UNIVERSITY OF EDUCATION, WINNEBA

EFFECT OF BRAIN-BASED LEARNING ON THE ACADEMIC ACHIEVEMENT OF SENIOR HIGH SCHOOL STUDENTS WITH DIFFERENT LEARNING STYLES IN SELECTED CONCEPTS IN INTEGRATED SCIENCE

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MASTER OF PHILOSOPHY

2024

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A Thesis in the Department of Science Education,
Faculty of Science Education, submitted to the School
of Graduate Studies, in partial fulfilment
of the requirements for award of the degree of
Master of Philosophy
(Science Education)
in the University of Education, Winneba

JUNE, 2024

DECLARATION

STUDENT'S DECLARATION

I, **IBRAHIM SALAMI**, declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE:…………………………….

DATE:…………………………………….

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of thesis as laid down by the University of Education, Winneba.

SUPERVISOR: PROF. KODJO DONKOR TAALE

SIGNATURE: …………………….…….….……

DATE: …………………………………….………

DEDICATION

I dedicate this academic work to my entire family, whose unwavering love and support have been a constant source of inspiration and encouragement throughout this journey

ACKNOWLEDGEMENTS

I am eternally grateful to the Almighty God for the gift of life, grace, and wisdom, guiding me to the successful completion of this research work. This journey would have been inconceivable without the invaluable contributions of many. My deepest and most enduring gratitude goes to Professor Kodjo Donkor Taale, my supervisor. His insightful suggestions, unwavering support, and generous guidance were instrumental throughout the study. I am truly indebted to his mentorship.

Special thanks to Dr. Stephen Twumasi Annan, my mentor, for his profound insights and invaluable guidance. His contributions were crucial in shaping this research. A heartfelt appreciation to all the lecturers in the Department of Science Education of the University of Education, Winneba. Their collective impact has been transformative for me and my colleagues.

My profound gratitude to the Heads of Science Department of College of Music Senior High School and Mozano Senior High School for their enormous efforts in making this dream a reality.

To my loving wife (Mrs. Amina Masawudu), whose unwavering support and understanding fuelled my every step, my warmest appreciation. Words cannot express the debt I owe you.

Finally, I am grateful to all authors whose works enriched my research, and to everyone who contributed in any way to this accomplishment. Your love and support are forever cherished.

TABLE OF CONTENTS

Content **Page**

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF ABBREVIATIONS

AC	**:**	Abstract Conceptualisation
AE	**:**	Active Experimentation
BBL	**:**	Brain-Based Learning
BBT	**:**	Brain-Based Teaching
BBTM	**:**	Brain-Based Teaching Methods
CE	**:**	Concrete Experience
CRDD	**:**	Curriculum Research and Development Division
ELT	**:**	Experiential Learning Theory
GES	**:**	Ghana Education Service
HOTS	**:**	Higher Order Thinking Skills
ISAT	**:**	Integrated Science Achievement Test
KLSIPIF	**:**	Kolb's Learning Style Inventory Personal Information Form
LOTS	**:**	Lower Order Thinking Skills
LSI	**:**	Learning Style Inventory
MOE	**:**	Ministry of Education
OECD	**:**	Organisation for Economic Co-operation and Development
PPMC	**:**	Pearson Product Moment Correlation
RO	**:**	Reflective Observation
SHS	**:**	Senior High School
SPSS	**:**	Statistical Package for the Social Science
UG	**:**	University of Ghana
UHAS	**:**	University of Health and Allied Sciences
NCLB	**:**	No Child Left Behind

ABSTRACT

The purpose of this study was to investigate the effect of brain-based learning on the academic achievement of senior high school students with different learning styles in selected concepts in Integrated Science. The study adopted the quasi-experimental research design and utilised purposive sampling procedure to choose the two schools. Four intact form-three General Arts classes of one hundred and thirty (130) students were selected using the basic randomised sampling procedure for the research. The study sought to answer four research questions: 1. What are the learning style distribution of the students in College of Music Senior High School? 2. To what extent does Brain-Based Learning approach affect the academic achievement of students? 3. To what extent does different learning styles have impact on academic achievement of the students? 4. What is the extent of performance between male and female students exposed to the Brain-Based Learning approach? Data were gathered using achievement tests (ISAT) and questionnaire (KLSIPIF), and analysed using descriptive and inferential statistics. The findings of the study reveal significant insights into their preferences and diversity. Accommodator is the prevalent learning style, assimilator shows a balanced preference across both genders, converger is characterised by a higher number of low preferences and diverger also displays a balanced distribution but with a higher preference among females. The t-test analysis revealed a statistically significant difference between the experimental group (COMSEC) and control group (MOSEC) with mean scores of 73.52 and 51.88 respectively. The t-test analysis revealed a statistically significant difference between the post-test mean scores of the experimental and control groups ($p = 0.000$, sig. at 0.05). With regards to the effect of learning styles on academic achievement of the students, the analysis of covariance used indicates that, the p-values for learning styles and preferences were 0.245 and 0.863 respectively, which were greater than 0.05. This shows that there is no significant difference in the academic performance of students who were administered the brain-based learning approach in relation to their preference levels and learning styles. The t-test conducted with regards to gender indicates that, the p-value of 0.804 was much greater than the significance level ($\alpha=0.05$). This shows that there is no significant difference in the mean post-test scores between male and female students after being taught with brain-based learning approach. Moreover, the findings of the study revealed that SHS students have overwhelmingly positive mindsets on the use of brain- based learning in the teaching and learning of Integrated Science. In light of these findings, it was recommended that Integrated Science teachers should consider incorporating brain-based learning strategies to improve student learning outcomes. Also, policymakers and educators should collaborate to promote widespread adoption of brain-based learning, recognizing its positive impact. Furthermore, government and educational bodies should sponsor workshops and seminars, while curriculum planners are advised to incorporate brain- based learning in developing the Integrated Science curriculum.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This study aims to describe the effect of Brain- Based Learning on the academic achievement of senior high school students with different learning styles in integrated science. The subjects for the study are SHS 3 students of Mozano Senior High School and College of Music Senior High School students in the Central Region. The research design used for the study was quasi-experimental with non-randomized static group pre-test and post-test design. The teaching and learning process was based on the three fundamentals of brain-based learning. These are orchestrated immersion, relaxed alertness and active processing. A multiple-choice achievement test and essay type test was administered to both the experimental group and the control group to test their pre-knowledge. Data concerning the students' academic achievements in relation to their learning styles was collected with the diagram designed according to Kolb's (1984) Experiential Learning Theory. Kolb's (Learning Styles Inventory) Personal Information Form was developed by the researcher in order to determine the learning style distribution of the experimental groups.

