performance of the four groups in the post-test. The study concluded that WBTS is more effective to improve students' performance. The study is similar to the present study as it investigated the effects of Whole brain teaching (WBT) verses traditional teaching method using Control Grouped pre-test post-test quasi – experimental design. However, the study was conducted in Philippines while the present study was conducted in Nigeria. Also, the study investigated the effects of Whole brain teaching (WBT) on academic performance leaving a gap for other variables such as retention which the present study addressed.

2.10 Implications of Related Literature Reviewed to the Present Study

According to Akinbobola (2009), an average science teacher in a classroom in Nigeria is confronted with the problem of selecting and using appropriate instructional strategy to disseminate idea to his students and how to make curriculum more relevant to the lives and experiences of the learner which are serious hindrances to effective teaching and learning of science (Physics inclusive). In an effort to curtail this problem, several studies suggested the use of various strategies in which some are reviewed in this study. The literature reviewed in this study show that use of Herrmann's Whole brain teaching method enhances academic performance of students through active participation of the students, attention getting techniques, immediate feedback and motivational strategy in the lesson.

From the literature reviewed so far, there is clear evidence that Herrmann's Whole Brain Model is more effective compared with the traditional method of teaching. However,

majority of the studies reviewed are foreign studies (Bawaneh, et al., 2011; Bawaneh, et al., 2012; Clark, 2016; Edward, 2016; Melani, 2015; Sontillano, 2018) only few of such studies are local. Hence, there was need for such studies in Nigeria.

The literature reviewed so far shows that most of the studies such as (Bawaneh, et al., 2011; Bawaneh, et al., 2012; Clark, 2016; Edward, 2016; Melani, 2015; Sontillano, 2018) concentrate more on Academic self-concept and motivation. There were a little attempt to investigate the effectiveness of Herrmann's Whole Brain Model on students' academic performance and retention. Therefore, there was need for bridging this gap. Hence, this study investigated the effects of Herrmann's Whole Brain Model on retention and academic performance among Physics students in Zaria education zone Kaduna state, Nigeria in other to fill the gap.

Unlike the present study, most of the studies reviewed concentrated on brain-based teaching strategies/model other than Herrmann's Whole Brain Model (Thomas & Swamy, 2014; Mahnaz & Mahbobeh, 2016; Olaoluwa & Ayantoye, 2016 & Uzezi & Jonah, 2017) which encompasses not only active participation of the students but also attention getting techniques and motivational strategy in the lesson and involves learning with whole brain. This was another gap which the present study addressed.

From the literature reviewed so far, there is clear evidence that most of the studies reviewed were conducted at primary and tertiary levels which are of different age group from the students in secondary school level (Bawaneh et al., 2011; Bawaneh et al., 2012; Clark, 2016; Edward, 2016; Melani, 2015; Sontillano, 2018) leaving secondary school level as a gap for further studies. Hence, there was need for bridging this gap. As such, this study investigated the effects of Herrmann's Whole Brain Model on retention and

academic performance among Physics students in Zaria education zone Kaduna state, Nigeria in other to fill the gap.

The literature reviewed so far prove that most of the studies reviewed were conducted in English language, mathematics and some field of studies other than Physics (Clark, 2016; Edward, 2016; Melani, 2015 & Sontillano, 2018). This is another significant gap which the present study addressed.

From the literature reviewed so far, there is clear evidence that most of the studies reviewed analyzed data using some statistical tools other than t-test such as Mann Whitney U-test, Analysis of Co-variance (ANCOVA) and Multiple Analysis of Co-variance (MANOVA) (Bawaneh et al., 2011; Bawaneh et al., 2012; Clark, 2016; Edward, 2016; Melani, 2015). This is also another significant gap which the present study addressed. In other bridge these gaps, the researcher investigated the effects of Herrmann's Whole Brain Model on retention and academic performance among Physics students in Zaria education zone Kaduna state, Nigeria.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter contains a description of the research design, methodology and procedure for the study and it is presented under the following sub-headings:

3.2 Research Design

3.3 Population of the Study

3.4 Sampling and Sampling Techniques

3.5 Instrumentation

3.5.1 Wave Performance Test (WPT)

3.5.2 Validity of the Instruments

3.5.3 Pilot Study

3.5.4 Reliability of the Instruments

3.5.5 Item Analysis

3.6 Administration of the Treatment

3.7 Procedure for Data Collection

3.8 Procedure for Data Analysis

3.2 Research Design

The design for this study is pre-test, posttest, and post-posttest quasi-experimental research design. This design involves the tagging of two groups, one as experimental group and the other as control group. Both groups were pretested to ensure equality of the groups in the study concepts before giving the treatment. The use of equivalent groups was important in the sense that any difference(s) observed between the groups after the treatment would be associated to the different treatment received by each group. The experimental group (EG) was exposed to the wave concepts using HWBM for six weeks while the control group was exposed to the same concepts using lecture method for the same period. A post-test was administered to both groups in other to determine if there was any significant difference in students' academic performance between the groups in wave concepts. Two weeks after the posttest administration, a post-posttest was administered to both groups in other to determine if there was any significant difference in students' retention ability between the groups in the wave concepts.

The research design is illustrated in figure 3.1

$$EG \longrightarrow O_1 \longrightarrow X_1 \longrightarrow O_2 \rightarrow O_3$$

$$CG \longrightarrow O_1 \longrightarrow X_0 \longrightarrow O_2 \rightarrow O_3$$

Figure 3.1: Research Design

Where:

EG – Experimental Group

CG _ Control Group

O_1 _ Pretest

O_2 _ Posttest

O_3 – Post-posttest

X_1 _ Herrmann's Whole-Brain Model (Treatment)

X_0 _ Lecture method

3.3 Population of the Study

The population of this study comprised all public co-educational Senior Secondary Schools (SSII) Physics students in Zaria education zone. Public Secondary Schools were used for the purpose of this study because both resources and services are distributed equally among the schools and the schools use the same academic calendar. Senior Secondary two (SSII) students were used for the purpose of this study because at this level, students are neither introductory SSI students engaging in registration, accommodation nor final year SSIII students who were deeply concentrating on mock and final year examinations. Co-educational Senior Secondary Schools were used for the purpose of this study because the schools comprise male and female students which helped in tapping information to address gender related issues. There were fifteen public co-educational Senior Secondary Schools offering Physics in the zone with total population of 1,422 students out of which 787 were males and 635 were females. Detail of the population is shown in Table 3.1below.

Table 3.1: Population of the Study

Name of School	Location	Male	Female	Total
GSS Kofar Kuyam Bana	Zaria	77	98	175
GSS Muchia (Senior)	Sabon gari	46	59	105
GSS Tudun Jukun	Zaria	60	84	144
SIASSS Karau-Karau	Giwa	33	10	43

GSSS Kaura	Zaria	65	38	103
GSS Dakace	Zaria	52	26	78
GSS Magajiya (Senior)	Zaria	78	47	125
GSS Aminu (Senior)	Sabon gari	52	71	123
GSS Gyellesu	Zaria	73	45	118
GSS Likoro	Kudan	30	15	45
GSS K/Doka	Zaria	105	90	195
GSS Yakasai	Soba	17	09	26
GSS Kugu	Zaria	32	12	44
GSS Dinya	Soba	16	4	20
GSS T/Saibu (Senior)	Soba	51	27	78
Total		**787**	**635**	**1,422**

Source: Zonal Inspectorate Division Zaria (2019)

3.4 Sample and Sampling Techniques

The sample was selected using simple random sampling. The name of each of the 15 senior secondary co-educational schools were written in a piece of paper, squeezed, put in a container and shuffled. One piece of paper was picked at a time and reshuffled in each case until four papers were selected. The names that appeared on those papers were the sampled schools. GSS Tudun Jukun, GSS Aminu, GSS Muchia and GSS Magajiya were selected at random. The sampled schools were pretested using Wave Performance Test (WPT) to ascertain the academic equivalent or parity among the groups and reduce internal validity threat which may occur due to the non-random assignment of subject into group. The scores of the schools pretested were analysed using analysis of variance

(ANOVA) by which two academically equivalent schools in the wave concepts A and B were randomly tagged as experimental and control group respectively using tossing of coin. The detail of this analysis is shown in appendix F. In each of the two schools selected, intact class was used for both treatment administration and administration of instrument so that no student would be discarded. Therefore, this study consisted of 228 students which are viable for the study based on the recommendation of Tuckman (1975). Detail of the sample is shown in Table 3.2.

Table 3.2 Sample for the Study

S/No.	Name of School	Male	Female	Total	Group
1.	School A	52	71	123	Experimental
2.	School B	46	59	105	Control
	Total	**98**	**130**	**228**	

3.5 Instrumentation

An instrument named Wave Performance Test (WPT) was developed by the researcher in the waves concepts taught from SSII Physics curriculum based on Bloom's taxonomy (1958) for the purpose of generating data.

3.5.1 Wave Performance Test (WPT)

The instrument Wave Performance Test (WPT) comprises 30 multiple choice test questions (one mark for each). Each item of the instrument carried four options (A, B, C, & D) with one correct answer. The instrument was used for the study in order to measure the students' academic performance in the concepts taught (wave concepts). The instrument was administered by the researcher with the help of two teachers during the

pretest, post-test and post-posttest for the purpose of generating data. A copy of the instrument is attached in appendix C (P. 128). The details of the instrument based on Bloom's taxonomy (1958) reflected in the table of specification (Table 3.3).

Table 3.3: Table of Specification Based on Bloom's Taxonomy.

Contents	**Weight (%)**	**Know. (30%)**	**Comp. (20%)**	**App. (13%)**	**Ana. (10%)**	**Syn. (10%)**	**Eva. (17%)**	**Total 100%**
Waves	17	3(13, 19,27)	1(14)	-	1(7)	1(12)	-	**5**
Types of waves	17	2(16, 17)	1(20)	-	-	-	2(8,10)	**5**
Properties of waves	13	1(29)	2(1,22)	-	-	-	1(15)	**4**
Wave equations	17	-	1(28)	2(11, 25)	-	1(24)	-	**5**
Snell's law	16	1(23)	-	2(3,5)	-	-	2(2,4)	**5**
Electromagnetic spectrum	20	2(21, 30)	1(26)	-	2(6,9)	1(18)	-	**6**
Total	**100**	**9**	**6**	**4**	**3**	**3**	**5**	**30**

veloped by the Researcher (2019)

Keys: Know. = Knowledge

Comp. = Comprehension

App. = Application

Ana. = Analysis

Syn. = Synthesis

Eva. = Evaluation

3.5.2 Validity of the instrument

In other to establish both content and face validation of the instrument (WPT), the instrument was given to three lecturers with the rank of Senior Lecturers and above in the Department of Science Education and one Senior Lecturer in Physics Department Faculty Of Physical Sciences, A.B.U. Zaria for the relevance justification. Forty (40) items were initially submitted and corrections were made. For example item number one was initially tagged as knowledge question and finally corrected as comprehension. Similarly item number twenty-five which was initially number thirty-three asked both period and wavelength but gave only wavelengths in the options. Also item number thirty-three was found to be out of the content and thereby discarded.

3.5.3 Pilot Testing

The instrument WPT was tried out in a pilot study in order to check the item difficulties, facility index, reliability coefficient, and discriminating index and decide for time frame for the test. The pilot test was conducted at GSS Likoro Kudan local government area Kaduna state with the population of 54 SSII Physics students (34 males and 20 females). The first submission of script was made at exactly 38 minutes after the commencement of the test and the last script was submitted at exactly 51 minutes after the commencement of the test. As such the average of these periods (45 minutes) was allocated for any test using this instrument at SSII level.

3.5.4 Reliability of the Instrument

The instrument was pilot tested at GSS likoro kudan local government area kaduna state with the population of 54 SSII students (34 males and 20 females). Out of the 54 SSII students (34 males and 20 females) of GSS likoro kudan local government area kaduna state, 52 SSII students comprised 32 males and 20 females were used for the pilot test. One-shot test was used. Hence, the scores were subjected to cronbach alpha coefficient

using statistical package for social sciences (SPSS). The reliability co-efficient of the instrument was found to be r = 0.762 which indicated that the test questions would test what it was designed to test. Hence, the instrument is reliable. The detail of this analysis is shown in appendix E (P. 138).

3.5.5 Item Analysis

Each item of the instrument was analyzed and both facility index and discriminating index were computed.

3.5.5.1 Facility Index (FI) for WPT

Facility index (FI) of a test is define as the percentage of candidates that got an item right over the total candidates that attempted the item Sambo (2008). In other word, facility index (FI) of a test item can be define as the number of candidates that got an item right out of hundreds of the total candidates that attempted the item and is given by

$$FI = R/T \times 100$$

Where FI = Facility index

R = Number of correct responses

T = Number of total responses

A good item shall be neither too simple nor highly complicated. Hence, any item with FI below 40% or above 60% were dropped out and only those items with FI within the range of 40% to 60% were used for this study. This is in line with sambo (2008). The detail of this analysis is shown in appendix G (P. 141).

3.5.5.2 Discriminating Index (FI) for WPT

Discriminating index is the ability of an item to distinguish between low and high achievers among the candidates participated in the test (the students that response to the item) and is given by:

DI = (RU – RL)/T.

Where DI = discriminating index

RU = number of students that score higher

RL = number of students that score lower

T = number of students that response to the item

The minus sign that appeared between RU and RL indicated that the discriminating index can either be positive value, zero or negative value. A good item is consider to be moderately positive. Hence, only those items with DI within the range of 0.40 to 0.60 were retained for this study. This is in line with sambo (2008). The detail of this analysis is shown in appendix G (P. 141).

3.6 Administration of Treatment

3.6.1 Treatment Administration for the Experimental Group

The experimental group was taught the wave concepts by the researcher and two research assistants (for effectiveness and efficiency of the treatment) using Herrmann's Whole Brain Model (HWBM) treatment format adapted from Sontillano (2018). This treatment format consists of seven stages lesson procedure as highlighted as follow:

Stage 1 – Introduction: (5 minutes)

The introductory part of the lesson consist of two steps as discussed as follow:

Step 1: Attention-Getting Techniques (Class Yes!) **(2 minutes)**

Before beginning every class (or lesson), the teacher used an attention getter. The teacher must say “Class” in any way or tone that they wish, then the students must mimic the teacher’s voice and respond with the word “Yes.” There are a few ways that you can do this. The teacher can say the word once or twice. For example, the teacher would say “Class, class,” and the students would respond “Yes, yes.” Another option is to switch up the word (such as “Classy class,” or “Classity class”) and say it three or four times, and the students would respond saying “Yes” in the same way. After the teacher has got the attention of the students, he moves on to step two.

Step 2 - Classroom Rules **(3 minutes)**

There are three classroom rules that students should follow. Before the instructional part of the lesson, the teacher should go over these three rules to ensure students understand. Each rule is said with a gesture. The rules are as follows.

- **Rule 1** – Raise your hand for permission to speak (raise your hand then make a talking motion with your mouth).
- **Rule 2 -** Raise your hand for permission to leave your chair (raise your hand and make a waving motion with your fingers).
- **Rule 3** – Keep your dear teacher happy.

Stage 2: Presentation (51 minutes)

Teacher presents the lesson in the following steps;

Step 1: Introduction of the Content **(8 minutes)**

The teacher introduces the content of the lesson (chunks) by the means of video show, picture/chart/diagram show, demonstration and/or story-telling. This took care of the external learning and correspond to the function of upper-left quarter of the brain.

Step 2: Individual Task: **(13 minutes)**

Teacher prepared a comprehensive note about the segments introduced (Individual task paper including; chart, diagrams & so on as appropriate) and distributed to the students. The students were given time to study the segments over and over individually for at least three minutes and were encouraged to comprehend not to just memorize. This took care of the external learning and correspond to the function of upper-left quarter of the brain due to the fact that the students learn from external body (the note). It also took care of the procedural learning and correspond to the function of lower-left quarter of the brain due to the fact that the note is step by step structured and is studied individually and repeatedly.

Step 3: Group Task: **(20 minutes)**

The teacher grouped the students (4-5 students per group), shares the group task sheets and guided them to interact, discuss, share ideas and put the information in their own words about the same chunks. This took care of the interactive learning and correspond to the function of lower-right quarter of the brain.

Step 4: Scoreboard game **(10 minutes)**

The teacher played scoreboard game with the students (teacher vs students). This took care of the internal learning and correspond to the function of upper-right quarter of the brain. Scoreboard game is a classroom engagement game that was played between the teacher and the students (Teacher versus students). In the Scoreboard game, a scoreboard

is drawn on one side of the board (Teacher versus students). The teacher asked questions base on the information on the segment for the students to answer. If the students answer a question right they get their points otherwise the points goes to the teacher. This took care of the internal learning and correspond to the function of upper right quarter of the brain. Scoreboard game helps the teacher to identify the missing part of the lesson (If any) and prepare for re-teaching. Reward was given to the students at the end of the each lesson. However, the rewards are not extrinsic. Recommended rewards include a little less assignment, the ability for students to choose their own seats, or time to play a game.

Stage 3: Movement/Celebration (4 minutes)

Teacher allowed the students to make one minute movement to celebrate their performance and give room for questions. This movement increases the level of oxygen in the blood which consequently increases the flow of blood to the brain for better performance of the brain.