1.1 Background to the Study

Due to the diversity of students' histories, feelings, and emotions, each person in the classroom absorbs and processes information in a unique way. This assertion is supported by the claim that individual learning styles and brain function are related. There are differing opinions about how humans interpret and utilize information (McCarthy, 2000).

Numerous educators and neuroscientists, such as Dun and Dunn (1992), Kolb (1984), Hebb (1949), Gregorc (1984), McCarthy (2000), Butler (1987), and Felder (1996), have explored the relationship between students' learning styles and the hemispheres of the brain through studies. Since every student learns differently, it is important to adopt multi-dimensional teaching models when instructing and learning. According to Syakdiyah et al., (2018), the use of suitable learning strategies can enhance students' learning outcomes and make it easier to reach specified learning goals.

Science course topics are integral parts of many academic disciplines and are based on real-world experiences. The goal of Ghana's integrated science curriculum is to teach pupils about cycles, energy, diversity of matter, interactions of matter, and systems. Senior high school students’ performance is reportedly influenced by a number of connected and interconnected factors (Chua & Mosha, 2015). The science curriculum, the teacher, and the instructional strategies are the three that stand out among these variables. The success of students in science is strongly correlated with the implementation of effective teaching strategies, according to Opoku-Agyemang (2013) and Beccles (2012). According to Blazar (2016), the successful teaching strategy for integrated science is still mainly unknown.

Brain-Based Learning is defined as a way of thinking about the learning process. It is a set of principles and a base of knowledge and skills through which we can make better decisions about the learning process (Jensen, 2008). Teaching to individual differences, maximizing the brain's natural learning processes, and diversifying teaching methodologies are among the goals of brain research studies (Gülpınar, 2005; Tileston, 2005; Zadina, 2004). Without an understanding of how the brain functions, it is hard to comprehend the nature of learning. Given that the brain naturally seeks to make connections and ask questions about meaning, inquiry-based science education and exploration may be compatible with the tenets of brain-based learning (Mangan, 1998). Because these learning settings consider the functions of the brain and their roles in learning in terms of the teaching and learning process, brain-based classrooms are considered brain-friendly spaces.

Furthermore, it is thought that each student is different in brain-based classrooms and that prior knowledge is a prerequisite for new learning (Fogarty, 2002). The art of teaching has to be the art of brain modification, according to Zull (2002). According to Kolb and Kolb (2005), since the brain functions as a unit while learning, meaningful learning happens in a unity of circulation rather than a single method.

Learning styles are defined as factors directly affecting students' learning processes. The individual differences observed in the acquisition and processing of information during the learning process result in different learning styles (Felder, 1996). Therefore, to be able to conceive individual differences, one must understand learning styles (Hall, 2005). Meanwhile, an understanding of learning styles requires some knowledge of how the brain works and learns and how it functions. Thus, the content, design and presentation of each learning activity should be developed in such a way as to cater for the different thinking and learning styles of students (De Vita, 2001). What matters is how to design and carry out effective learning activities to meet the needs of students with different learning styles. Teaching pupils about how the brain works and learns during the acquisition and processing of information appears to be essential.

In an era of inclusive educational environments as described in No Child Left Behind (NCLB, 2001), where the goal is to provide each child with equal access to a high-quality education program irrespective of their gender, educators are mandated by accountability measures to increase student performance with limited resources. Again, policymakers stress that all students should be supported to develop their knowledge and skills at their own level (Rock et al., 2008; Schleicher, 2016) and there is a wish to improve equity or equality among male and female students (UNESCO, 2017; Kyriakides et al., 2018). In light of this, researchers urge teachers to embrace diversity and adapt their instruction to the diverse learning needs of students in their classrooms by considering the gender of the students (Schleicher, 2016). Teachers can respond to this diversity by adapting their lessons to individual students' needs; a set of principles and a base of knowledge and skills through which we can make better decisions about the learning process (Jensen, 2008).

Various learning objectives call for distinct teaching philosophies (Gagne, Briggs, & Wagner, 1992). According to Gardner (1993), teaching should take into account the many learning styles of the pupils, and no one teaching-learning theory is sufficient on its own. Therefore, in order to acquire knowledge, it is necessary to integrate several models that are based on learning environments and learning styles that are suitable with the brain. Brain-based learning theories suggest that experiencing real-world experiences is the only way for learning to be effective. When the brain facilitates the processes involved in looking for patterns and meaning, learning becomes more expressive. As a result, it gives students the ability to internalize and customize their educational experiences.

Therefore, it is essential that learners be encouraged to participate in the teaching and learning processed actively and that teaching materials be chosen according to their learning preferences.

It is thought that the left and right hemispheres of the brain use distinct techniques to process information in various ways, based on findings supported by Hebb's (1949) neurophysiologic hypothesis (Jensen, 2008; Kolb, 1984; Williams, 1983). Rich in neurons or nerve cells, the cognitive, emotional, and psychomotor domains are facilitated by the unique contributions of each hemisphere (Jensen, 2008; Walls, 1999). These hemispheres just do distinct specialized tasks; neither is superior than the other (Gazzaniga, 1998; Organisation for Economic Co-operation and Development (OECD), 2002).

The brain functions as a whole, and the hemispheres independently decide how much time is spent thinking about a certain topic (Sprenger, 2002). Therefore, it is crucial for integrated science teachers in senior high school to ascertain how Brain-Based Learning affects pupils with varying learning styles' academic accomplishment. Research in the field of neurobiology (Hari & Lounasmaa 2000; Posner & Raichle, 1994) has advanced our knowledge of how the brain works and how learning is generated based on the experiences of the learner. Collaborating with neurobiologists, educators use brain function knowledge and adapt to different learning styles (Cross, 1999; Wortock, 2002).

There aren't many studies on learning styles and brain-based learning in Ghanaian literatures. Prior studies focused on the dominance of students' chosen learning styles as well as the connections and distinctions between them. In the meanwhile, it is beneficial to combine learning styles and brain-based learning and apply this combination in an experimental classroom setting. Unfortunately, little is known about the research conducted in Gomoa West District which combined the approach to learning that takes into account pupils' individual learning as proposed by Fleming and Mills in 1992 (auditory, kinesthetic and visual) as well as the brain-based learning strategy.

Additionally, the effect of the brain-based learning approach on the academic achievement of both male and female students according to their preferred methods of learning. In the experimental regions (Mozano Senior High School and College of Music Senior High School), it is useful to combine brain-based learning approach and students learning styles so as to determine if the preferred learning styles of students in these areas have an impact on their academic achievement using brain-based learning strategy as far as their gender is concerned. In this regard, a learning and instruction model that aligns with the conditions and tenets of brain-based learning as described in the literature was created and implemented. Understanding how the brain thinks is essential for teaching and learning integrated science. The application of social and emotional learning processes is fundamental to science teaching and learning (Konecki & Schiller, 2003). Therefore, students can reinforce the synaptic connections between neurons through experiences and physical activities.

Through both internal and external inputs, experiences physically alter the brain (Roberts, 2002). Change involves learning because it is a change in the brain and this will lead to a change in ourselves, claims Zull (2002). Experiences are the means by which learning happens. Research on the impact of brain-based learning on the academic performance of senior high school students with diverse learning styles in integrated science is therefore necessary.

1.2 Statement of Problem

According to Kolb and Kolb (2005), learning happens on a continuous sequence that ranges from concrete to abstract, or from reflective observation to active exploration, and this has to do with the brain's capacity. Meanwhile, majority of Ghanaian teachers continue to use one teaching approach to teach all students the same concept (Ako et al., 2019; Mohammed, 2021). Observations and interactions with teachers of College of Music Senior High School and Mozano Senior High School revealed that most teachers of the two schools use the lecture method to deliver integrated science lessons. However, this teaching method has not yielded the expected results in integrated science as students continue to perform abysmally in class exercises, end of semester examinations and West African Senior School Certificate Examination (WASSCE). Therefore, using a single instructional method to deliver lessons is believed to ignore the different learning needs of students in a class (Subban, 2006). Most students do not benefit from classroom instructions in the two schools as they are expected to achieve.

For this reason, integrated science teachers must consider the variations in the cognitive capacities and learning styles of their pupils when teaching and learning. Various pedagogical approaches such as discussion, demonstration, talk for learning think-pair-share might be combined according to the cognitive capacities and learning preferences of the pupils. Thus, research into how brain-based learning approach affects academic achievement of senior high school students with varying learning styles is necessary.

1.3 Purpose of the Study

The purpose of this study is to investigate the effect of brain-based learning approach on the academic achievement of senior high school students with different learning styles in selected concepts in integrated science. The rationale behind the study is to investigation whether or not students with varying learning styles benefit academically from brain-based learning.

1.4 Objectives of the Study

The objectives of the study are to determine the:

1. Learning style distribution of the students in College of Music Senior High School.
2. Outcome of the Brain-Based Learning approach on the academic achievement of students.
3. Academic achievement of the students with different learning styles.
4. Extent of performance between male and female students exposed to Brain-Based Learning approach.

1.5 Research Questions

1. What are the learning style distribution of the students in College of Music Senior High School?
2. To what extent does Brain-Based Learning approach affect the academic achievement of students?
3. To what extent does different learning styles have impact on academic achievement of the students?
4. What is the extent of performance between male and female students exposed to the Brain-Based Learning approach?

1.6 Research Hypothesis

Null hypothesis (H_O)for research question 2,3 and 4.

1. There is no significant effect of Brain-Based Learning approach on the academic achievement of students with different learning styles.
2. There is no significant correlation between students preferred Learning Styles and academic achievement of students in Integrated Science.
3. There is no significant difference in the performance of male and female students exposed to Brain- Based Learning Approach

1.7 Significance of the Study

The findings of this research work are sought to add to knowledge in the following ways:

This study's conclusions will give students insight into how their learning preferences would affect their cognitive capacities in integrated science learning, the research will also act as a guide for students.

This project will significantly advance the teacher's understanding of the effects of brain-based learning, the identification of student learning styles, and the consequences of those learning styles.

This would put teachers in a very good position with regard to classroom behaviour, instructional strategies, classroom dynamics, and the subject matter expertise needed to support students.

In order to enhance students' learning of integrated science, policy makers, implementers, and other education stakeholders will have access to information that may be used to create better strategies for interacting with students who have varying learning styles.

It is expected that the empirical data, which will be analyzed after the study's conclusion, will aid in the diagnosis of issues and the development of solutions pertaining to students' learning preferences as they relate to integrated science in the district.