Stage 4: Evaluation (10 minutes)

Teacher evaluated the lesson by asking questions based on the behavioural objectives of the lesson.

Stage 5: Conclusion (10 minutes)

Teacher concluded the lesson by summarizing the main points or missing part(s) if any.

There is hope that the treatment given provided the students with the opportunity to learn with whole brain (upper-left quarter, lower-left quarter, lower-right quarter and upper right quarter of the brain). Learning with whole brain is the emphasis of Herrmann's Whole Brain Model and help learners to attend neuroplasticity. The summary of the

given treatment is shown in figure 3.2 and the lesson plan for this treatment is cited in appendix A (Page 85).

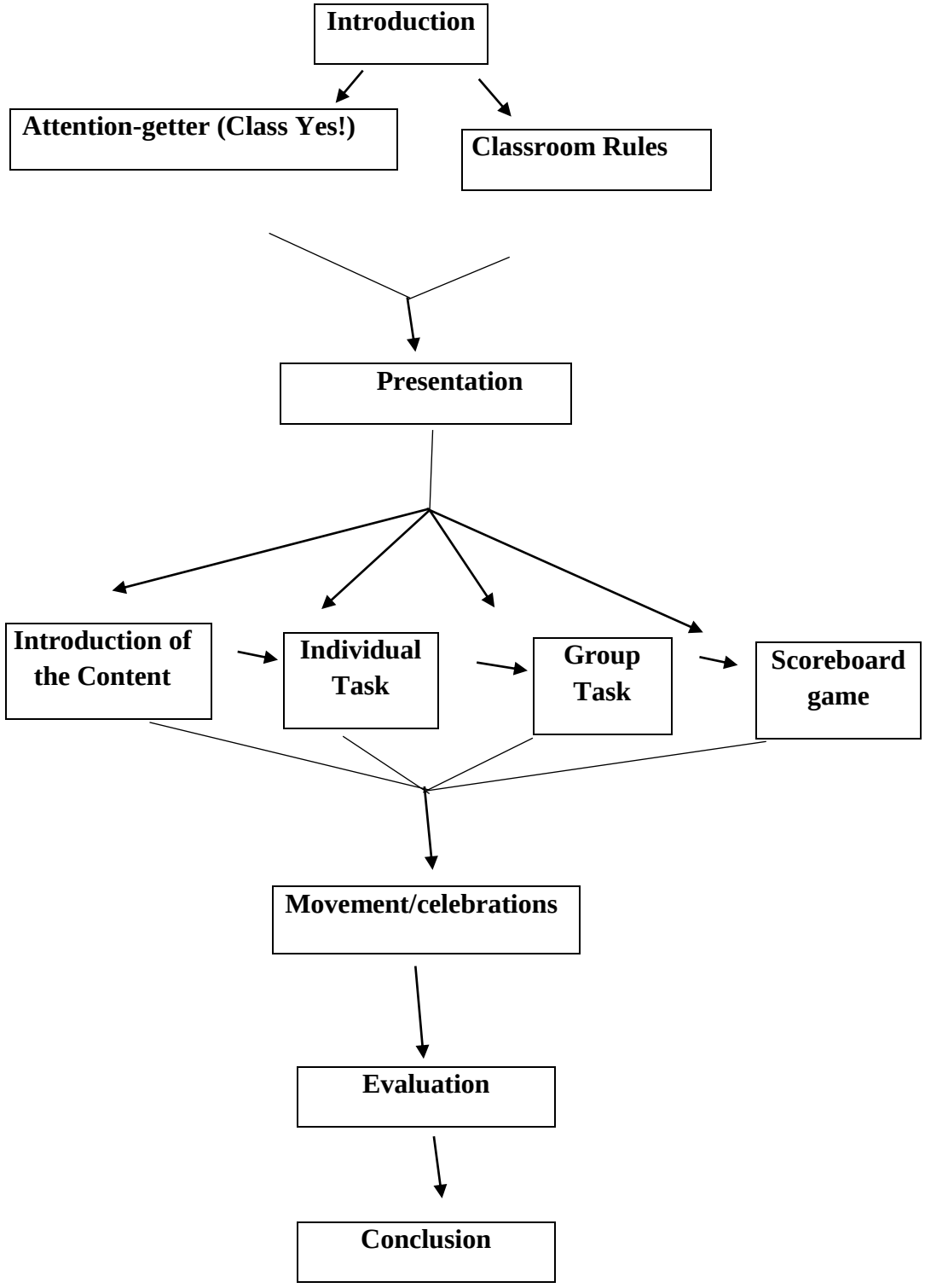


Figure. 3.2: Herrmann's Whole Brain Model Flow Chart Adapted from Sontillano (2018)

3.6.2 Lesson Procedure for the Control Group

The control group was taught the wave concepts (the same as that of the experimental group) by the researcher and two Physics teacher from the sampled school (B) for effectiveness and efficiency of the treatment using lecture method. Lecture method procedure adapted from Isa (2018) was used for the teaching the control group. This procedure consist of five stages lesson procedure as highlighted below:

Stage 1: Introduction: (5 minutes)

The lesson is introduce by asking the students same questions based on the students' entry behavior.

Stage 2: Presentation: (45 minutes)

The content of the lesson is verbally presented by defining, stating, explaining, differentiating, drawing and solving sampled problems using chalk and board.

Stage 3: Summary: (10 minutes)

The lesson's content presented in stage 2 above was summarized on the board for the students to copy.

Stage 4: Students' Activities: (10minutes)

At this stage, students are allowed to copy down the summary in their note books and give the students room for asking questions.

Stage 5: Evaluation: (10 minutes)

Teacher evaluates the lesson by asking questions based on the behavioural objectives of the lesson.

The lesson plan for this treatment is cited in appendix B (Page 116).

3.7 Procedure for Data Collection

A pre-test was administered to both experimental and control groups using the instrument Wave Performance Test (WPT). The results obtained from the pretest administration were stored as pretest data. After the treatment of both experimental and control groups, a posttest was administered to both groups using WPT. The results collected from the posttest administration were stored as posttest data. Two weeks after the posttest administration, a post-posttest was administered to both groups using WPT. The results obtained from the post-posttest administration were stored as post-posttest data. These three sets of data were used for data analysis.

3.8 Procedure for Data Analysis

The sets of data collected from the administrations of the instrument were analyzed using appropriate statistical tools. In order to answer the research questions mean and standard deviation were used while the null hypotheses were tested using t-test statistical tool at 0.05 level of significance. The null hypotheses and the corresponding statistical tools were restated thus:

$H0_1$: There is no significant difference between the academic performance of students taught Physics concepts using Herrmann's Whole-Brain Model and those taught the same concepts using the lecture method.

The two set of data collected for testing this null hypothesis (posttest experimental and posttest control) are parametric in nature. Hence, t-test statistical tool was used for testing this null hypothesis.

$H0_2$: There is no significant difference between the retention ability of Physics students taught Physics concepts using Herrmann's Whole-Brain Model and those taught same using lecture method.

The two set of data collected for testing this null hypothesis (post-posttest experimental and post-posttest control) are parametric in nature. Hence, t-test statistical tool was used for testing this null hypothesis.

$H0_3$: There is no significant difference between the mean performance scores of male and female students taught Physics using Herrmann's Whole-Brain Model.

The two set of data collected for testing this null hypothesis (posttest experimental male and posttest experimental female) are parametric in nature. Hence, t-test statistical tool was used for testing this null hypothesis.

$H0_4$: There is no significant difference between the retention ability of male and female students taught Physics using Herrmann's Whole-Brain Model.

The two set of data collected for testing this null hypothesis (post-posttest experimental male and post-posttest experimental female) are parametric in nature. Hence, t-test statistical tool was used for testing this null hypothesis.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.1 Introduction

This study investigated effects of Herrmann's Whole-Brain Model on retention and academic performance among secondary school Physics students in Zaria Education Zone, Kaduna State, Nigeria. This chapter gives the analysis and presentation of results as well as the discussion of the findings under the followings subheadings:

4.2 Data Presentation and Analysis

4.3 Summary of Major Findings

4.4 Discussion of Results

4.2 Data Presentation and Analysis

The data collected from the administration of the instrument Wave Performance Test (WPT) were analyzed and used to answer the research questions and test the stated null hypotheses.

4.2.1 Answering the Research Questions and Testing Hypotheses

Research Question One: what is the difference in the mean scores of students taught wave concepts using Herrmann's Whole-Brain Model and those taught the same concepts using the lecture method?

To answer this research question, means and standard deviations of performance scores were computed. The posttest mean scores of experimental and control groups were subjected to descriptive statistics. Mean and standard deviation were computed and used to draw Table 4.1

Table 4.1 Mean and Standard Deviation of Posttest Scores of the Experimental and Control Groups:

Groups	N	Mean	. Deviation	Mean Difference
Experimental	123	21.54	3.41	11.14
Control	105	10.40	2.89	

The results from Table 4.1 show that the academic performance mean scores for the experimental and control groups are 21.54 and 10.40 respectively. The standard deviation for the experimental and control groups were 3.41 and 2.89 respectively. The mean difference was 11.14. This means the experimental group performed higher than the control group, and this could be attributed to the different treatments received by the groups.

$H0_1$: There is no significant difference between the academic performance of students taught Physics concepts using Herrmann's Whole-Brain Model and those taught the same concepts using the lecture method.

To test this hypothesis, the mean academic performance scores of students in experimental and control groups were subjected to t- test statistic and summary of analysis is shown on Table 4.2.

Table 4.2: Summary of the t-test Analysis of Academic Performance Mean Scores of

Experimental and Control Groups:

Groups	N	Mean	S.D	t	df	P-value	Decision
Experimental	123	21.54	3.41	26.33	226	0.00	Significant
Control	105	10.40	2.89				

Significant at P≤0.05

The experimental group has higher mean scores of 21.54 as compared to that of control group with mean scores of 10.40. The p-value is 0.00 which is less than 0.05 level of significance at 226 degree of freedom. Hence, the null hypothesis is rejected. This means Herrmann's Whole-Brain Model is effective in enhancing students' academic performance in wave concepts (P=0.00 at α≤0.05).

Research Question Two: what is the difference in the retention level among Physics students exposed to Herrmann's Whole-Brain Model and those exposed to lecture method?

To answer this research question, mean and standard deviations of performance scores were computed. The post-posttest scores of experimental and control groups are subjected to descriptive statistics. Mean and standard deviation are computed and used to draw Table 4.3

Table 4.3 Mean and Standard Deviation of Post-posttest Scores of the Experimental and Control Groups

Groups	N	Mean	Std. Deviation	Mean Difference
Experimental	123	20.65	3.69	11.73
Control	105	8.92	2.64	

lts from Table 4.3 show that the post-posttest mean scores for the experimental and control groups are 20.65 and 8.92 respectively with the mean difference of 11.73 and the standard deviations for the experimental and control group are 3.69 and 2.64 respectively. This means the experimental group retained higher than the control group, and this could be attributed to the different treatments received by the groups.

$H0_2$: There is no significant difference between the retention ability of Physics students taught Physics concepts using Herrmann's Whole-Brain Model and those taught same using lecture method.

To test this hypothesis, the mean academic performance scores of students in experimental and control groups are subjected to t-test statistic and summary of the analysis is shown in Table 4.4

Table 4.4 Summary of t- Test Analysis of Post-posttest Scores of Experimental and Control Groups:

Groups	N	Mean	S.D	t	df	P-value	Decision
Experimental	123	20.65	3.69	27.18	226	0.00	Significant
Control	105	8.92	2.64				

Significant at P≤ 0.05

The results from Table 4.4 show a p- value of 0.00 at $p \leq 0.05$ with the degree of freedom of 226. This shows that the experimental group has higher retention ability than the control group, hence the null hypotheses is rejected (P=0.00 at $\alpha \leq 0.05$).

Research Question Three: Is there any difference in mean performance scores of male and female students taught Physics using Herrmann's Whole-Brain Model?

To answer this research question, mean and standard deviations of performance scores were considered. The post test scores of the experimental group were sorted according to

gender and subjected to descriptive statistics. Mean and standard deviation are computed and used to draw Table 4.5

Table 4.5 Mean and Standard Deviation of Posttest Scores of Males and Females Taught Physics Concepts Using HWBM.

Groups	N	Mean	Std. Deviation	Mean Difference
Male	52	21.62	3.38	0.59
Female	71	21.03	3.69	

lts from Table 4.5 show that academic performance means scores for the male and female students are 21.62 and 21.03 respectively. The mean Difference is 0.59. This means that male students performed very slightly higher than the female students and this may be attributed to the gender differences among male and female students in the experimental group. However, the differences appear to be negligible.

$H0_3$: There is no significant difference between the mean performance scores of male and female students taught Physics using Herrmann's Whole-Brain Model.

To test this hypothesis, the mean academic performance scores of students in experimental and control groups were subjected to t- test statistic and summary of analysis are shown in Table 4.6

Table 4.6: Summary of t-test Analysis of Posttest Means Scores of Male and Female Students in the Experimental Group.

Groups	N	Mean	S.D	t	df	P-value	Decision
Male	52	21.62	3.38	0.90	121	0.37	Not significant
Female	71	21.03	3.69				

Significant at P≤ 0.05

The results in Table 4.6 show that at df = 121 and P-value = 0.37 which is higher than 0.05 level of significance. Consequently the null hypothesis is retained. This implies that Herrmann's Whole-Brain Model is gender friendly in the learning of wave concepts (P=0.37 at $\alpha \leq 0.05$).

Research Question Four: Is there any difference in the retention ability of male and female students taught Physics using Herrmann's Whole-Brain Model?

To answer this research question, mean and standard deviations of performance scores are considered. The post-posttest scores of the experimental group are sorted according to gender and subjected to descriptive statistics. Mean and standard deviation are computed and used to draw Table 4.7

Table 4.7: Mean and Standard Deviation of Post-posttest Scores of Male and Female Students Taught Physics Concepts Using HWBM.

Groups	N	Mean	Std. Deviation	Mean Difference
Male	52	19.00	3.81	
				0.34
Female	71	19.33	3.31	

lts from Table 4.7 show that the post-posttest mean scores for the male and female students are 19.00 and 19.33.respectively with the mean Difference of 0.34 and the standard deviation for the male and female students are 3.81 and 3.31 respectively. This means that the female students retained very slightly higher than the male students, and this may be attributed to the gender differences among male and female students in the experimental group. However, the difference appears to be negligible.

$H0_4$: There is no significant difference between the retention ability of male and female students taught Physics using Herrmann's Whole-Brain Model.

To test this hypothesis, the mean post-posttest scores of male and female students are subjected to t- test statistic and summary of analysis are shown in Table 4.8

Table 4.8 T-test Analysis of Post-posttest Mean Scores of Male and Female Students in the Experimental Group.

Groups	N	Mean	S.D	t	df	P-value	Decision
Male	52	19.00	3.81				
				0.51	121	0.60	Not significant
Female	71	19.33	3.31				

Significant at P≤ 0.05

The t-test analysis from Table 4.8 shows that the p-value is 0.60 which is higher than 0.05 level of significance, Hence the null hypotheses which states that there is no significant difference between the retention ability of male and female students taught Physics using Herrmann's Whole-Brain Model is retained (P=0.60 at $\alpha \leq 0.05$).

4.3 Summary of Major Findings:

Based on the results obtained from the analysis, the followings were the major findings of this study:

1. There is a significant difference between the academic performance of students taught Physics concepts using Herrmann's Whole-Brain Model and those taught the same concepts using the lecture method in favour of the experimental group.

2. There is a significant difference between the retention level of students taught Physics concepts using Herrmann's Whole-Brain Model and those taught same using lecture method in favour of the experimental group.
3. There is no significant difference between the mean performance scores of male and female students taught Physics using Herrmann's Whole-Brain Model.
4. There is no significant difference between the retention level of male and female students taught Physics using Herrmann's Whole-Brain Model.

4.5 Discussion of Results

This study investigated the effects of Herrmann's Whole-Brain Model on Retention and Performance among Secondary School Physics Students in Zaria Education Zone, Kaduna Nigeria. To achieve this aim, students in experimental group were taught wave concepts using Herrmann's Whole-Brain Model while students in control group were taught the same concepts using lecture method. Therefore, the observed differences in the result were due to the different treatments. The results of the analysis of the data on the research questions and null hypotheses are hereby discussed.