The association that has been found will offer more data that can be utilized to enhance the methods for identifying how brain-based learning affects students with various learning preferences in terms of academic achievement.

1.8 Limitations

The enormity of the task coupled with time factor caused me to limit the work to Mozano Senior High School and College of Music Senior High School students in the central region of Ghana. Research of this nature was also limited by language barrier and some teaching and learning materials which will facilitate the smooth implementation of the treatment to the experimental group. Even in the schools, only form three General Arts students were considered.

1.9 Delimitations

College of Music Senior High School and Mozano Senior High School were the two schools selected for the study. Also, the study focused on only form three General Arts students of the two schools. Only some selected concepts in Integrated Science were used in this study. Time span for the intervention was six weeks.

1.10 Operational Definition of Terms

Terms applicable to this research were defined as follows:

Academic Performance: refers to a student's achievements and accomplishments in an educational setting, typically measured through assessments, examinations, grades, and other indicators of learning.

Brain-based learning: It is a set of principles and a base of knowledge and skills through which we can make better decisions about the learning process (Jensen, 2008).

Content: Content is what we plan to teach, what we want students to learn (Sousa & Tomlinson, 2011).

Effect: Effect is a change that results when something is done or happens: an event, condition, or state of affairs that is produced by a cause.

Gender: Refers to the socially constructed roles, behaviours, expressions and identities of girls, women, boys, men, and gender diverse people.

Interest: Topics or pursuits that intrigue students (Tomlinson & Allan, 2000)

Learning styles: A learning style is a preferred way of thinking, processing, and understanding information.

Pre-assessment: Pre-assessment is any means used by teachers to gather information about students prior to instruction.

Process: Process is how students come to own what they should know, understand, and can do (Sousa & Tomlinson, 2011).

Product: Methods for students to demonstrate what they have learned, grasped, and can accomplish as a consequence of a long period of study.

Readiness: This has to do with a student's proximity to or proficiency with particular knowledge, understanding, and skill (Tomlinson & McTighe, 2006)

Views: The beliefs or opinions that people have about something, for example whether they think it is good, bad, right, or wrong.

1.11 Organisation of the Study

This research study has been organized into five chapters. Chapter one covers the introduction of the study. Chapter two covers a review of relevant related literature. Chapter three covers the research methodology used to accomplish this study. Chapter four deals with the presentation of results. It also includes the analysis and discussion of the findings. It provides answers to the research questions outlined in chapter one. Finally, Chapter five covers the summary of the findings, conclusions and recommendations made.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.0. Overview

This chapter is an overview of the research literature that relates to the effect of the BBL approach on the academic achievement of students with different learning styles in integrated science. The literature review includes Theoretical framework, Conceptual framework, The Concept of Integrated Science, Teaching and Learning Integrated Science, Gender and Academic Achievement in Science, Brain-Based Learning Strategies, functioning of the brain, Relationship between BBL and Kolb's Experiential Learning, Learning Styles, Main characteristics of Learning Styles and Empirical Evidence of the study. The intention of the literature review and its concluding sections were to provide support for the need of the study.

2.1. Conceptual Framework

Experience-related changes have been shown to cause physiological changes in the brain. According to Caulfield et al., (2000), students are able to better understand knowledge and skills when teachers create a learning atmosphere that is both engaging and calming, allowing them to see the links between the concepts they have studied and their practical applications. It is crucial for teachers to empower students' cognitive powers to make learning more meaningful. The Brain-Based Learning Strategy is a student-centred approach that is enabled by teachers who make use of the cognitive abilities of students (Batlolona et al., 2018; Uzezi & Jonah, 2017). Recognizing the complexity of intelligence is another significant application of brain-based learning. Educators need to recognize the differentiation of instructional methods to address the learning needs of a diversity of learners.

According to Klassenbach (1999), learning becomes more meaningful and authentic when students are given more choices and learning routes that correspond with their intelligence levels. The experimental group was presented slide shows explaining the workings of the brain. In accordance with the BBL model, the researcher created a content-methodology relationship. This model illustrates a learning-teaching design that is predicated on gains, conditions, and processes that are correlated in a way that is mutually beneficial. Many scholars' descriptions of the BBL circumstances and principles used as the basis for this design (Caine et al., 2005; Jensen, 2008; Jensen & Dabney, 2000). The researcher adapted the "Hart's 1983 BBL integrated learning-teaching" approach, which was applied in the current study to teach every topic in the unit. This model is shown in Figure 1.