The result of analysis presented in Tables 4.1 and 4.5 showed that the students taught Physics concepts using Herrmann's Whole-Brain Model performed significantly higher than the students taught the same concepts using lecture method. This result is in agreement with the findings of Bawaneh et al. (2011) who investigated the effect of Herrmann Whole Brain Teaching Method over conventional teaching method on eight graders in their understanding of simple electric circuits in Jordan and reported the superiority of HWBM over lecture method. This result is also in line with that of Sontillano (2018) who investigated the impact of whole brain teaching based instruction on academic performance of grade 8 students in algebra and reported that Whole-Brain

Teaching has a positive impact on the academic performance of grade 8 students in Algebra. This significant difference in academic performance in favour of the experimental group could be attributed to the fact that multiple areas of the brain were activated when using HWBM throughout the lessons. During the treatment of the experimental group, the researcher observed that the students were excited, focused, attentive and immediately responded when the attention getter (Class-Yes) was used. This is in line with Sontillano (2018) who found that positive students' response increased when attention getters like Class-Yes were used in the classroom. The researcher also observed that the students were highly participative in the group tasks which was another significant advantage in favour of the experimental group. The three classroom rules were found helpful in class room management and helped the students were emotionally free in the classroom. However, this result is not in line with Tezcan and Güvenç (2017) who investigated the effects of 4mat teaching model and whole brain model on academic achievement in science and revealed the superiority of 4mat teaching model over whole brain teaching model. This may be due to the fact that the above study compered 4mat teaching model and whole brain teaching model while the present study compered whole brain teaching model and lecture method.

The results of the analysis are presented in Tables 4.2 and 4.6. The results show that the experimental group has higher retention ability on the concepts taught than the control group. This finding is supported by Howard-Jones (2014) who proved that words when accompanied with gestures yields better retention. This finding is also in line with Sontillano (2018) who concluded that there was a greater retention of the topics learned when taught using Whole brain teaching techniques compare to lecture method. The significant difference in retention level of the experiment and control groups in favour of the experimental group could be due to the fact that HWBM involves the use of multiple learning styles in the classroom. During the treatment of the experimental group, the

researcher observed that the time allocated for individual task allowed the students to study the individual task paper step by step and repeatedly which in turn solidified the information in their brains. The researcher also observed that the use of Scoreboard game helped the students to internalize the material learned which in turn aided their retention abilities. This was another significant advantage of the experimental group over the control group as Sontillano (2018) evident that engaging students to play the role of teacher (answering question inclusive) facilitates retention.

The analysis of the mean performance scores in Tables 4.3 and 4.7 shows that there is no significant difference between male and female students taught Physics concepts using HWBM. This finding indicates that gender has no effect on learning Physics concepts using HWBM. This finding concurs with that of Bawaneh et al. (2011) who established that there was no significant differences attributed to gender among the students taught simple electric circuits using HWBM. This finding also agrees with that of Bawaneh et al. (2012) who reported that HWBM was not gender sensitive towards learning of science. This insignificant difference may be based on the fact that the structure and functions of human brain are similar regardless to the gender dissention. The researcher observed that the students in the experimental group were excited, focused, attentive and immediately responded when the attention getter (Class-Yes) was used regardless of the gender discord. This converged with the findings of Kelso (2009) and Sontillano (2018) who revealed that positive students' response increased when attention getters like Class-Yes were used in the classroom. The researcher also observed that the students were independently concentrative during the individual tasks and highly participative in the group tasks regardless of the gender difference. This may be another reason for the insignificant difference in academic performance between male and female students in the experimental group. However, this finding diverged with that of Thomas and Swamy

(2014) who reported that girls possessed higher mean scores than the boys. This disagreement lies on the fact that Thomas and Swamy (2014) adopted three techniques of BBTA developed by Caine and Caine (1991) which does not consider individual differences in terms of learning styles. This is an advantage of HWBM over Caine and Caine's BBTA.

Table 4.4 and 4.8 show the analysis of the post-posttest of male and female students in the experimental group. From the result of this analysis, there is no significant difference between the mean retention scores of male and female students taught Physics concepts using HWBM (experimental group). This finding reveals that the use of HWBM is gender friendly. The insignificant difference in retention level between male and female students in the experiment group could be due to the fact that both male and female students were given equal opportunity to embrace the various learning styles involved in HWBM including Scoreboard game which aid their retention abilities as Sontillano (2018) evident that engaging students to play the role of teacher (answering question inclusive) facilitate retention. The time allocated for individual task allowed both male and female students to study the individual task paper step by step and repeatedly which in turn solidified the information in their brains. These might be the reasons for the insignificant difference in retention level between male and female students in the experimental group.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This study investigates effects of Herrmann's Whole-Brain Model on retention and academic performance among secondary school Physics students in Zaria Education Zone, Kaduna State, Nigeria. This chapter gives the summary, conclusion and recommendations under the followings subheadings:

5.2 Summary

5.3 Major Findings

5.4 Conclusions

5.5 Contributions to Knowledge

5.6 Recommendations

5.7 Limitation of the Study

5.8 Suggestions for Further Studies

5.2 Summary

This study investigated the effects of Herrmann's Whole-Brain Model on retention and academic performance among secondary school Physics students in Zaria Education

Zone Kaduna State, Nigeria. Pre-test, posttest and post-posttest quasi-experimental design was used for this study. Four research questions and four null hypotheses were formulated and tested using independent t-test at 0.05 level of significant. The reviewed related literature based on the followings subheadings: Physics as a teaching subject in Nigerian secondary schools, science teaching methods in Nigerian secondary schools, retention in science education, academic performance in science education, gender and students' academic performance in Physics, overview of similar studies and implication of the related literature reviewed to the present studies.

The study adopted the pretest, posttest and post-posttest quasi experimental design with control group. A pretest was administered before the treatment to establish the academic equivalence of the experimental and control groups. The students in experimental group were taught waves concepts (drown from senior secondary school curriculum) using HWBM while those in control group were taught the same concepts using lecture method for the period of Six weeks. The instrument used for the study was Wave Performance Test (WPT). The population of this study comprise all public co-educational Senior Secondary Schools (SSII) Physics students in Zaria Education zone with the total population of 1,422 students. Two academically equivalent schools out of the 15 public co-educational Senior Secondary Schools of the zone with population of 228 constituted the sample for the study

5.3 Major Findings

The followings are the major findings from this study:

1. There is significant difference between the mean academic performance scores of students taught Physics concepts using HWBM (experimental group) and those

taught the same concepts using lecture method (control group) in favour of the experimental group.

2. There is significant difference between the mean retention scores of students taught Physics concepts using HWBM (experimental group) and those taught the same concepts using lecture method (control group) in favour of the experimental group.

3. There is no significant difference between the mean academic performance scores of male and female students taught Physics concepts using HWBM (experimental group).

4. There is no significant difference between the mean retention scores of male and female students taught Physics concepts using HWBM (experimental group).

5.4 Conclusions

Based on this study, the following conclusions were made:

1. HWBM enhances Academic performance of Physics students taught wave concepts
2. HWBM promotes meaningful learning and facilitates retention of Physics students taught wave concepts in secondary schools.
3. HWBM is gender-friendly as it promotes academic performance and retention of males and females students taught wave concepts.

5.5 Contribution to Knowledge

The concern of this study is the exploration of the effects of Herrmann's Whole Brain Model on retention and academic performance among Secondary School Physics students in Zaria education zone Kaduna state, Nigeria. The findings of this study have a number of significant contributions and great implication for educational practices;

1. The study established that HWBM enhances the performance and retention of secondary school Physics students in Zaria education zone.
2. The modified treatment package for HWBM by the researcher can be used by secondary school Physics teachers to improve performance and retention in Physics concepts.
3. Based on the available literature reviewed, this research work may be the first of its kind in Zaria education zone, Kaduna State, Nigeria. It could be replicated by other researchers in other zones within and outside the state.
4. The study established that males and females students benefitted equally well when taught wave concepts using HWBM.

5.6 Recommendations

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

1. The use of HWBM should be encouraged among secondary school Physics teachers because from this study, HWBM was found to be very effective in enhancing meaningful learning
2. Both coeducational and single sex schools should be encouraged to use HWBM because HWBM was found to be gender friendly in this study. In other words all genders could benefit from the use of HWBM during instructions.
3. Professional bodies such as Science Teachers Association of Nigeria (STAN) and Mathematics Association of Nigeria (MAN) should emphasize the use of HWBM in teaching and learning of science in order to benefit from the current neurocognitive research findings about how brain naturally learn best.

4. State government should embark on training and retaining of Physics teachers on HWBM through seminars, workshops.
5. Nigerian institutions of education such as Federal Colleges of Education (FCE), National Teachers Institute (NTI) and the faculties of education in universities should include brain-compatible education otherwise known as brain-based education in their curriculum in order to provide the prospective teachers with the adequate knowledge of brain related to education as it is found worthy in educational practice internationally.

5.7 Limitations of the Study

The limitations of this study are:

1. Most of the students in the experimental group were not familiar with the learning strategies involved in HWBM especially working in group and independent study. However, this was overcome by the use of three (3) trained research assistants.
2. Over population in the sample schools selected for the study was another limitation that caused the researcher to seek for the help of three (3) research assistants. Hence, caused the researcher to train the research assistants.
3. Hawthorne effect may be another limitation in this study because as the researcher participated in the treatments administration the students may behave differently which may consequently affect the result.

5.8 Suggestions for Further Studies

The following suggestions are put forward for further studies:

1. Further studies of this kind could be carried out in junior secondary schools, colleges of education, polytechnics, and universities as the result obtained here is restricted to senior secondary schools.
2. Such study could also be extended to other education zones in Kaduna State, and other states of the federation for wider generalization.
3. Further studies of this kind could be extended to other subjects in science and art disciplines.
4. Such study could be replicated to include other variables such as interest, attitude, and self-efficacy of students toward learning wave concepts using HWBM.

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APPENDIX A

LESSON PLAN FOR EXPERIMENTAL GROUP (HWBM)

WEEK ONE

Subject: **Physics**

Topic: **Waves**

Period: **80 minutes**

Group: **Experimental**

Class: **SS II**

Sex: **Mixed**

Average age: **17 years**

Model of Instruction: **Herrmann's Whole Brain Model**

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

i. define wave,

ii. state examples of wave,

iii. list four characteristics of waves and

iv. explain at least three.

Entry Behaviour: Students are familiar with sun-light, sound and water surface.

Instructional Materials: Individual task papers, group work sheets, transparent water container, needle and touch light.

Presentation:

Content	Teacher's Activities	Students' Activities
Step 1 Attention-getting technique (2 minutes)	The teacher say "Class" in any way or tone that he wishes,	The students must mimic the teacher's voice and respond with the word "Yes."
Step 2 Class-room rules (3 minutes)	The teacher go over the three rules to ensure students understand. Each rule is said with a gesture. The rules are as follows: • Rule 1 – • Rule 2 - • Rule 3 –	The students respond as follows in each case: • Raise your hand for permission to speak (raise your hand then make a talking motion with your mouth) • Raise your hand for permission to leave your chair (raise your hand and make a waving motion with your

<table>
<tr><td></td><td></td><td>fingers).
• Keep your dear teacher happy.</td></tr>
<tr><td>Step 3
Introduction of the concept
(8 minutes)</td><td>Teacher guide the students to observe what light, water surface and sound share in common through the following activities:
• On and off the touch light.
• Drop a needle in a transparent water container.
• Shout once.</td><td>The students observed what light, water surface and sound share in common based on the followings:
• transferring energy
• transferring no mass
• travelling in a medium</td></tr>
<tr><td>Step4
Individual task
(13 minutes)</td><td>Teacher distributed the prepared individual task paper (see page 87) to the students and give them time to study. The teacher encourage the students to comprehend not to memorize.</td><td>The students study the information (in the prepared individual task paper) over and over individually and repeatedly for at least ten minutes and attempt the questions that follow.</td></tr>
<tr><td>Step 5
Group task
(20 minutes)</td><td>Teacher grouped the students (4-5 students per group) and distributes the prepared group work sheets (see page 89) and guide them to interact, discuss, share ideas and put the information in their own words about the same information. The students separate immediately after the group work.</td><td>The students accomplished the task (in the prepared group work sheets) via interact, discuss, share ideas and put the available information in their own words about the task. The students separate immediately after the group work.</td></tr>
<tr><td>Step 6
Scoreboard game
(10 minutes)</td><td><table><tr><th>S/N</th><th>Questions</th><th>Students’ scores</th><th>Teacher’s scores</th></tr><tr><td>1.</td><td>λ, T, A and f represents…., …., ….., and ….. respectively</td><td></td><td></td></tr><tr><td>2.</td><td>Waves transfer both</td><td></td><td></td></tr></table></td><td>The students answer the questions and monitor the record.</td></tr>
</table>

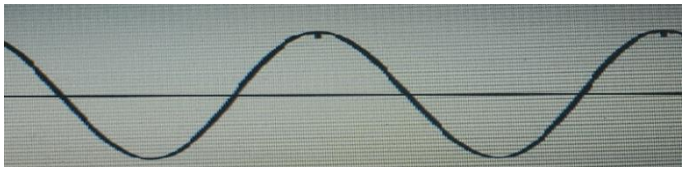
		energy and mass. True or false?		
	3.	Light, sound and mirror are examples of waves except……		
		Total		
	The teacher ask the following questions and record the scores as appropriate.			
Step 7 Celebrating performance (4 minutes)	Teacher allowed the students to make one minute movement to celebrate their performance and gives room for questions.			The students make one minute movement to celebrate their performance and ask questions if any.
Step 8 Evaluation (10 minutes)	Teacher ask the following questions; 1. Define wave. 2. State three examples of wave. 3. List four characteristics of waves and explain any three.			The students respond to the questions individually.
Step 9 Conclusion (10 minutes)	Teacher concluded the lesson by summarizing the main points and give the students assignment.			The students take on their assignment.

INDIVIDUAL TASK PAPER

First Chunk (Meaning of wave).

Study the following information and make a good definition of wave the space provided.

- Wave is a continual disturbance, vibration or oscillation. Oscillation refers to regular vibration in magnitude and position. Oscillation can be represented by a sinusoidal path as shown below;



Regular vibration in magnitude and position (wave diagram).

- Wave travels through a medium and transfer energy from one point to another.
- Wave transfers energy without transferring mass.

Define

wave.……

……..……

Second Chunk (Examples of wave).

Study the following information and state three examples of wave.

- Water surface oscillates when it is disturbed, it is called water wave
- Light travels in a medium and transfer energy without transferring mass.
- Sound travels through a medium transferring energy from one point to another without causing any permanent displacement of the medium.

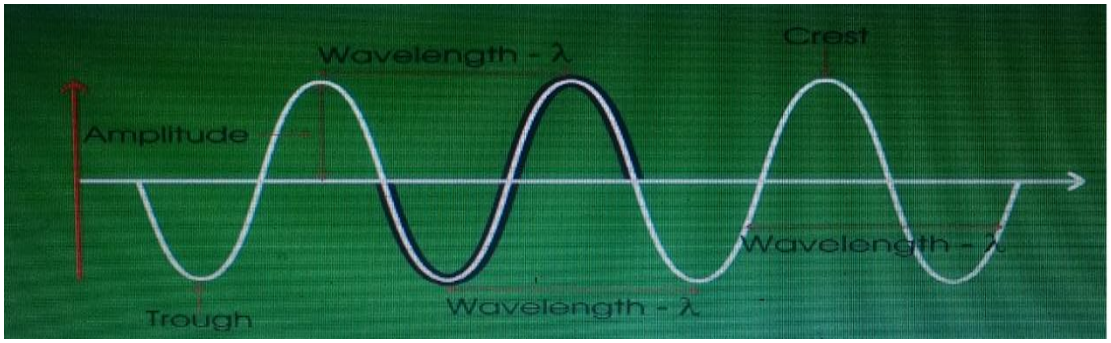
State three examples of wave.

1. ……2. ……..……3 ……..

Third Chunk (Characteristics of wave).

Study the following information and list three characteristics of wave with their symbols.

- All waves have amplitude, wavelength, frequency and period.
- Amplitude donated by "A" is the maximum displacement of the wave measured from the equilibrium position to the crest or to the trough, it is measured in meter (m).
- Wavelength donated by "λ" is the distance between two successive troughs or crests, it is measured in meter (m).
- If a wave takes five seconds to make one complete oscillation, the period is 5s.
- If a wave makes ten complete oscillations in one second, the frequency is 10Hz



Wave diagram showing amplitude, wavelength, trough and crest.

GROUP WORK SHEETS

First Chunk.

Use the experiences acquired from the individual task paper, define wave.

……

……

Second Chunk.

Use the experiences acquired from the individual task paper, list three examples of waves.……

Third Chunk.

Use the experiences acquired from the individual task paper, list four characteristics of waves and explain any three.

……..……..……

WEEK TWO

Subject:	**Physics**
Topic:	**Types of Waves**
Period:	**80 minutes**
Group:	**Experimental**
Class:	**SS II**
Sex:	**Mixed**

Average age: **17 years**

Model of Instruction: **Herrmann's Whole Brain Model**

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

i. state the types of waves,

ii. explain each types of wave, and

iii. list two examples of each type of wave

Entry Behaviour: The Students have learnt about the definition, examples and characteristics of waves.

Instructional Materials: Individual task papers, group work sheets, transparent water container, needle, airproof container, cellphone and touch light.