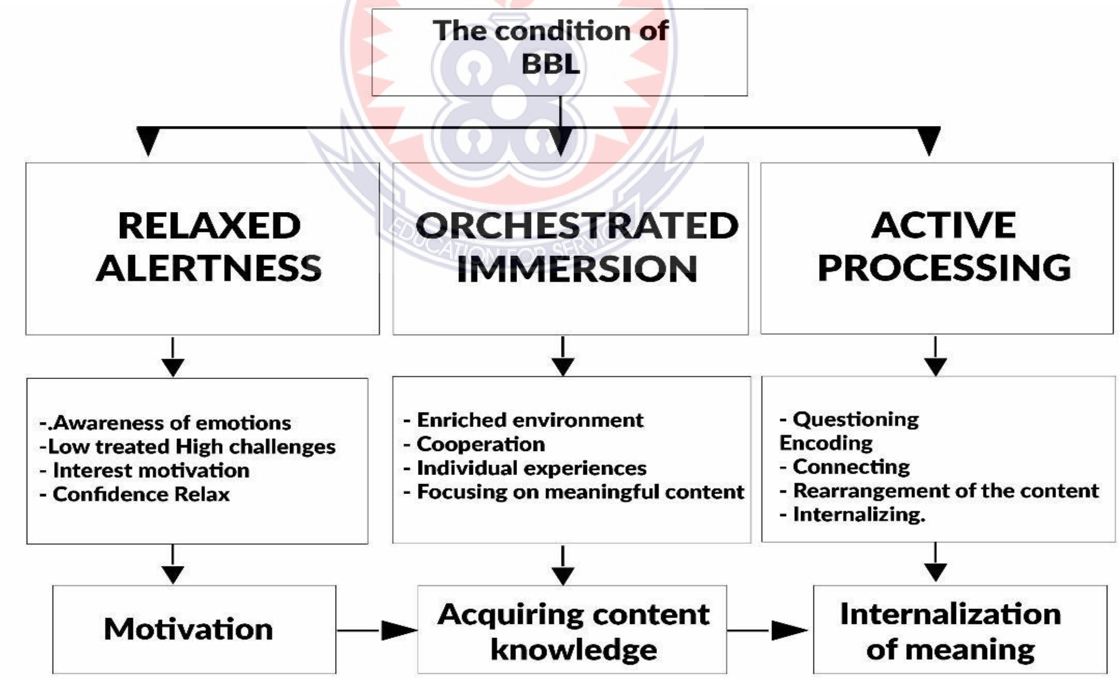


Fig. 1: BBL integrated teaching learning approach used in the teaching process

Three vertical and three horizontal frameworks make up this model. The first horizontal axis shows the BBL conditions; the second shows the teaching-learning procedure based on these conditions; and the third shows the learning outcomes at the conclusion of the procedure. The elements pertaining to the fulfilment of the three BBL requirements in the teaching-learning process are represented by the vertical axis. Gains pertaining to any BBL condition can be attained by utilising these components. Here are some ways to investigate these processes:

(a). The Relaxed Alertness phase: The lesson began with music, and students were encouraged to drink water throughout the several brief breaks. To improve emotional awareness and relaxation, opportunities for cooperation and group activity were offered. In order to brainstorm and have open discussions, students were also permitted to move about the classroom. The lesson to the pupils was that it is each person's responsibility to challenge and decompress from within. Students were encouraged to take integrated science classes seriously by creating a classroom environment that promoted both psychological and physiological safety throughout the teaching and learning process.

(b). The focus of the brain-based learning condition known as Orchestrated Immersion was on individual experiences, enhanced environments, collaboration, and meaningful information. These were intended to improve the amount of subject knowledge acquired. Posters, images, graphics, and multimedia pertinent to the subject were tacked up and shown in the classroom during the teaching and learning process for the enhanced surroundings. The topics of integrated science were combined for cooperation-based binding of energy. A cooperative group was given responsibility for each of the unit's major topics, and each group produced a project pertaining to the subjects being discussed. The students' projects were on display in the classroom, and they were presented in front of the entire group. Students were encouraged to participate in whole class discussions about the topics in integrated science considered. These activities were associated with the life experiences of the students.

(c). According to the conditions of brain-based learning theory's active processing phase, the teaching and learning process entails critical thinking and questioning, as well as internalising and rearranging the knowledge to improve meaning internalisation. The fundamental prerequisite for demanding that a pupil think is asking questions. A question always has a meaning or an answer associated with it. When the actions were being carried out during the entire experimental procedure, these concepts were being utilised. Students with varying learning styles were combined for the purpose of internalising and rearranging the knowledge. Activities were carried out based on each group's preferred method of learning.

2.2. Theoretical Framework

Students' learning styles and brain-based learning processes form the basis of the study's theoretical framework. Gregory and Chapman (2004) state that there are many different ways that learners might differ, such as appearance, learning styles, multiple intelligences, past experiences, personal preferences, and social and emotional growth. Hart's groundbreaking study on the use of neuroscience to education indicates that Brain-Based Learning theory serves as the foundation for the BBL tactics. The first to present a complete model of teaching techniques based on the anatomy and known cognitive functions of the brain was Hart (1983). Students' learning styles are derived from Kolb's Experiential Learning Theory (1984).

The underlying disparities in student learning styles and performance are intended to be explained by the theories taken into consideration in this study. Different assumptions regarding brain power and learning are made by each of these theories.

The present study is particularly grounded in Hart's (1983) brain-based learning theory and Kolb's (1984) experiential learning theory.

2.2.1. Brain-Based Learning (BBL) Theory

According to Anderson et al. (2014), the BBL approach offers educators and teachers the advantages of neuroscience applied to the classroom, with a focus on challenging kids. According to Roe et al. (2011), early education teachers can create plans and tailor them to the unique learning styles of individual pupils using the BBL theory. Based on the knowledge of how human knowledge is acquired and the characteristics of different student learning styles, BBL is a useful tool for teachers in the classroom. As a result, teachers create activities to encourage and facilitate the interest and performance of struggling students in the subject (Richardson et al., 2011).

As per Jensen (2000) and Farrington-Flint (2015), Brain-Based learning (BBL) is expected to be widely used in all possible environmental educational settings, and the learners' emotions are crucial for the process of learning. In order to implement BBL, instructors and educators must take into account the motivations and attitudes of their students (Hart, 1969, “1975”, 1983). According to Jensen (2000), emotions play a comprehensive role in BBL. This is due to the fact that one of the most crucial components of learning is coming to terms with students' emotions, sentiments, beliefs, appetites, issues, attitudes, and talents.

The goal of BBL is to maximise students' cognitive abilities through learning strategies. BBL operates under the premise that the brain is a parallel processor, capable of doing multiple tasks concurrently. The brain comprehends information best when it is stored in spatial memory; learning is enhanced and inhibited by challenges and threats; learning requires both conscious and unconscious processes; learning involves both concentration and peripheral perceptions; and each brain is different (Jensen, 2008). These are some additional BBL tenants. Students experience enjoyable, engaging, and relevant learning scenarios when the BBL technique is applied in the classroom.