Presentation:

Content	Teacher's Activities	Students' Activities
Step 1 Attention-getting technique (2 minutes)	The teacher say "Class" in any way or tone that he wishes,	The students must mimic the teacher's voice and respond with the word "Yes."
Step 2 Class-room rules (3 minutes)	The teacher go over the three rules to ensure students understand. Each rule is said with a gesture. The rules are as follows: • Rule 1 – • Rule 2 - • Rule 3 –	The students respond as follows in each case: • Raise your hand for permission to speak (raise your hand then make a talking motion with your mouth) • Raise your hand for permission to leave your chair (raise your hand and make a waving motion with your fingers). • Keep your dear teacher happy.
Step 3 Introduction of the concept (8 minutes)	Teacher guide the students to observe what light, water surface and sound share in common through the following activities:	The students make observation based on the followings: • Waves that require

<table>
<tr><td></td><td>

On and off the touch light through air and then through the water container.
Drop a needle in a transparent water container and then in empty container.
Play music from the cellphone, put the cellphone in airproof container and cover it.

</td><td>
material medium their propagation.

Waves that those not require material medium their propagation.

</td></tr>
<tr><td>Step4
Individual task
(13 minutes)</td><td>Teacher distributed the prepared individual task paper (see page 92) to the students and give them time to study. The teacher encourage the students to comprehend not to memorize.</td><td>The students study the information (in the prepared individual task paper) over and over individually and repeatedly for at least ten minutes and attempt the questions that follow.</td></tr>
<tr><td>Step 5
Group task
(20 minutes)</td><td>Teacher grouped the students (4-5 students per group) and distributes the prepared group work sheets (see page 94) and guide them to interact, discuss, share ideas and put the information in their own words about the same information. The students separate immediately after the group work.</td><td>The students accomplished the task (in the prepared group work sheets) via interact, discuss, share ideas and put the available information in their own words about the task. The students separate immediately after the group work.</td></tr>
<tr><td>Step 6
Scoreboard game
(10 minutes)</td><td>
<table>
<tr><th>S/N</th><th>Questions</th><th>Students’ scores</th><th>Teacher’s scores</th></tr>
<tr><td>1.</td><td>The most common examples of longitudinal waves is…….</td><td></td><td></td></tr>
<tr><td>2.</td><td>……..requires material medium while…….does not</td><td></td><td></td></tr>
<tr><td>3</td><td>Radio waves,</td><td></td><td></td></tr>
</table>
</td><td>The students answer the questions and monitor the record.</td></tr>
</table>

	. sound waves, x-rays and gamma rays are examples of electromagnetic waves except…… Total The teacher ask the following questions and record the scores as appropriate.	
Step 7 Celebrating performance (4 minutes)	Teacher allowed the students to make one minute movement to celebrate their performance and gives room for questions.	The students make one minute movement to celebrate their performance and ask questions if any.
Step 8 Evaluation (10 minutes)	Teacher ask the following questions; 4. State the types of waves. 5. Explain each types of wave. 6. List two examples of each type of wave	The students respond to the questions individually.
Step 9 Conclusion (10 minutes)	Teacher concluded the lesson by summarizing the main points and give the students assignment.	The students take on their assignment.

INDIVIDUAL TASK PAPER

First Chunk (Types of wave).

Study the following information and list four types of wave.

There are basically two ways of classifying waves;

1. Based on the medium require for their propagation we have mechanical waves and electromagnetic waves.
2. Based on the motion of the wave we have transverse waves and longitudinal waves.

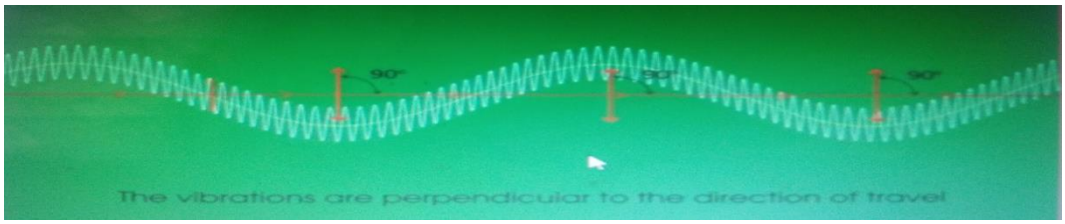
List four types of wave……..……

……

Second Chunk (Explanations of the types of wave).

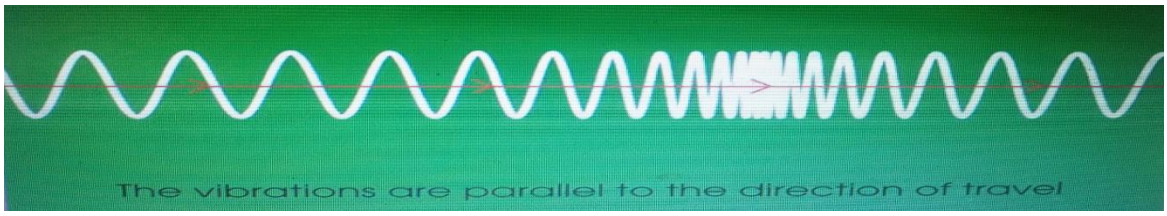
Study the following information and explain the four types of waves.

- Waves that require material medium for their propagation are known as mechanical waves.
- Waves that do not require material medium for their propagation are known as electromagnetic waves.
- A wave in which the particles of the medium oscillate perpendicular to the motion of the wave is known as transverse wave.



Transverse wave.

- A wave in which the particles of the medium oscillate parallel to the motion of the wave is known as longitudinal wave.



Longitudinal wave

Third Chunk (Examples of each type of wave).

Study the following information and give example of each of the four types of wave.

- Examples of Electromagnetic waves are radio waves, x-rays and gamma rays.
- Examples of Mechanical waves: water waves, sound waves, waves on a rope or string.
- Examples of transverse waves are light waves and radio waves.
- The most common examples of longitudinal waves is sound waves.

Explain any two types of waves……..……

……

……

GROUP WORK SHEETS

First Chunk.

Use the experiences acquired from the individual task paper, list four types of wave**s**.

……

……

Second Chunk.

Use the experiences acquired from the individual task paper, explain four types of waves

……...……

……

Third Chunk.

Use the experiences acquired from the individual task paper, give example of each of the followings type of waves:

1. Longitudinal waves ……
2. Mechanical waves……
3. Electromagnetic waves.……
4. Transverse waves…….……

WEEK THREE

Subject: **Physics**

Topic: **Properties of Waves**

Period: **80 minutes**

Group: **Experimental**

Class: **SS II**

Sex: **Mixed**

Average age: **17 years**

Model of Instruction: **Herrmann's Whole Brain Model**

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

i. state the properties of wave (refraction, reflection interference and diffraction),

ii. explain any two properties of wave, and

iii. differentiate between the incidence ray, the refracted ray and the reflected ray using diagram

Entry Behaviour: The students have learnt about the definition, types and characteristics of wave.

Instructional Materials: Individual task papers, group work sheets, transparent water container, meter-rule, touch light, mirror, ray-box and slit.

Presentation:

Content	Teacher's Activities	Students' Activities
Step 1 Attention-getting technique (2 minutes)	The teacher say "Class" in any way or tone that he wishes,	The students must mimic the teacher's voice and respond with the word "Yes."
Step 2 Class-room rules (3 minutes)	The teacher go over the three rules to ensure students understand. Each rule is said with a gesture. The rules are as follows: • Rule 1 – • Rule 2 - • Rule 3 –	The students respond as follows in each case: • Raise your hand for permission to speak (raise your hand then make a talking motion with your mouth) • Raise your hand for permission to leave your chair (raise your hand and make a waving motion with your fingers). • Keep your dear teacher happy.

Step 3 Introduction of the concept (8 minutes)	Teacher guide the students to observe what light, water surface and sound share in common through the following activities: • Flash the touch light through the mirror • Immerse the meter-rule into the transparent water container. • Flash the touch light through the slit using the ray-box	The students make observation based on the followings: • reflection • refraction • diffraction
Step4 Individual task (13 minutes)	Teacher distributed the prepared individual task paper (see page 97) to the students and give them time to study. The teacher encourage the students to comprehend not to memorize.	The students study the information (in the prepared individual task paper) over and over individually and repeatedly for at least ten minutes and attempt the questions that follow.
Step 5 Group task (20 minutes)	Teacher grouped the students (4-5 students per group) and distributes the prepared group work sheets (see page 99) and guide them to interact, discuss, share ideas and put the information in their own words about the same information. The students separate immediately after the group work.	The students accomplished the task (in the prepared group work sheets) via interact, discuss, share ideas and put the available information in their own words about the task. The students separate immediately after the group work.

<table>
<tr>
<td>Step 6
Scoreboard game
(10 minutes)</td>
<td>
<table>
<tr><th>S/N</th><th>Questions</th><th>Students' scores</th><th>Teacher's scores</th></tr>
<tr><td>1.</td><td>What happens when rays of light incidence on mirror?</td><td></td><td></td></tr>
<tr><td>2.</td><td>What happens when rays of light pass the boundary of two different optical media?</td><td></td><td></td></tr>
<tr><td>3.</td><td>What happens when rays of light pass through a slit?</td><td></td><td></td></tr>
<tr><td></td><td>Total</td><td></td><td></td></tr>
</table>
The teacher ask the above questions and record the scores as appropriate.
</td>
<td>The students answer the questions and monitor the record.</td>
</tr>
<tr>
<td>Step 7
Celebrating performance
(4 minutes)</td>
<td>Teacher allowed the students to make one minute movement to celebrate their performance and gives room for questions.</td>
<td>The students make one minute movement to celebrate their performance and ask questions if any.</td>
</tr>
<tr>
<td>Step 8
Evaluation
(10 minutes)</td>
<td>Teacher ask the following questions;
7. State three properties of wave.
8. Explain any two properties of wave.
9. Differentiate between the incidence ray, the refracted ray and the reflected ray using diagram</td>
<td>The students respond to the questions individually.</td>
</tr>
<tr>
<td>Step 9
Conclusion
(10 minutes)</td>
<td>Teacher concluded the lesson by summarizing the main points and give the students assignment.</td>
<td>The students take on their assignment.</td>
</tr>
</table>

INDIVIDUAL TASK PAPERS

First Chunk (Properties of waves).

Study the following information and state three properties of waves.

Waves can undergo refraction, reflection, diffraction, interference, and polarization.

Second Chunk (Explanations properties of waves).

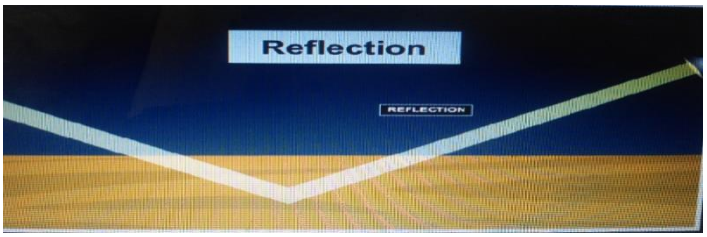
Study the following information and explain the three properties of waves.

- Refraction is the change in speed and direction of the waves as they cross the boundary pass from the medium.



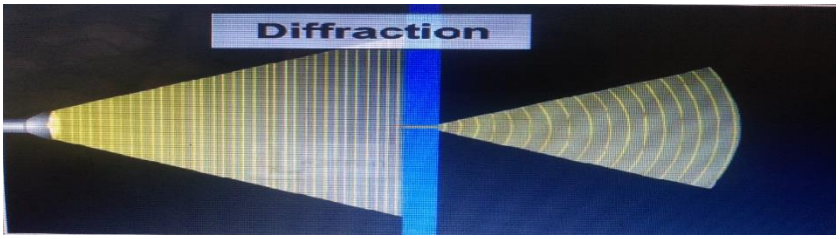
Refraction of light wave as it passed from a rarer medium to an optically denser medium.

- Reflection is a property of propagated wave being thrown back from a surface (such as mirror)



Reflection of light wave as it being thrown back from a surface.

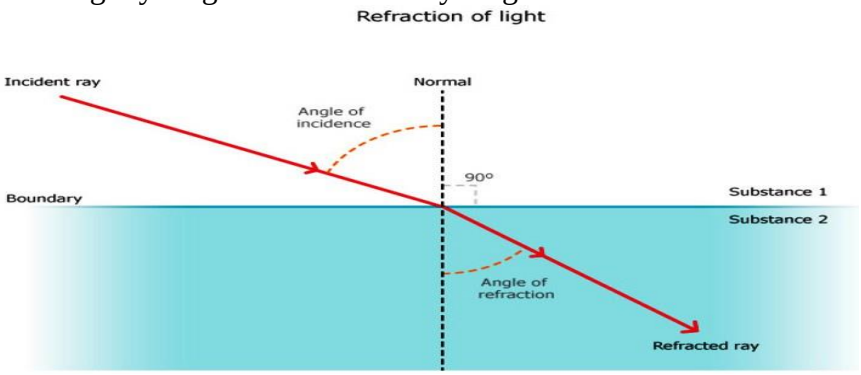
- Diffraction is the breaking or bending up of electromagnetic wave as it passes geometric structure (such as slit).



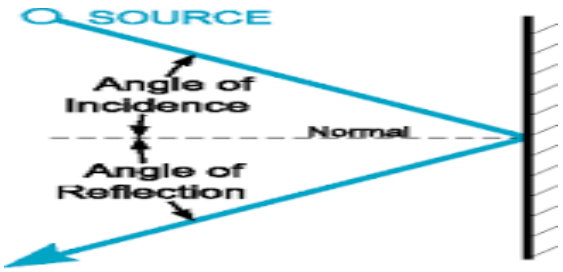
Diffraction of light wave as it passed through a slit.

Third Chunk (Ray diagrams for refraction and reflection).

Study the following ray diagrams and draw ray diagrams for refraction and reflection.



Ray diagram for refraction



Ray diagram for reflection.

GROUP WORK SHEET

First Chunk.

Use the experiences acquired from the individual task paper, list three properties of wave.

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Second Chunk.

Use the experiences acquired from the individual task paper, explain the three properties of wave.

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Third Chunk.

Use the experiences acquired from the individual task paper, draw the ray diagrams for refraction and reflection showing the incidence ray, refracted ray and reflected ray.

WEEK FOUR

Subject: **Physics**

Topic: **Wave Equation and Their Applications**

Period: **80 minutes**

Group: **Experimental**

Class: **SS II**

Sex: **Mixed**

Average Age: **17 Years**

Model of Instruction: **Herrmann's Whole Brain Model**

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

i. draw magic triangle for velocity, wavelength and frequency,

ii. state the relationships for frequency, wavelength and velocity, and

iii. solve problems using the wave equation

Entry Behaviour: The Students have learnt about the characteristics of wave.

Instructional Materials: Individual task papers, group work sheets and cardboard containing magic triangle for velocity (v), wavelength (λ) and frequency (f) and their relationships.

Presentation:

Content	Teacher's Activities	Students' Activities
Step 1 Attention-getting technique (2 minutes)	The teacher say "Class" in any way or tone that he wishes,	The students must mimic the teacher's voice and respond with the word "Yes."
Step 2 Class-room rules (3 minutes)	The teacher go over the three rules to ensure students understand. Each rule is said with a gesture. The rules are as follows: • Rule 1 – • Rule 2 - • Rule 3 –	The students respond as follows in each case: • Raise your hand for permission to speak (raise your hand then make a talking motion with your mouth) • Raise your hand for permission to

<table>
<tr><td></td><td></td><td>leave your chair (raise your hand and make a waving motion with your fingers).
• Keep your dear teacher happy.</td></tr>
<tr><td>Step 3
Introduction of the concept
(8 minutes)</td><td>Teacher displayed the cardboard containing magic triangle for velocity (v), wavelength (λ) and frequency (f) and their relationships on the board and guide the students to study the content.</td><td>The students study the content.</td></tr>
<tr><td>Step4
Individual task
(13 minutes)</td><td>Teacher distributed the prepared individual task paper (see page 102) to the students and give them time to study. The teacher encourage the students to comprehend not to memorize.</td><td>The students study the content.</td></tr>
<tr><td>Step 5
Group task
(20 minutes)</td><td>Teacher grouped the students (4-5 students per group) and distributes the prepared group work sheets (see page 103) and guide them to interact, discuss, share ideas and put the information in their own words about the same information. The students separate immediately after the group work.</td><td>The students accomplished the task (in the prepared group work sheets) via interact, discuss, share ideas and put the available information in their own words about the task. The students separate immediately after the group work.</td></tr>
<tr><td>Step 6
Scoreboard game
(10 minutes)</td><td><table><tr><th>S/N</th><th>Questions</th><th>Students' scores</th><th>Teacher's scores</th></tr><tr><td>1.</td><td>Draw a magic triangle for velocity, frequency and wavelength</td><td></td><td></td></tr><tr><td>2.</td><td>Copy and complete the following V = ……</td><td></td><td></td></tr></table></td><td>The students answer the questions and monitor the record.</td></tr>
</table>

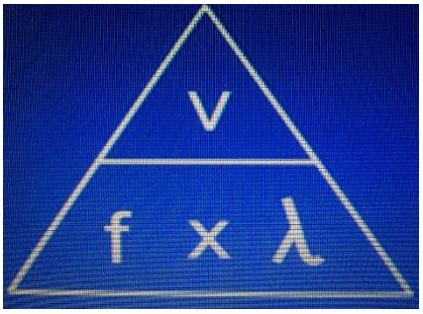
	3. Copy and complete the following f = …….		
	Total		
	The teacher ask the following questions and record the scores as appropriate.		
Step 7 Celebrating performance (4 minutes)	Teacher allowed the students to make one minute movement to celebrate their performance and gives room for questions.		The students make one minute movement to celebrate their performance and ask questions if any.
Step 8 Evaluation (10 minutes)	Teacher ask the following questions; 1. Draw magic triangle for velocity, wavelength and frequency 2. state the relationships between frequency, wavelength and velocity 3. A person shouted and his voice created a sound wave with a frequency of 540Hz. His voice travels a distance of 540m in 0.467s. Calculate the speed, the wavelength and the period of the wave?		The students respond to the questions individually.
Step 9 Conclusion (10 minutes)	Teacher concluded the lesson by summarizing the main points and give the students assignment.		The students take on their assignment.

INDIVIDUAL TASK PAPERS

First Chunk (magic triangle for velocity, wavelength and frequency).

Study the following information and draw magic triangle for v, λ and f.

A magic triangle for velocity (v), wavelength (λ) and frequency (f) is triangle containing velocity 'v' at the top angle, frequency 'f' and wavelength 'λ' at the base angles as shown thus:



Magic triangle for velocity (v), wavelength (λ) and frequency (f)

Second Chunk (Application of the relationships for velocity, wavelength and frequency).

Study the following example and attempt the exercise that follows:

Example

The frequency of a vibrating source is 0.9kHz and the velocity of the sound it produces in air is $330ms^{-1}$. Find how far the sound travels when the source completes 50 vibrations.

Solution:

Given that f = 0.9kHz = 900Hz and $v = 330ms^{-1}$.

Recall that $\lambda = v/f$

Therefore $\lambda = 330ms^{-1}/900Hz = 0.3667m$

⇨ The distance traveled by the wave in 50 complete vibrations = 0.3667 x 50 = 18m.

Exercise

What is the velocity of wave that has a wavelength of 1.4m and a frequency of 240kHz?

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GROUP WORK SHEETS

First Chunk.

Use the experiences acquired from the individual task paper, draw a magic triangle velocity (v), wavelength (λ) and frequency (f) and deduce from it the relationships for velocity (v), wavelength (λ) and frequency (f)

Second Chunk.

Study the following example and attempt the exercise that follows:

Example.

What is the velocity wave that has a wavelength of 1.4m and a frequency of 240kHz?

Solution

Given that f = 240kHz = 240000Hz and λ = 1.4m. Recall that v = f x λ

Therefore v = 240000s^{-1} x 1.4m = 336000 ms^{-1} = 336 kms^{-1}.

Exercise

A person shouted and his voice created a sound wave with a frequency of 540Hz. His voice travels a distance of 540m in 0.467s.

a. What is the speed of the wave?

b. What is the wavelength of the wave?

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WEEK FIVE

Subject: **Physics**

Topic: **Second Law of Refraction and Its Applications**

Period: **80 minutes**

Group: **Experimental**

Class: **SS II**

Sex: **Mixed**

Average Age: **17 Years**

Method of Instruction: **Herrmann's Whole Brain Model**

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

i. state the second law of refraction,

ii. write the mathematical representation of the law (formula), and

iii. solve problems using the mathematical representation of the law.

Entry Behaviour: The Students have learnt about the types and properties of wave.

Instructional Materials: Individual task papers, group work sheets, cardboard containing a ray-diagram showing the angle of incidence, angle of refraction and their relationships.

Presentation:

Content	Teacher's Activities	Students' Activities
Step 1 Attention-getting technique (2 minutes)	The teacher say "Class" in any way or tone that he wishes,	The students must mimic the teacher's voice and respond with the word "Yes."
Step 2 Class-room rules (3 minutes)	The teacher go over the three rules to ensure students understand. Each rule is said with a gesture. The rules	The students respond as follows in each case: • Raise your hand for

<table>
<tr><td></td><td>are as follows:
Rule 1 –
Rule 2 -
Rule 3 –</td><td>permission to speak (raise your hand then make a talking motion with your mouth)
Raise your hand for permission to leave your chair (raise your hand and make a waving motion with your fingers).
Keep your dear teacher happy.</td></tr>
<tr><td>Step 3
Introduction of the concept
(8 minutes)</td><td>Teacher displayed the cardboard containing a ray-diagram on the board and guide the students to identify the first law of refraction.</td><td>The students study the content.</td></tr>
<tr><td>Step4
Individual task
(13 minutes)</td><td>Teacher distributed the prepared individual task paper (see page 107) to the students and give them time to study. The teacher encourage the students to comprehend not to memorize.</td><td>The students study the content.</td></tr>
<tr><td>Step 5
Group task
(20 minutes)</td><td>Teacher grouped the students (4-5 students per group) and distributes the prepared group work sheets (see page 108) and guide them to interact, discuss, share ideas and put the information in their own words about the same information. The students separate immediately after the group work.</td><td>The students accomplished the task (in the prepared group work sheets) via interact, discuss, share ideas and put the available information in their own words about the task. The students separate immediately after the group work.</td></tr>
<tr><td>Step 6
Scoreboard game
(10 minutes)</td><td><table><tr><th>S/N</th><th>Questions</th><th>Students’ scores</th><th>Teacher’s scores</th></tr><tr><td>1.</td><td>State the first law of refraction</td><td></td><td></td></tr><tr><td>2.</td><td>State the second law of</td><td></td><td></td></tr></table></td><td>The students answer the questions and monitor the record.</td></tr>
</table>

		refraction			
	3.	What is refractive index?			
		Total			
	The teacher ask the following questions and record the scores as appropriate.				
Step 7 Celebrating performance (4 minutes)	Teacher allowed the students to make one minute movement to celebrate their performance and gives room for questions.				The students make one minute movement to celebrate their performance and ask questions if any.
Step 8 Evaluation (10 minutes)	Teacher ask the following questions; 10. State the second law of refraction 11. Write the mathematical representation of the law (formula). 12. Light ray incidence on the boundary of two different optical media and refracted in the second medium at an angle of 45^0. Find the angle of incidence if the refractive index of the two media is 1.5.				The students respond to the questions individually.
Step 9 Conclusion (10 minutes)	Teacher concluded the lesson by summarizing the main points and give the students assignment.				The students take on their assignment.

INDIVIDUAL TASK PAPERS

First Chunk (Second law of refraction).

Study the following information and state the second law of refraction.

According to Snell, the ratio of sine of angle of incidence (i) to the sine of angle of refraction (r) remains the same (known as refractive index) for any given pair of media.

The statement above is the second law of refraction and is mathematically represented/written as;

$$\textbf{Sin i / Sin r} = {}_1\mathbf{n}_2$$

Where, $\mathbf{n}$ is the refractive index, 1 and 2 refer to the 1st and 2nd medium respectively.

Second Chunk (Application of the second law of refraction).

Study the following example and attempt the exercise that follows:

Example

If the angles of incidence and refraction are 60^0 and 30^0 respectively. Calculate the refractive index for the media.

Solution.

Given that the angles of incidence (i) = 60^0 and the angles of refraction (r) = 30^0

Recall that, **Sin i / Sin r** = refractive index ($_1\mathbf{n}_2$). Substitute for i and r

Therefore, **Sin i / Sin r** = sin 60^0 / sin 30^0 = $_1\mathbf{n}_2$

0.8660/0.5 = $_1\mathbf{n}_2$

1.7321= $_1\mathbf{n}_2$

Exercise

Light ray incidence on the boundary of two different optical media at 30^0. Find the angle of refraction if the refractive index of the two media is 1.5.

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GROUP WORK SHEETS

First Chunk.

Use the experiences acquired from the individual task paper, state the Snell's laws of refraction, write the mathematical representation of the second law of refraction and define each term.

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Second Chunk.

Study the following example and attempt the exercise that follows:

Example

1. Light ray incidence on the boundary of two different optical media at 30^0. Find the angle of refraction if the refractive index of the two media is 1.5.

Solution

Given that the angles of incidence (i) = 30^0 and the refractive index ($_1\mathbf{n}_2$) = 1.5

Recall that, **Sin i / Sin r** = refractive index ($_1\mathbf{n}_2$).

=> **Sin i / $_1\mathbf{n}_2$ = Sin r**

=> r = $\sin^{-1}$(Sin i / $_1\mathbf{n}_2$)

Therefore **r = $\sin^{-1}$(sin** 30^0 /1.5) = **$\sin^{-1}$**(0.5/1.5)

=> r = **$\sin^{-1}$(0.3333**) = 19.47^0

Exercise

Light ray incidence on the boundary of two different optical media and refracted in the second medium at an angle of 45^0. Find the angle of incidence if the refractive index of the two media is 1.5..……...……..

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WEEK SIX

Subject: **Physics**

Topic: **Electromagnetic Spectrum**

Period: **80 minutes**

Group: **Experimental**

Class: **SS II**

Sex: **Mixed**

Average Age: **17 Years**

Model of Instruction: **Herrmann's Whole Brain Model**

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

i. state the different waves in electromagnetic spectrum,
ii. arrange the different waves in electromagnetic spectrum in order of their wavelength, and
iii. state at least one use of each wave in the electromagnetic spectrum.

Entry Behaviour: The students have learnt about types, properties and characteristics of waves.

Instructional Materials: Individual task papers, group work sheets, cardboard containing the waves in electromagnetic spectrum and their arrangement in the order of their wavelength using the statement "Remember My Instructions Visible-light Under X-Ray Glasses".

Presentation:

Content	Teacher's Activities	Students' Activities

<table>
<tr><td>Step 1
Attention-getting technique
(2 minutes)</td><td>The teacher say “Class” in any way or tone that he wishes,</td><td>The students must mimic the teacher’s voice and respond with the word “Yes.”</td></tr>
<tr><td>Step 2
Class-room rules
(3 minutes)</td><td>The teacher go over the three rules to ensure students understand. Each rule is said with a gesture. The rules are as follows:
Rule 1 –
Rule 2 -
Rule 3 –</td><td>The students respond as follows in each case:
Raise your hand for permission to speak (raise your hand then make a talking motion with your mouth)
Raise your hand for permission to leave your chair (raise your hand and make a waving motion with your fingers).
Keep your dear teacher happy.</td></tr>
<tr><td>Step 3
Introduction of the concept
(8 minutes)</td><td>Teacher displayed the cardboard mentioned above on the board and guide the students to the content.</td><td>The students study the content.</td></tr>
<tr><td>Step4
Individual task
(13 minutes)</td><td>Teacher distributed the prepared individual task paper (see page 112) to the students and give them time to study. The teacher encourage the students to comprehend not to memorize.</td><td>The students study the content.</td></tr>
<tr><td>Step 5
Group task
(20 minutes)</td><td>Teacher grouped the students (4-5 students per group) and distributes the prepared group work sheets (see page 114) and guide them to interact, discuss, share ideas and put the information in their own words about the same information. The students separate immediately after the group work.</td><td>The students accomplished the task (in the prepared group work sheets) via interact, discuss, share ideas and put the available information in their own words about the task. The students separate immediately after the group work.</td></tr>
<tr><td>Step 6
Scoreboard game
(10 minutes)</td><td><table><tr><td>S/</td><td>Questions</td><td>Students’</td><td>Teacher’s</td></tr></table></td><td>The students answer the questions and monitor the record.</td></tr>
</table>

<table>
<tr><td></td><td><table>
<tr><td>N</td><td></td><td>scores</td><td>scores</td></tr>
<tr><td>1.</td><td>State the electromagnetic wave with highest wavelength.</td><td></td><td></td></tr>
<tr><td>2.</td><td>State the electromagnetic wave with highest wavelength.</td><td></td><td></td></tr>
<tr><td>3.</td><td>Which wave is use in modern kitchen for cooking?</td><td></td><td></td></tr>
<tr><td></td><td>Total</td><td></td><td></td></tr>
</table>The teacher ask the following questions and record the scores as appropriate.</td><td></td></tr>
<tr><td>Step 7
Celebrating performance
(4 minutes)</td><td>Teacher allowed the students to make one minute movement to celebrate their performance and gives room for questions.</td><td>The students make one minute movement to celebrate their performance and ask questions if any.</td></tr>
<tr><td>Step 8
Evaluation
(10 minutes)</td><td>Teacher ask the following questions;
1. State the different waves in electromagnetic spectrum.
2. Arrange the different waves in electromagnetic spectrum in order of their wavelength.
3. State at least one use of each wave in the electromagnetic spectrum.</td><td>The students respond to the questions individually.</td></tr>
<tr><td>Step 9
Conclusion
(10 minutes)</td><td>Teacher concluded the lesson by summarizing the main points and give the students assignment.</td><td>The students take on their assignment.</td></tr>
</table>

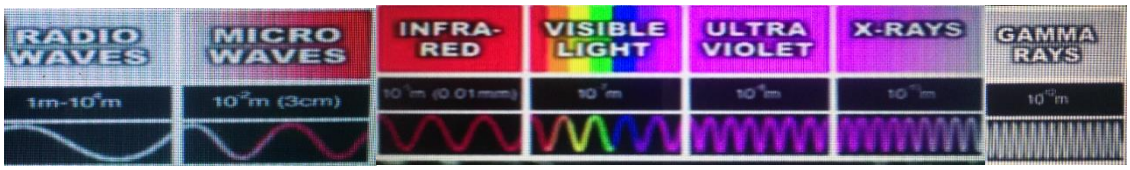
INDIVIDUAL TASK PAPERS

First Chunk (The different waves in electromagnetic spectrum).

Study the following information and list the different waves in electromagnetic spectrum. The different waves in electromagnetic spectrum are; x- rays, visible-light, ultraviolet ray, micro-wave, Infra-red rays, Gamma rays and Radio wave. These waves differ in their characteristics and are arrange in descending order of their wavelength using the statement thus:

Remember **M**y **I**nstructions **V**isible-light **U**nder **X**- ray **G**lasses

'R' for Radio wave, **'M'** for Micro-wave, **'I'** for Infra-red rays, **'V'** for Visible-light, **'U'** for Ultraviolet ray, **'X'** for X- Ray and **'G'** for Gamma rays.



The different waves in electromagnetic spectrum

Second Chunk (The uses of the different waves in electromagnetic spectrum).

Study the following information and state one use of each waves in electromagnetic spectrum.

The use of different waves in the electromagnetic spectrum are as follow;

- Radio waves are used for radio transmissions



Radio

- Micro-wave are used for cooking in micro-wave oven. It is also for receiving satellite signals

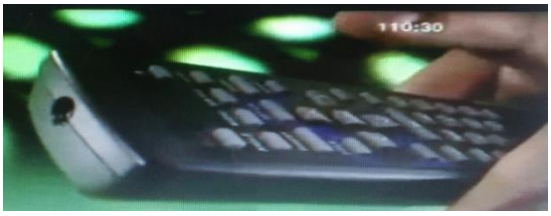


Micro-wave oven



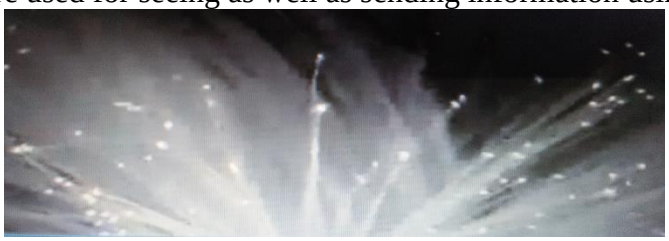
Satellite

- Infra-red rays are used for television remote control



Remote control

- Visible-light are used for seeing as well as sending information using optical fiber



Optical fiber.

- Ultraviolet light is used in night clubs and for viewing bank's note security



Night club



Bank's note security

- X- Ray is used for detecting broken bones and undergrounded pipes

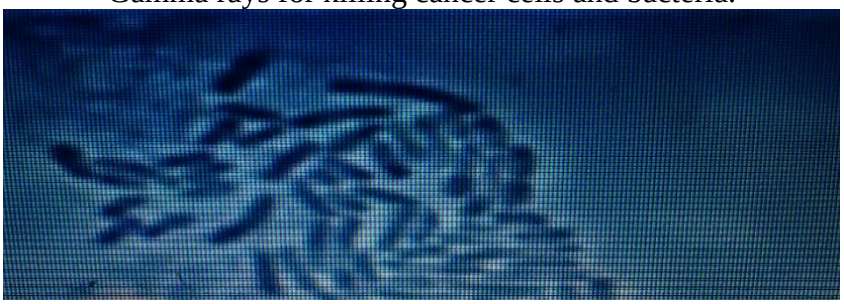


Bones



Undergrounded pipes

- Gamma rays for killing cancer cells and bacteria.



Cancer cell.

GROUP WORK SHEETS

First Chunk.

Use the experiences acquired from the individual task paper, state the different waves in electromagnetic spectrum and arrange them in ascending order of their wavelengths

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Second Chunk.

Use the experiences acquired from the individual task paper, list ten (10) uses of electromagnetic

spectrum……...……

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APPENDIX B

LESSON PLAN FOR CONTROL GROUP (LECTURE METHOD)

WEEK ONE

Subject: **Physics**

Topic: **Waves**

Period **80 minutes**

Group: **Control**

Class: **SS II**

Sex: **Mixed**

Average age: **17 years**

Method of Instruction: **Lecture method**

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

i. define wave,
ii. state examples of wave,
iii. list the characteristics of waves and
iv. explain atlease three.