The process of comprehending an issue involves some time to discover how the brain functions, as does the creation of a learning environment that is conducive to learning. Adequate resources are also necessary. Teachers may maximise their students' brain capacity by utilising the BBL in a way that aligns with all learning stages. By understanding how the brain functions best, teachers may design a learning environment that will increase students' chances of success in the classroom. Teachers and students can create an engaging learning environment where students anticipate each new challenge as an exciting opportunity to learn and view learning as a means of becoming great problem solvers (Ramakrishnan & Annakodi, 2013).

2.2.2. Learning Style Model

The fact that pupils learn differently has been extensively documented (Litzinger & Sif, 1993; Budeva, Kehaiova, & Petkus, 2015). According to Shanker (1990), determining the elements that affect each student's learning style is essential to guaranteeing efficient instruction and improved student success. The primary thing that needs to be taken into account is the learning style of the student. A person's ability to learn can be influenced by a multitude of factors and personal characteristics, which give rise to a huge variety of Learning Style Models. The models of learning styles developed by Kolb and Gardner (1984) are among the most widely used.

Scholars in education assert that each student has a unique learning style (Litzinger & Osif, 1990; Murphy et al., 2004; Shah et al., 2013). This fact requires teachers in a variety of fields, including integrated science, to be cognisant of the learning preferences of their pupils. The Kolb experiential learning approach from 1984 was examined in this study. One of the most well-known educational theories in higher education is the Kolb Learning Style Theory (Kolb, 1984). Studies in a variety of disciplines have become more aware of Kolb learning style, especially those that call for hands-on experience, such as science, life skills (Othman & Othman, 2004), engineering (Harb et al., 1995), medical, entrepreneurship (Norasmah, 2002), and accounting (Jonick, 1998).

For pupils with this learning style, in-class or laboratory activities are permitted. By taking action, students can aid in the retention of prior knowledge gained through experience. Two dimensions are used by the Kolb inventory to categorise learners: a preferred method of processing (active experimentation or reflective observation) and a preferred mode of perception (concrete or abstract) (Gogus & Gunes, 2011; Zacharis, 2011; Pashler et al., 2009). The four phases of the learning cycle include: concrete experience, reflective observation, abstract conceptualisation, and active experimentation that David Kolb (1994) identified are necessary for learning to occur. Assimilators, convergers, accommodators, and divergers are the four learning styles that Kolb defined and categorised into accordance with these stages.

According to Kolb, in an ideal world, this procedure would resemble a learning spiral or cycle in which the student covers every ground. Observations and reflections come from direct or actual experiences. New experiences can then be created as a result of these reflections being integrated into abstract notions with actionable implications that the individual can actively test and play with. Conversely, Kolb Learning Styles was able to distinguish four main learning styles by combining the four learning cycle stages: Doer (active exercise plus concrete experience), Watcher (reflective observation plus concrete experience), Thinker (reflective observation plus abstract concepts), and Feeler (active experiments plus abstract concepts). Learning styles refer to the distinct ways in which people move through learning cycles according to their preferences for the four main learning modes (Kolb & Kolb, 2013). Every Kolb Learning Style type possesses unique strengths and tendencies when it comes to the learning tasks. Human cognitive abilities can be divided into two main categories. These are Higher Order Thinking Skills (HOTS) and Lower Order Thinking Skills (LOTS) (Tanujaya et al., 2017). The MOE (2015) defines HOTS as the capacity to use knowledge, skills, and values in a way that makes sense while reflecting and problem-solving, decision-making, innovating, and creating.

Researchers now favour the Learning Style Inventory (LSI), which David Kolb created to evaluate the experiential learning theory (Kolb, 1984). This theory places a strong emphasis on how learners get experiences and translate those experiences into ideas for producing or creating new experiences. It also sees learning as two continuums in four stages. The grabbing continuum shows how pupils take in information, while the internalising continuum shows how they process it (Kolb, 1984). The diagram presented in Figure 2 shows how these two continuums combine to generate an axis with four learning modes.