Entry Behaviour: Students are familiar with same phenomena such as light, sound and so on.

Instructional Materials: Lesson note and chalk

Introduction (5 minutes): The teacher introduced the lesson by asking students some questions based on their entry behaviour such as:

1. What happen to water surface when something drop in?
2. What happen if you touch the part of drum while some one is beating it?
3. What do you observe when water is moving in the pond or dam?

Presentation: The teacher presents the lesson based on the following steps:

Step 1 (15 minutes): Teacher defines and explains the term 'waves'.

Step 2 (10 minutes): Teacher states and explains some examples of wave such as water wave, sound wave, radio wave, light wave among others.

Step 3 (15 minutes): Teacher lists and explains the characteristics of waves.

Step 4 (5 minutes): Teacher gives room for questions.

Students' Activity (10 minutes): Teacher allows the students to jot the summary in their books.

Evaluation (10 minutes): Teacher evaluates the lesson by asking students the following questions;

1. Define wave.
2. State three examples of wave.
3. List and explain four characteristics of wave.

Conclusion (10 minutes): Teacher concludes the lesson by giving the students the following take home assignment to be submitted next class.

Assignment: Write a short note on wave and its characteristics with common examples.

WEEK TWO

Subject: **Physics**

Topic: **Types of Waves**

Period **80 minutes**

Group: **Control**

Class: **SS II**

Sex: **Mixed**

Average Age: **17 Years**

Method of Instruction: **Lecture Method**

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

i. state the types of waves,
ii. explain each types of wave, and

iii. state examples of each wave type.

Entry Behaviour: The Students have learnt about the definition, examples and characteristics of waves.

Instructional Materials: Lesson note and chalk

Introduction (5 minutes): The teacher introduces the lesson by asking students some questions based on their entry behaviour such as:

1. What is wave?
2. What are the examples of wave?
3. What are the characteristics of wave?

Presentation: The teacher presents the lesson based on the following steps:

Step 1 (15 minutes): Teacher States the types of waves (Electromagnetic waves, Mechanical waves, Transverse wave and longitudinal waves).

Step 2 (15 minutes): Teacher explains each type of waves (Electromagnetic waves, Mechanical waves, Transverse wave and Longitudinal waves).

Step 3 (10 minutes): Teacher states some examples of each types of waves.

Step 4 (5 minutes): Teacher gives room for questions.

Students' Activity (10 minutes): Teacher allows the students to jot down the summary in their books.

Evaluation (10 minutes): The teacher evaluates the lesson by asking students the following questions:

1. State the two main types of waves.

2. Explain each types of wave.
3. State examples of each wave type.

Conclusion (10 minutes): Teacher concludes the lesson by giving the students the following take home assignment to be submitted next class.

Assignment: Write a short note on the four types of wave with common examples.

WEEK THREE

Subject:	**Physics**
Topic:	**Properties of Waves**
Period	**80 minutes**
Group:	**Control**
Class:	**SS II**
Sex:	**Mixed**
Average Age:	**17 Years**
Method of Instruction:	**Lecture Method**

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

i. state the properties of waves (refraction, reflection interference, polarization and diffraction),

ii. explain refraction, reflection and diffraction, and

iii. differentiate between the incidence ray, the refracted ray and the reflected ray using diagram.

Entry Behaviour: The Students have learnt about the definition, types and characteristics of wave.

Instructional Materials: Lesson note and chalk

Introduction (5 minutes): Teacher introduces the lesson by asking students some questions based on their entry behaviour such as:

1. What is wave?
2. What are the types of wave?
3. What are the characteristics of wave?

Presentation: Teacher presents the lesson based on the following steps:

Step 1 (10 minutes): Teacher states the properties of waves (Refraction, reflection and diffraction).

Step 2 (15 minutes): Teacher explains the properties of waves.

Step 3 (15 minutes): Teacher differentiates between the incidence ray, the refracted ray and the reflected ray using diagram.

Step 4 (5 minutes): Teacher gives room for questions.

Students' Activity (10 minutes): Teacher allow the students to jot the summary in their books.

Evaluation (10 minutes): Teacher evaluates the lesson by asking the followings questions:

1. State five properties of waves you know.
2. Explain any three properties of waves.
3. With the aid of diagram, differentiate between the incidence ray, the refracted ray and the reflected ray.

Conclusion (10 minutes): Teacher concludes the lesson by giving the students the following take home assignment to be submitted next class.

Assignment: With aid of diagrams explain the properties of waves you know.

WEEK FOUR

Subject: **Physics**

Topic: **Wave Equations and Their Applications**

Period **80 minutes**

Group: **Control**

Class: **SS II**

Sex: **Mixed**

Average Age: **17 Years**

Method of Instruction: **Lecture Method**

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

i. draw magic triangle for velocity, wavelength and frequency,

ii. state the relationships between frequency, wavelength and velocity, and

iii. solve problems using the wave equation.

Entry Behaviour: The students have learnt about the types of wave.

Instructional Materials: Lesson note and chalk

Introduction (5 minutes): Teacher introduces the lesson by asking students some questions based on their entry behaviour such as:

1. What are the main types of waves?
2. What are the examples of electromagnetic waves?
3. What are the examples of mechanical waves?

Presentation: Teacher presents the lesson based on the following steps:

Step 1 (10 minutes): Teacher draws and explains magic triangle for v, λ and f.

Step 2 (15 minutes): Teacher states the relationships between frequency, wavelength and velocity and use the magic triangle above to show the relationships between f, λ and v mathematically.

Step 3 (15 minutes): Teacher solves and explains the followings examples;

1. The frequency of a vibrating source is 0.9kHz and the velocity of the sound it produces in air is $330ms^{-1}$find how far the sound travels when the source completes 50 vibrations.
2. A radio station broadcasts at using a wave of wavelength 300×10^{-3}m. If the speed of the wave is $3 \times 10^{9}ms^{-1}$, calculate the period and frequency of the wave.

Step 4 (5 minutes): Teacher gives room for questions.

Students' Activity (10 minutes): Teacher allows the students to jot the summary in their books.

Evaluation (10 minutes): Teacher evaluates the lesson by asking the following questions;

1. Draw magic triangle for velocity, wavelength and frequency.
2. State the relationships between frequency, wavelength and velocity.
3. A person shouted and created a sound wave with a frequency of 540Hz. His voice travels a distance of 540m in 0.467s. Calculate the speed, wavelength and the period of the wave?

Conclusion (10 minutes): Teacher concludes the lesson by giving the students take home assignment to be submitted next class.

Assignment: find the frequency, speed and wavelength of a wave whose period is 5s and covered 1km in 20s.

WEEK FIVE

Subject: **Physics**

Topic: **Laws of Refraction and the Applications of the second**

Period **80 minutes**

Group: **Control**

Class: **SS II**

Sex: **Mixed**

Average Age: **17 Years**

Method of Instruction: **Lecture Method**

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

i. state the law of refraction,

ii. write the mathematical representation of the law (formula), and

iii. solve problems using the mathematical representation of the law.

Entry Behaviour: The students have learnt about the definition, types and properties of wave.

Instructional Materials: Lesson note and chalk

Introduction (5 minutes): Teacher introduces the lesson by asking students some questions based on their entry behaviour such as:

1. What is wave?
2. What are the types of wave?
3. What are the properties of wave?

Presentation: Teacher presents the lesson based on the following steps:

Step 1 (10 minutes): Teacher states and explains the laws of refraction.

Step 2 (10 minutes): Teacher writes and explains the mathematical representation of the second law (formula).

Step 2 (15 minutes): Teacher solves and explains the following examples:

1. If the angles of incidence and refraction are 60^0 and 30^0 respectively. Calculate the refractive index for the media.
2. Light ray incidence on the boundary of two different optical media at 30^0. Find the angle of refraction if the refractive index of the two media is 1.5.

Step 4 (10 minutes): Teacher gives room for questions.

Students' Activity (10 minutes): Teacher allow the students to jot the summary in their books.

Evaluation (10 minutes): Teacher evaluates the lesson by asking the followings questions:

1. State the second law of refraction.
2. Write the mathematical representation of the law (formula) and define the parameters.
3. Light ray incidence on the boundary of two different optical media and refracted in the second medium at an angle of 45^0. Find the angle of incidence if the refractive index of the two media is 1.5.

Conclusion (10 minutes): Teacher concludes the lesson by giving the students take home assignment to be submitted next class.

Assignment: 1. With aid of the diagram state and explain the first law of refraction.

2. Write the mathematical representation of the law and define all the Parameters.

WEEK SIX

Subject: **Physics**

Topic: **Electromagnetic Spectrum**

Period **80 minutes**

Group: **Control**

Class: **SS II**

Sex: **Mixed**

Average Age: **17 Years**

Method of Instruction: **Lecture Method**

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

i. state the different waves in electromagnetic spectrum,
ii. arrange the different waves in electromagnetic spectrum in order of their wavelength, and
iii. state the use of each wave in the electromagnetic spectrum.

Entry Behaviour: The Students have learnt about the definition, types and characteristics of wave.

Instructional Materials: Lesson note and chalk

Introduction (5 minutes): Teacher introduces the lesson by asking students some questions based on their Entry behaviour such as:

1. What is wave?
2. What are the types of wave?
3. What are the characteristics of wave?

Presentation: Teacher presents the lesson based on the following steps:

Step 1 (15 minutes): Teacher states and explains the different waves in electromagnetic spectrum x- rays (visible-light, ultraviolet ray, micro-wave, Infra-red rays, Gamma rays and Radio wave).

Step 2 (10 minutes): Teacher arranges the different waves in electromagnetic spectrum in descending order of their wavelength.

Step 3 (15 minutes): Teacher states and explains the uses of each wave in the electromagnetic spectrum.

Step 4 (5 minutes): Teacher gives room for questions.

Students' Activity (10 minutes): Teacher allows the students to jot down the summary in their books.

Evaluation (10 minutes): Teacher evaluates the lesson by asking the followings questions;

1. State the different waves in electromagnetic spectrum.
2. Arrange the different waves in electromagnetic spectrum in ascending order of their wavelength.
3. State one for each, the use of different waves in electromagnetic spectrum.

Conclusion (10 minutes): Teacher concludes the lesson by giving the students take home assignment to be submitted next class.

Assignment: In a tabular form arrange the different waves in electromagnetic spectrum in ascending order of their frequencies and write their corresponding wavelengths.

APPENDIX C

WAVE PERFORMANCE TEST (WPT)

Dear Respondent,

This Wave Performance Test is meant for collection of data in order to determine students' academic performance and retention in wave concepts in Zaria education zone, Kaduna, Nigeria as a partial fulfillment for the award of Master's degree in Physics

Education at Department of Science Education, Ahmadu Bello University Zaria. All information provided will be kept confidential and will be used only for the purpose of this study. Therefore, your honest response is hereby required.

Thanks.

Yours Faithfully,

MUSA Yusuf
P16EDSC8093

INSTRUCTIONS:

This test consists of 30 objective items. Each question is followed by alternative response lettered a-d. You are expected to choose and circle the correct responses for each question. Each question carries equal marks.

SECTION A.

PERSONAL INFORMATION

School……

Gender: Male [ ] Female [ ]

1. The change of the direction of the wave-front due to the change in velocity of the wave in another medium is called…….

(a) Refraction

(b) Reflection

(c) Interference

(d) Polarization

2. Which of the following statements is true?

a) Angle of refraction is always greater than the angle of incidence for any given pair of media.

b) Refracted ray is always faster than the incidence ray for any given pair of media.

c) Angle of incidence is always equal to the angle of refraction for any given pair of media.

d) Refracted ray, incidence ray and normal always meet at a point for any given pair of media.

3. The Light ray incidence on the boundary of two different optical media is 45^0. Find the refractive index of the two media if the angle of refraction is 30^0.

a) 0.5

b) 1.0

c) 1.5

d) 2.0

4. Which of the following statements is true?

a) The ratio of sine of angle of incidence to the sine of angle of refraction is always constant for any given pair of media.

b) The ratio of angle of incidence to the angle of refraction is always constant for any given pair of media.

c) Refractive index of a given pair of media remain the same as the pair of the media is inverted.

d) Visible light has the same speed both in glass and in air?

5. When Light ray incidences on the boundary of two different optical media and refracted in the second medium at an angle of 30^0. Find the angle of incidence if the refractive index of the two media is 1.5.

a) 80^0

b) 60^0

c) 90^0

d) 30^0

6. Which of the following has the highest penetrating power?

a) x- rays

b) Infra-red rays

c) Gamma rays

d) Radio wave

7. Which of the following remains unchanged as light travels from one medium to another? I. speed II. Wavelength III. Frequency.

a) I only

b) II only

c) III only

d) I and II only

8. Which of the following waves travels in vacuum? I. Water wave II. Radio wave III. Sound wave.

(a) I only

(b) II only

(c) III only

(d) I and II only

9. Which of the following has the longest wavelength?

a) x- rays

b) Infra-red rays

c) Gamma rays

d) Radio wave

10. Which of the following media allows the transmission of sound wave more readily?

a) Air

b) Vacuum

c) Water

d) Glass

11. If a wave has a period of 0.02s and a speed of 330m/s, find its wavelength in meter.

a) 6.6m

b) 4.0m

c) 4.6m

d) 4.4m

12. The distance between two successive crests of a water is 100cm, if a particle on the surface of the water makes 60 complete vertical oscillations in 1minute, calculate the speed of the wave.

a) 1.0m/s

b) 5.0m/s

c) 2.0m/s

d) 4.0m/s

13. A disturbance which travels through a medium transferring energy from one point to another without causing any permanent displacement of the medium is known as…….

(a) Force

(b) Momentum

(c) Wave

(d) Gravity

14. Which of the following can be used alone to estimate the frequency of a given wave?

(a) Period

(b) speed

(c) Amplitude

(d) wavelength

15. Which of the following properties of light is the most useful at home?

(a) Polarization

(b) Diffraction

(c) Reflection

(d) Interference

16. All the following are types of waves except.....

(a) Mechanical

(b) Electromagnetic

(c) sun

(d) Transverse

17. A type of wave that does not requires material medium for its propagation is known as.....

(a) Mechanical wave

(b) Electromagnetic wave

(c) Sun wave

(d) Transverse wave

18. Which of the following arranges the waves in electromagnetic spectrum in the ascending order of their wavelengths?

(a) Radio waves, Micro waves, Infrared, Visible light, Ultra-violet, X- rays, and Gamma rays

(b) Gamma rays, X- rays, Ultra-violet, Visible light, Infrared, Micro waves and Radio waves

(c) Gamma rays, X- rays, , Visible light, Infrared, Ultra-violet Micro waves and Radio waves

(d) Radio waves, Micro waves, Ultra-violet, Infrared, Visible light, X- rays, and Gamma rays

19. Wave consists of------- that moves without carrying matter with them.

(a) Oscillations

(b) Mechanism

(c) Solidification

(d) Vectors

20. A wave which travels in a direction parallel to the vibration of medium is called.....

(a) Transverse wave

(b) Longitudinal wave

(c) Horizontal wave

(d) Vertical wave

21. ……. is used for detecting broken pipes berried underground?

(a) x- rays

(b) Infra-red rays

(c) Gamma rays

(d) Radio wave

22. Which of the following is not a property of wave?

(a) Reflection

(b) Diffraction

(c) Interference

(d) Reproduction

23. An angle which the direction of motion of a plane wave-front makes with the normal to the metal surface is known as angle of.....

(a) Reflector

(b) Incidence

(c) Reflection

(d) Convex

24. The frequency of a vibrating source is 450Hz and the velocity of the sound it produces in air is $330ms^{-1}$. Find how far the sound travels when the source completes 50 vibrations.

(a) 26.67m

(b) 67.26m

(c) 36.67m

(d) 67.26km

25. A radio station broadcasts at frequency of 300 kHz. If the speed of the wave is $3 \times 10^{9}ms^{-1}$, calculate the wavelength of the wave.

(a) 0.1km

(b) 10km

(c) 1km

(d) 11km

26. Which of the following is used for killing cancer cells?

(a) x- rays

(b) Infra-red rays

(c) Gamma rays

(d) Radio wave

27. In a wave, the maximum displacement of particles from their equilibrium positions is called.....

(a) Amplitude

(b) Frequency

(c) Period

(d) wavelength

28. Which of the following best describes the relationship between frequency, wavelength and velocity?

(a) $f = \lambda/v$

(b) $\lambda = f/v$

(c) $v = f\lambda$

(d) $f = v\lambda$

29. …… is a property of propagated wave being thrown back from a surface (such as mirror)?

(a) Interference

(b) Reflection

(c) Polarization

(d) Diffraction

30. Television remote control uses …… to change channels.

(a) Gamma rays

(b) Radio wave

(c) x- rays

(d) Infra-red rays

APPENDIX D

MARKING SCHEME FOR WAVE PERFORMANCE TEST

1. A
2. D
3. D
4. A
5. B
6. C
7. C
8. B
9. D
10. A
11. A
12. A
13. C

14. A
15. C
16. C
17. B
18. B
19. A
20. B
21. A
22. D
23. B
24. C
25. B
26. C
27. A
28. C
29. B
30. D

Total: 1 mark x 30 = 30marks

APPENDIX E

Reliability Value of WPT

```
RELIABILITY
  /VARIABLES=Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8 Q9 Q10 Q11 Q12 Q13 Q14 Q15 Q16 Q17
Q18 Q19 Q20 Q21 Q22 Q23 Q24 Q25 Q26 Q27 Q28 Q29 Q30
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /STATISTICS=SCALE.
```

Notes

Output Created		25-JAN-2019 11:48:55
Comments		
Input	Active Dataset	DataSet0
	Filter	<none>
	Weight	<none>
	Split File	<none>

	N of Rows in Working Data File	52
Missing Value Handling	Matrix Input	
	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the procedure.
Syntax		RELIABILITY /VARIABLES=Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8 Q9 Q10 Q11 Q12 Q13 Q14 Q15 Q16 Q17 Q18 Q19 Q20 Q21 Q22 Q23 Q24 Q25 Q26 Q27 Q28 Q29 Q30 /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /STATISTICS=SCALE.
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Scale: ALL VARIABLES

Reliability Statistics

Cronbach's Alpha	N of Items
.762	30

APPENDIX F

Results of Pretest Analysis

```
ONEWAY pretest BY sample
  /MISSING ANALYSIS
  /POSTHOC=SCHEFFE ALPHA(0.05).
```

Oneway

```
[DataSet0]
```

ANOVA

Pretest

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	2917.087	3	972.362	138.535	.000
Within Groups	3460.317	493	7.019		

Total	6377.404	496			

Multiple Comparisons

Dependent Variable: pretest

Scheffe

(I) sample	(J) sample	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Muchia	Magajiya	3.153*	.351	.000	2.17	4.14
	Aminu	-.003	.352	1.000	-.99	.98
	Tudun-jukun	-3.430*	.340	.000	-4.38	-2.48
Magajiya	Muchia	-3.153*	.351	.000	-4.14	-2.17
	Aminu	-3.156*	.336	.000	-4.10	-2.21
	Tudun-jukun	-6.584*	.324	.000	-7.49	-5.67
Aminu	Muchia	.003	.352	1.000	-.98	.99
	Magajiya	3.156*	.336	.000	2.21	4.10
	Tudun-jukun	-3.427*	.325	.000	-4.34	-2.51
Tudun-jukun	Muchia	3.430*	.340	.000	2.48	4.38
	Magajiya	6.584*	.324	.000	5.67	7.49
	Aminu	3.427*	.325	.000	2.51	4.34

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

Homogeneous Subsets

Pretest

Scheffe

Sample	N	Subset for alpha = 0.05		
		1	2	3
Magajiya	125	4.10		
Muchia	105		7.26	
Aminu	123		7.26	
Tudun-jukun	144			10.69
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 122.706.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

APPENDIX G

FI and DI for WPT

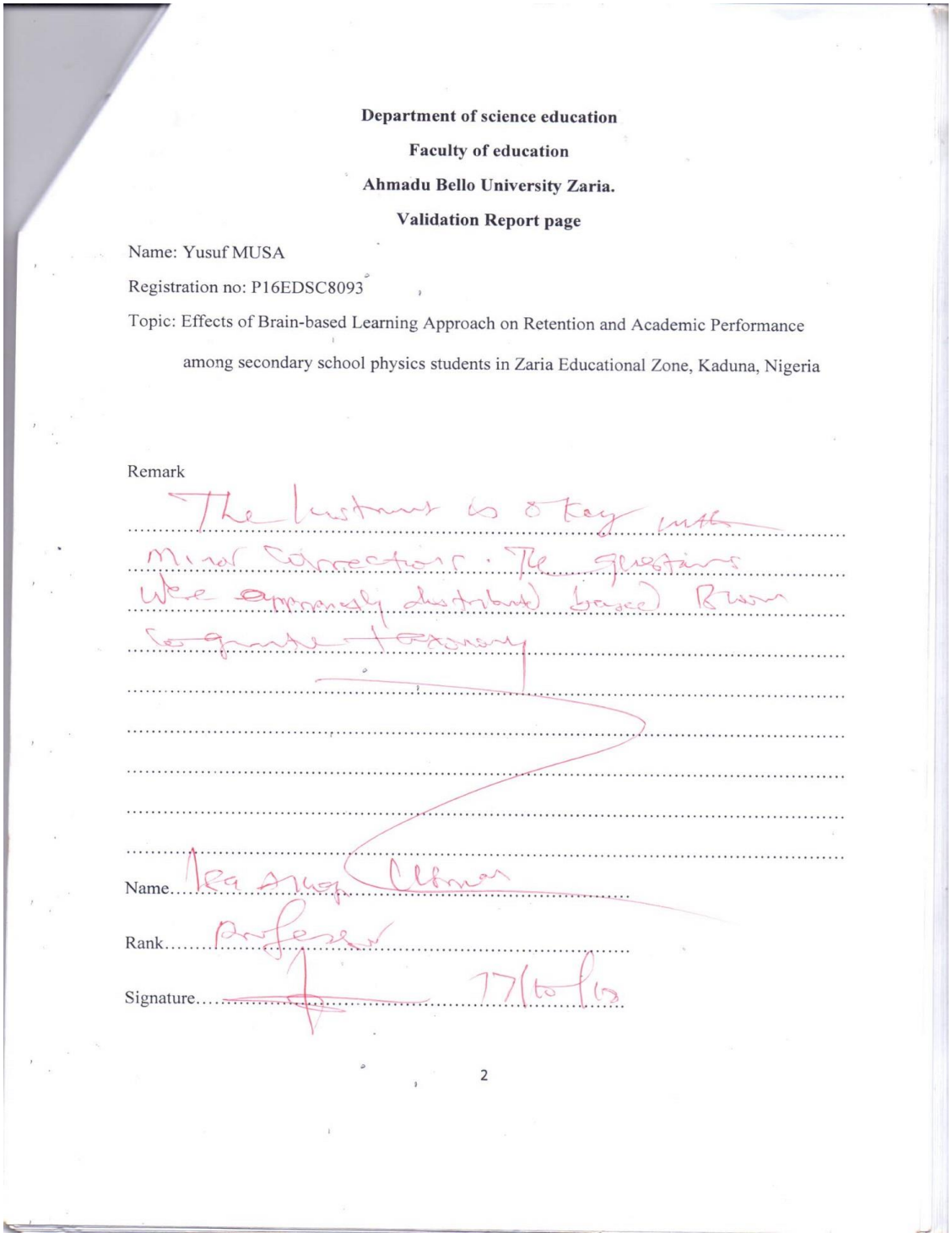
No. of Item	FI=(R/T)x100	DI=(RU-RL)/N
1.	48	0.54
2.	46	0.57
3	53	0.51
4	56	0.46
5	46	0.58
6	54	0.54
7	51	0.55
8	44	0.49
9	45	0.58
10	54	0.56
11	51	0.60

	12	56	0.44
	13	48	0.50
	14	45	0.49
	15	49	0.50
	16	46	0.50
	17	44	0.56
	18	49	0.49
	19	47	0.55
	20	56	0.58
A	21	52	0.54
	22	46	0.50
P	23	55	0.42
	24	40	0.43
P	25	49	0.55
	26	41	0.43
E	27	55	0.45
	28	57	0.47
N	29	52	0.46
	30	51	0.52
D			

I

X H

Validation Forms



Department of science education

Faculty of education

Ahmadu Bello University Zaria.

Validation Report page

Name: Yusuf MUSA

Registration no: P16EDSC8093

Topic: Effects of Brain-based Learning Approach on Retention and Academic Performance among secondary school physics students in Zaria Educational Zone, Kaduna, Nigeria

Remark

The instrument is okay with minor corrections. The questions were appropriately distributed based Bloom taxonomy

Name: Isa Alhaji Ahmar

Rank: Professor

Signature: 17/10/19

2

Department of science education

Faculty of education

Ahmadu Bello University Zaria.

Validation Report page

Name: Yusuf MUSA

Registration no: P16EDSC8093

Topic: Effects of Brain-based Learning Approach on Retention and Academic Performance among secondary school physics students in Zaria Educational Zone, Kaduna, Nigeria

Remark

The instructions are well written is few minor corrections only to be effected. The questions are widely spread within the area examined/tested.

Name: Dr. H. N. Garba

Rank: Lecturer I.

Signature: 2/11/2018

Department of science education

Faculty of education

Ahmadu Bello University Zaria.

Validation Report page

Name: Yusuf MUSA

Registration no: P16EDSC8093

Topic: Effects of Brain-based Learning Approach on Retention and Academic Performance among secondary school physics students in Zaria Educational Zone, Kaduna, Nigeria

Remark

✓ The lesson plan is vague, stated content in the lesson objectives have not been clearly featured in the spets of the lesson

✓ No duration and time spread in the lesson plan.

Name Dr M.K. Falalu

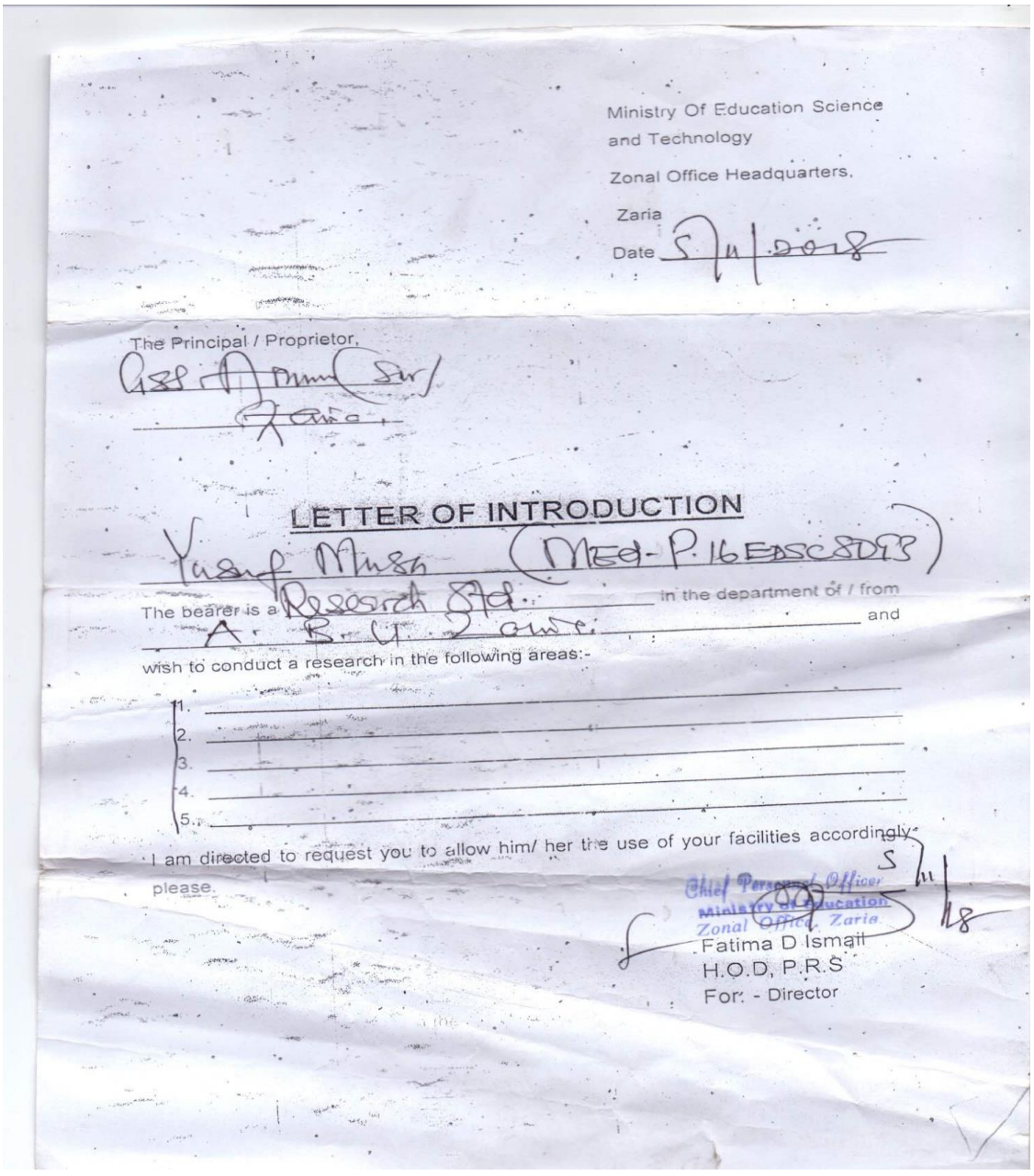
Rank Snr Lecturer

Signature [signature] 28/12/18

2

APPENDIX I

Letters for Permission to Collect Data



Ministry Of Education Science
and Technology

Zonal Office Headquarters,

Zaria

Date 5/11/2018

The Principal / Proprietor,

LETTER OF INTRODUCTION

Yusuf Musa (Med-P.16EDSC5D13)

The bearer is a Research Std. in the department of / from A. B. U. Zaria and wish to conduct a research in the following areas:-

1.
2.
3.
4.
5.

I am directed to request you to allow him/ her the use of your facilities accordingly please.

Chief Personnel Officer
Ministry of Education
Zonal Office, Zaria

Fatima D Ismail
H.O.D, P.R.S
For: - Director

Ministry Of Education Science
and Technology

Zonal Office Headquarters,

Zaria

Date 5/11/2018

The Principal / Proprietor,

GSS Tudun Jukun (SW)

ZARIA

LETTER OF INTRODUCTION

Yusuf Musa Mel PG/GSSC/8093

The bearer is a Research Student in the department of / from and wish to conduct a research in the following areas:-

1.
2.
3.
4.
5.

I am directed to request you to allow him/ her the use of your facilities accordingly please.

Chief Personnel Officer
Ministry of Education
Zonal Office, Zaria

5/11/18

Fatima D Ismail
H.O.D, P.R.S
For: - Director

Ministry Of Education Science
and Technology

Zonal Office Headquarters,

Zaria

Date 5/9/2018

The Principal / Proprietor,

(ISS Muchia (Sw)

IAPLA

LETTER OF INTRODUCTION

Yusuf MUSA Med P/Hlth/80973

The bearer is a RESEARCH STD in the department of / from _____ and wish to conduct a research in the following areas:-

1. _____
2. _____
3. _____
4. _____
5. _____

I am directed to request you to allow him/ her the use of your facilities accordingly please.

Chief Personnel Officer
Ministry of Education
Zonal Office Zaria
5/11/18

Fatima D Ismail
H.O.D, P.R.S
For: - Director

Ministry Of Education Science
and Technology

Zonal Office Headquarters,

Zaria

Date 5/11/2018

The Principal / Proprietor,

GSS LIGORO (Sw)

Zaria

LETTER OF INTRODUCTION

Yusuf Musa (MED. P16 GDSC 8093)

The bearer is a Research Std. in the department of / from

and wish to conduct a research in the following areas:-

1.
2.
3.
4.
5.

I am directed to request you to allow him/ her the use of your facilities accordingly please.

Chief Personnel Officer
Ministry of Education
Zonal Office, Zaria.

Fatima D Ismail
H.O.D, P.R.S
For: - Director

5/11/18

APPENDIX J

Results of Posttest Analysis

Experimental Group versus Control Group

```
T-TEST GROUPS=treatment(1 2)
  /MISSING=ANALYSIS
  /VARIABLES=scores
  /CRITERIA=CI(.95).
```

T-Test

```
[DataSet0]
```

Group Statistics

	Treatment	N	Mean	Std. Deviation	Std. Error Mean
scores	Experimental group	123	21.5366	3.41475	.30790
	Control group	105	10.4000	2.88764	.28180

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
scores	Equal variances assumed	1.742	.188	26.332	226	.000	11.13659	.42293	10.30320	11.96997
	Equal variances not assumed			26.681	225.983	.000	11.13659	.41739	10.31411	11.95906

Males versus Females within the Experimental Group

```
T-TEST GROUPS=gender(1 2)
  /MISSING=ANALYSIS
  /VARIABLES=scores
  /CRITERIA=CI(.95).
```

T-Test

```
[DataSet0]
```

Group Statistics

	gender	N	Mean	Std. Deviation	Std. Error Mean
Scores	Male	52	21.6154	3.37902	.46859
	Female	71	21.0282	3.68771	.43765

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
scores	Equal variances assumed	.090	.765	.903	121	.368	.58722	.64995	-.69952	1.87396
	Equal variances not assumed			.916	115.018	.362	.58722	.64118	-.68284	1.85727

APPENDIX K

Results of Post-posttest Analysis

Experimental Group versus Control Group

```
T-TEST GROUPS=treatment(1 2)
  /MISSING=ANALYSIS
  /VARIABLES=scores
  /CRITERIA=CI(.95).
```

T-Test

```
[DataSet0]
```

Group Statistics

	Treatment	N	Mean	Std. Deviation	Std. Error Mean
scores	Experimental group	123	20.6504	3.68645	.33240
	Control group	105	8.9238	2.64101	.25774

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
scores	Equal variances assumed	9.643	.002	27.178	226	.000	11.72660	.43148	10.87636	12.57684

	Equal variances not assumed			27.880	219.657	.000	11.72660	.42061	10.89764	12.55555

Males versus Females within the Experimental Group

```
T-TEST GROUPS=gender(1 2)
  /MISSING=ANALYSIS
  /VARIABLES=scores
  /CRITERIA=CI(.95).
```

T-Test

```
[DataSet0]
```

Group Statistics

	gender	N	Mean	Std. Deviation	Std. Error Mean
Scores	Male	52	19.0000	3.81432	.52895
	Female	71	19.3380	3.31207	.39307

Independent Samples Test

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper

scores	Equal variances assumed	2.687	.104	-.524	121	.601	-.33803	.64476	-1.61451	.93845
	Equal variances not assumed			-.513	100.541	.609	-.33803	.65901	-1.64540	.96934

APPENDIX L

Pretest, Posttest and Post-Posttest Row Data.