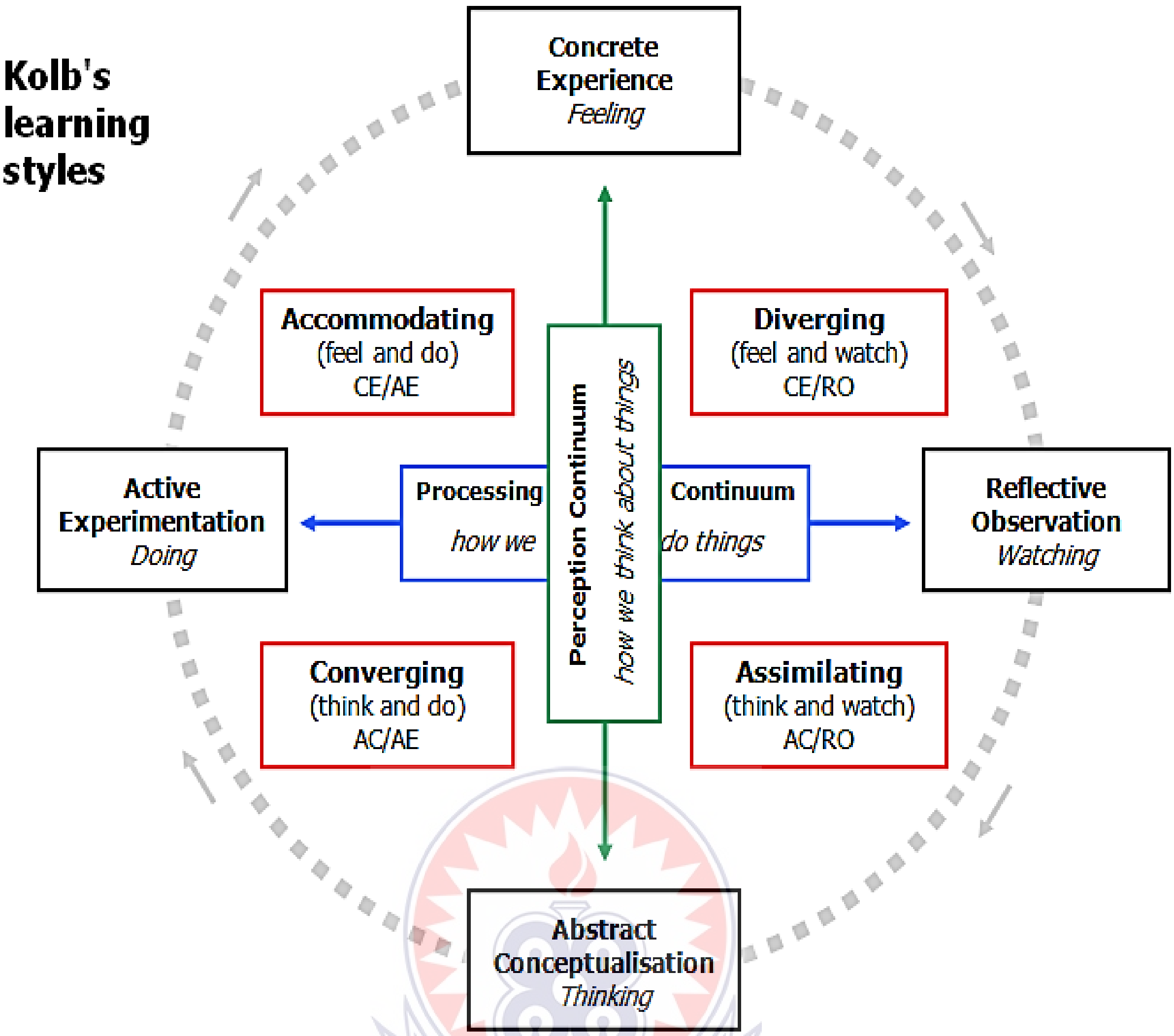


Fig.2 Diagram of the four Learning Modes based on Kolb's Learning Styles, 1984

On the vertical axis, the student's perception of experience (information) is divided into two categories: conceptualising a theory or idea (abstract conceptualisation, AC) and feeling and intuition (concrete experience, CE). According to Kolb (1984, 1985), students process experience (knowledge) on the horizontal axis by either performing (active experimentation, AE) or watching and reflecting (reflective observation, RO). The four learning styles that have been identified in numerous research (Kolb,1984; 1985; Holley & Jenkins, 1993; Felder 1996; Kolb & Kolb, 2005) are represented by the vertical and horizontal axes of learning styles: accommodating, diverging, converging, and assimilating.

(1). Accommodating learning styles (active experimentation/concrete experience): This characterises those who prefer to face novel and difficult situations and learn from experience and intuition rather than logical analysis. These are the people who would much rather do than contemplate (Pragmatist). They will question "what if?" and "why not?" when they learn to bolster their action-first strategy. They will take calculated chances to see what occurs since they dislike regularity. A person with an accommodating style is capable of learning mostly by doing, enjoys following out ideas, and is up for new and challenging situations. Individuals learn more effectively than in groups.

(2). Divergent learning styles (Concrete experience/ Reflective observer): These students like to brainstorm in groups to come up with ideas, and they are interested in cultural diversity to absorb information from various angles. Divergers consider experiences carefully. They change from one experience to several options (Activist). As they become more knowledgeable, they will ask "why" and go rationally from the small details to the larger picture. While they enjoy working with others, they also prefer things to be under control and they welcome constructive criticism. Administrators, coaches, social advisers, influencers, authors, journalists, political and cultural specialists, civil lawyers, and computer programmers working on comparatively straightforward jobs who regularly employ trial and error techniques can all be found in this category.

(3). Convergent learning style (Active experimenter/abstract conceptualisation): When it comes to utilising constructed theories in practical settings, students excel at doing so. In order to solve problems, they use a combination of active exploration and abstract conceptualisation along with deductive reasoning. This collective typically reflects on issues and then tests theories to determine if they hold up in real life. When they become knowledgeable, they will want to know "how" and will want to learn by seeing things done in real life. They enjoy facts and will try to improve efficiency by making gradual, deliberate adjustments (Reflector). Independent or alone labour is preferred by convergers. Converging style refers to the practical application of ideas and the preference for handling technical tasks and problems over social and interpersonal ones. This group includes practitioners in the fields of experimental science, engineering, economics, corporate law, and medicine. Action is coupled with modelling situations and thinking.

(4) Assimilation learning style (abstract conceptualisation and reflective observation): This group uses inductive reasoning to construct theories and places a greater focus on ideas than on individuals (Theorist). When making decisions, people with an absorbing learning style tend to analyse, summarise, and present a variety of facts. Instead of focusing on the usefulness of theories, they emphasise their logical consistency. In this instance, abstract conceptualisation, inductive reasoning, and reflective observation predominate in the brain processes that regulate behaviour. This is typical of thinkers, such as theoretical scientists, mathematicians, philosophers, attorneys, and computer designers.

2.3. The Concept of Integrated Science

A curriculum that combines two or more formerly distinct science topics is referred to as "integrated science" (Showalter, 1975). This word is sometimes used as a synonym for interdisciplinary and unified science. Four categories of meanings for integration in science were distinguished by Brown (1977): interdisciplinary, conceptually unifying the sciences, unifying all knowledge, and a cohesive process of scientific inquiry.