Control Group

S/NO	PRETEST	POSTTEST	POST-POSTTEST	SEX
1	9	14	6	M
2	5	13	12	M
3	3	14	7	M
4	10	10	13	M
5	11	6	10	M
6	5	12	6	M
7	7	4	11	M
8	12	13	10	M
9	11	11	12	M
10	6	8	9	M
11	9	13	7	M
12	8	8	11	M
13	10	14	6	M
14	6	6	13	M
15	4	10	9	M
16	6	9	12	M
17	9	12	4	M
18	8	11	10	M
19	7	6	8	M
20	9	11	10	M
21	9	7	9	M
22	10	14	9	M
23	11	7	11	M
24	6	14	9	M
25	4	6	6	M
26	5	10	5	M
27	9	10	10	M
28	11	9	11	M
29	5	12	8	M
30	6	11	4	M
31	3	14	7	M

32	3	12	9	M
33	8	5	10	M
34	5	11	7	M
35	11	8	5	M
36	9	13	13	M
37	4	11	10	M
38	7	11	7	M
39	3	15	14	M
40	4	7	8	M
41	10	12	12	M
42	11	10	8	M
43	6	9	4	M
44	10	12	7	M
45	11	13	5	M
46	5	14	6	M
47	7	13	12	F
48	12	14	7	F
49	11	10	13	F
50	6	6	10	F
51	9	12	6	F
52	8	4	11	F
53	10	13	10	F
54	6	11	12	F
55	4	8	9	F
56	6	13	7	F
57	9	8	11	F
58	8	14	6	F
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61	9	9	12	F
62	10	12	4	F
63	11	11	10	F
64	6	6	8	F
65	4	11	10	F
66	5	7	9	F
67	9	14	9	F
68	11	7	11	F
69	5	14	9	F
70	6	6	6	F
71	3	10	5	F
72	3	10	10	F
73	8	9	11	F
74	5	12	8	F
75	11	11	4	F

76	9	14	7	F
77	4	12	9	F
78	7	5	10	F
79	3	11	7	F
80	4	8	5	F
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82	11	11	10	F
83	6	11	7	F
84	7	15	14	F
85	9	7	8	F
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88	11	9	4	F
89	6	12	7	F
90	4	13	6	F
91	5	14	12	F
92	9	13	7	F
93	11	14	13	F
94	5	10	10	F
95	6	6	6	F
96	3	12	11	F
97	3	4	10	F
98	8	13	12	F
99	5	11	9	F
100	11	8	7	F
101	9	13	11	F
102	4	8	6	F
103	7	14	13	F
104	3	6	9	F
105	4	10	12	F

Experimental Group

S/NO	PRETEST	POSTTEST	POST-POSTTEST	SEX
1	8	19	22	M
2	6	23	19	M
3	8	24	21	M
4	9	22	20	M
5	10	25	20	M
6	10	24	23	M
7	5	22	16	M
8	7	21	15	M
9	13	21	14	M
10	9	25	20	M

11	11	15	16	M
12	2	21	22	M
13	10	24	19	M
14	8	26	26	M
15	6	19	18	M
16	3	28	17	M
17	5	21	22	M
18	5	25	24	M
19	8	20	21	M
20	12	19	17	M
21	6	18	15	M
22	7	21	19	M
23	10	25	21	M
24	10	23	24	M
25	6	24	22	M
26	7	22	20	M
27	7	17	15	M
28	13	24	23	M
29	4	17	25	M
30	8	22	23	M
31	5	12	15	M
32	4	21	20	M
33	6	23	24	M
34	7	16	21	M
35	8	21	22	M
36	4	26	17	M
37	5	27	15	M
38	10	26	24	M
39	5	20	21	M
40	2	17	15	M
41	3	18	23	M
42	9	17	10	M
43	3	21	20	M
44	9	15	17	M
45	8	21	18	M
46	11	27	15	M
47	6	23	20	M
48	10	19	15	M
49	8	25	13	M
50	11	22	20	M
51	6	19	16	M
52	8	19	25	M
53	6	23	22	F
54	8	24	19	F

55	9	22	19	F
56	10	25	23	F
57	10	24	24	F
58	5	22	22	F
59	7	21	25	F
60	13	21	24	F
61	9	25	22	F
62	11	15	21	F
63	2	21	21	F
64	10	24	25	F
65	8	26	15	F
66	6	19	21	F
67	3	28	24	F
68	5	21	26	F
69	5	25	19	F
70	8	20	28	F
71	12	19	21	F
72	6	18	25	F
73	7	21	20	F
74	10	25	19	F
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79	13	24	24	F
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82	5	12	24	F
83	4	21	17	F
84	6	23	22	F
85	7	16	12	F
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87	4	26	23	F
88	5	27	16	F
89	10	26	21	F
90	5	20	26	F
91	2	17	27	F
92	3	18	26	F
93	9	17	20	F
94	3	21	17	F
95	9	15	18	F
96	8	21	17	F
97	11	27	21	F
98	6	23	15	F

99	10	19	21	F
100	8	25	27	F
101	11	22	23	F
102	6	19	19	F
103	8	23	25	F
104	4	24	22	F
105	5	22	19	F
106	10	25	23	F
107	5	24	24	F
108	2	22	22	F
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111	3	25	22	F
112	9	15	21	F
113	8	21	21	F
114	11	24	25	F
115	6	26	15	F
116	10	19	21	F
117	8	28	24	F
118	9	21	26	F
119	3	25	19	F
120	9	20	28	F
121	8	19	21	F
122	11	18	25	F
123	6	20	15	F

APPENDIX M

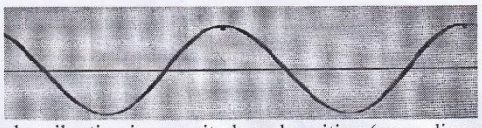
Sample of Individual Task Papers

INDIVIDUAL TASK PAPER

First Chunk (Meaning of wave).

Study the following information and make a good definition of wave the space provided.

- Wave is a continual disturbance, vibration or oscillation. Oscillation refers to regular vibration in magnitude and position. Oscillation can be represented by a sinusoidal path as shown below;



Regular vibration in magnitude and position (wave diagram).

- Wave travels through a medium and transfer energy from one point to another.
- Wave transfers energy without transferring mass.

Define

wave..is refers to ~~the~~ continual distur-
bance, vibration or oscillation.
.....
.....

1/2

Second Chunk (Examples of wave).

Study the following information and state three examples of wave.

- Water surface oscillates when it is disturbed, it is called water wave
- Light travels in a medium and transfer energy without transferring mass.

- Sound travels through a medium transferring energy from one point to another without causing any permanent displacement of the medium.

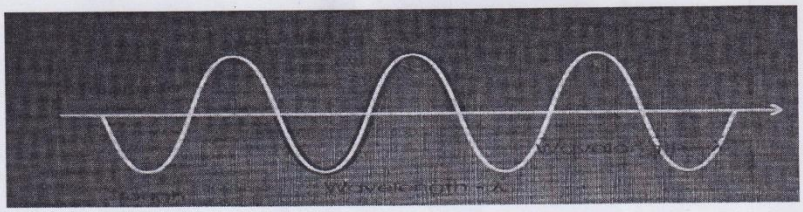
State three examples of wave.

1. Water ~~wave~~ Surface wave
2. Light ~~travels~~ wave
3. Sound ~~wave~~ travels wave

Third Chunk (Characteristics of wave).

Study the following information and list three characteristics of wave with their symbols.

- All waves have amplitude, wavelength, frequency and period.
- Amplitude donated by "A" is the maximum displacement of the wave measured from the equilibrium position to the crest or to the trough, it is measured in meter (m).
- Wavelength donated by "λ" is the distance between two successive troughs or crests, it is measured in meter (m).
- If a wave takes five seconds to make one complete oscillation, the period is 5s.
- If a wave makes ten complete oscillations in one second, the frequency is 10Hz



Wave diagram showing amplitude, wavelength, trough and crest.

INDIVIDUAL TASK PAPER

First Chunk (Types of wave).

Study the following information and list four types of wave.

There are basically two ways of classifying waves;

1. Based on the medium require for their propagation we have mechanical waves and electromagnetic waves.
2. Based on the motion of the wave we have transverse waves and longitudinal waves.

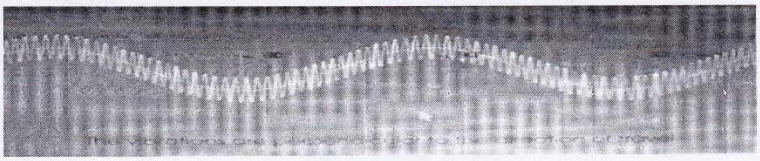
List four types of wave... 1. mechanical waves 2. electromagnetic waves 3. transverse waves 4. longitudinal waves ....

4/4

Second Chunk (Explanations of the types of wave).

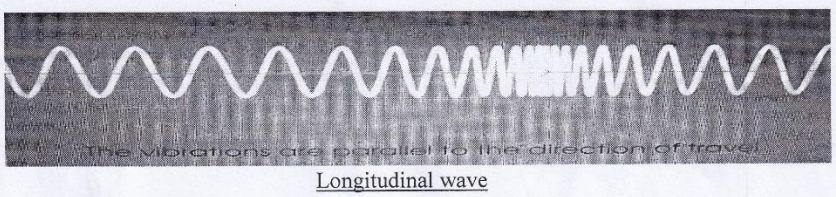
Study the following information and explain the four types of waves.

- Waves that require material medium for their propagation are known as mechanical waves.
- Waves that do not require material medium for their propagation are known as electromagnetic waves.
- A wave in which the particles of the medium oscillate perpendicular to the motion of the wave is known as transverse wave.



Transverse wave.

- A wave in which the particles of the medium oscillate parallel to the motion of the wave is known as longitudinal wave.



Longitudinal wave

Third Chunk (Examples of each type of wave).

Study the following information and give example of each of the four types of wave.

- Examples of Electromagnetic waves are radio waves, x-rays and gamma rays.
- Examples of Mechanical waves: water waves, sound waves, waves on a rope or string.
- Examples of transverse waves are light waves and radio waves.
- The most common examples of longitudinal waves is sound waves.

explain any two types of

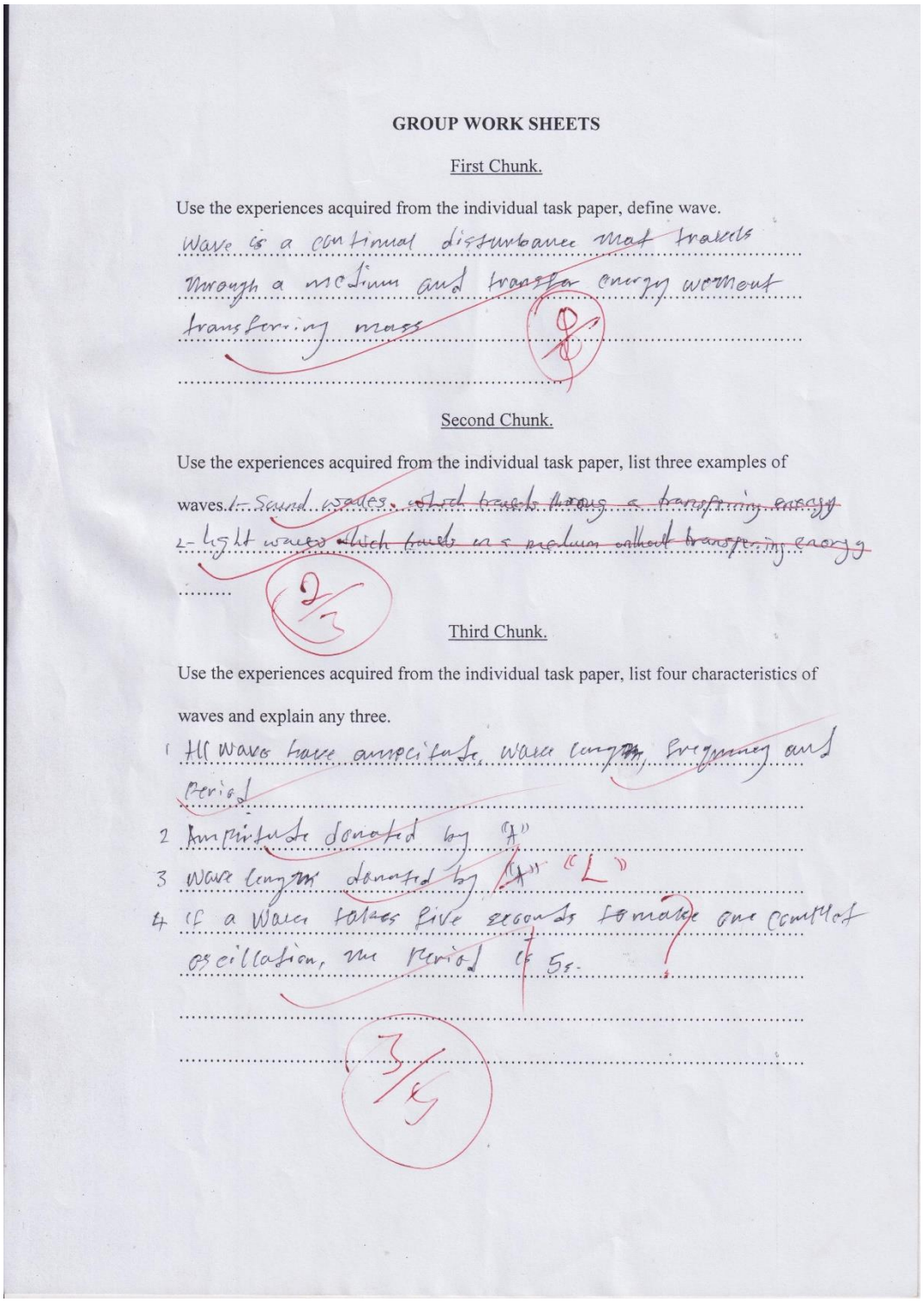
waves. ✓ Electromagnetic waves are: radio waves, xrays and gamma rays.

2 Longitudinal wave is sound wrues.

0/2

APPENDIX N

Sample of Group Task Papers



GROUP WORK SHEETS

First Chunk.

Use the experiences acquired from the individual task paper, define wave.

Wave is a continual disturbance that travels through a medium and transfer energy without transferring mass

8

Second Chunk.

Use the experiences acquired from the individual task paper, list three examples of waves. 1- Sound waves, which travels through a transferring energy

2- light waves which travels in a medium without transferring energy

2/3

Third Chunk.

Use the experiences acquired from the individual task paper, list four characteristics of waves and explain any three.

1 All waves have amplitude, wave length, frequency and period

2 Amplitude denoted by "A"

3 Wave length denoted by "λ" "L"

4 If a wave takes five seconds to make one complete oscillation, the period is 5s.

3/5

GROUP WORK SHEETS

First Chunk.

Use the experiences acquired from the individual task paper, list four types of waves.

(1) Mechanical waves
2) Electromagnetic waves
(3) transverse waves
4) Longitudinal waves

4/4

Second Chunk.

Use the experiences acquired from the individual task paper, explain four types of waves. (1) Mechanical waves are known as material medium of propagation. (2) Electromagnetic waves are known as materials that dunot require for propagation (3) transverse waves are known as waves that oscillate perpendicular to the motion of the waves (4) longitudinal waves are known as waves medium oscillate parallel to the motion.

Third Chunk.

Use the experiences acquired from the individual task paper, give example(s) of each of the followings type of waves:

1. Longitudinal waves... Sound waves
2. Mechanical waves... water waves, sound waves, wave on a rope or string
3. Electromagnetic waves... radio waves, x-rays and gamma rays
4. Transverse waves... light waves and Radio waves

4/4

APPENDIX O

Sample of Scoreboard Game Result.

Week One

S/N	Questions	Students' scores	Teacher's scores
1.	λ, T, A and f represents…., …., ….., and ….. respectively	2	1
2.	Waves transfer both energy and mass. True or false?	3	-
3.	Light, sound and mirror are examples of waves except……	3	-
	Total	8	1

Week Two

S/N	Questions	Students' scores	Teacher's scores
1.	The most common examples of longitudinal waves is…….	3	-
2.	……..waves require material medium while…….waves do not	1.5	1.5
3.	Radio waves, sound waves, x-rays and gamma rays are examples of electromagnetic waves except……	3	-
	Total	7.5	1.5