In developing nations, the majority of children receive no formal education at all, if any, beyond basic school (Awokoya, 1969). Consequently, it was imperative to introduce science to even the youngest school children and preschoolers, lest they completely overlook it. Science is integrated when all of its components; biology, chemistry, physics, and agriculture are approached comprehensively so that none of them stand alone, according to Abbey et al., (2001). For instance, a doctor of medicine needs to be well-versed in biology to comprehend a patient's anatomy, chemistry to learn about the makeup of drugs, and physics to gain knowledge about the ability to measure a patient's temperature, weight, and height accurately; additionally, agriculture can help with the patient's diet. A physician must possess all of these skills in order to provide high-quality healthcare.

The justification for teaching and learning Integrated Science in the SHS syllabus was given some attention by the Curriculum Research and Development Division (CRDD) and Ghana Education Service (GES) in September 2010 (CRDD, 2010). Every Ghanaian should be scientifically literate, according to the syllabus. They believed that it was the only way the nation could establish a scientific culture in order to quickly fulfil its strategic goal of having a scientific and technologically literate citizenry. Globally, people are living in better conditions because of the study of integrated science and the use of its results (Owusu & Baiden, 2018). According to Farrant (2002), teaching integrated science should aid students in comprehending both the concepts and the context in which they are found.

Their ability to think more clearly will grow as a result, making it easier for them to achieve other scientific goals. Teachers must therefore design lessons that will address the various requirements of the kids in their classes if they are to ensure that all pupils benefit from integrated science sessions.

2.4 Teaching and Learning of Integrated Science

Students frequently fail to integrate the content of one science with another because, according to Schwab (1964), science has been taught as rhetoric of conclusions, a presentation of facts previously known. Effective teachers support their students' learning in a way that prioritises comprehension over awareness, meaning over memory, and quality over quantity (Mintzes et al., 1998). Learning science is an evolving process that involves rearranging ideas in light of fresh information and encounters. According to Hammerman (2006), it is the imaginative and continuous synthesis of data, introspection, and observations concerning the material and social worlds. In the classroom, science students read a textbook that summarises the scientific community's decades' worth of discoveries.

The learner-centred, knowledge-centred, assessment-centred, and community-centred instructional design framework proposed by Donovan and Branford (1999) is a helpful one to adopt. In the teaching and learning of science, assessment plays a crucial role. It has been anticipated, according to Matthews (1998), that science education will improve students' understanding of science as well as their ability to comprehend and appreciate the nature of science, as well as the quality of culture and personal lives. According to Borich (2007), teaching methods are the most crucial strategies that educators use to accomplish a lesson's goals.

Numerous instructional strategies are available in education that improve students' learning outcomes. A specific teaching strategy must be related to the learner's characteristics and the kind of learning it is meant to facilitate in order to be effective and suitable. Ayeni (2011) asserts that teaching is an ongoing process that entails using the right techniques to help students change in the ways that are desired. According to Adunola (2011), teachers should employ the most effective teaching strategies for the material they are teaching in order to effect the desired changes in their pupils. Therefore, to improve the understanding of the subject, the teacher must use a method that will help pupils retain the knowledge they have learned and spark their interest in order to facilitate the process of imparting knowledge to the students. With this in mind, Nzewi (1993) promoted the adoption of a more successful approach to teaching science, and brain-based learning may be one such strategy. In order to examine students' academic performance in integrated science using Brain-Based Learning Theory, this study set out to determine the learning styles of the participants.

2.5. Academic Achievement and Gender in Science

This study also assumed that professors used the BBL theory to determine how well male and female students performed in the classroom. According to Kolb's (1984) experiential learning theory, teachers can tailor their own learning environments by knowing the individual learning styles of their pupils. Numerous research has looked at how gender differs in academic achievement in a range of topics, including Integrated Science. According to Smith and Johnson's (2015) study, 37 female students surpassed male students on the Integrated Science examination, which examined the test results of 500 high school students. The researchers hypothesised that girls' stronger linguistic abilities and greater desire for science courses may be responsible for this advantage.

On the other hand, a study by Jones et al. (2018) using a sample of 800 middle school pupils showed that male students outperformed their female counterparts in Integrated Science. The researchers hypothesised that males' stronger success in the subject was partly due to their interest in practical experiments and their greater capacity for spatial reasoning. Moreover, Smith (2018) discovered gender variations in Integrated Science academic performance after conducting an extensive study with a sizable sample of secondary school students. According to the study, male students typically perform better than female students, especially when it comes to higher-order thinking and practical components. Sharma (2013) conducted a study on the impact of gender on academic achievement. The findings show a markedly low performance of female students than their male counterparts in science educational programme and science related courses.

According to many academics, science is gendered in its practice because of the poor performance of women relative to men, which led to men's stronger control over women in the fields of science and technology (Akanbi, 2002). The disparities in academic achievement between genders in Integrated Science have been linked to a number of issues. Research has indicated that the provision of an inclusive and encouraging learning atmosphere, where educators uphold gender parity and offer equal chances for involvement, might have a favourable effect on female students' academic achievement (Master et al., 2017).

Incorporating inquiry-based learning, collaborative learning, and hands-on activities has also been shown to improve academic attainment for all students, regardless of gender (Tsui & Treagust, 2013). Female students performed worse academically when exposed to gender-biased classroom interactions and typical didactic teaching methods. Furthermore, a study by Brown and Davis (2016) found that students' academic performance and self-perception can be impacted by gender stereotypes about interests and skills linked to science. The threat of stereotypes may affect women, which has a detrimental effect on their participation and performance in science courses, particularly Integrated Science.

According to Martinez and Lee's (2017) research, parents' involvement in their kids' education and expectations for their own education were important indicators of their academic performance in Integrated Science. The study's findings revealed that parents with gender-biased views on science-related skills typically had lower expectations for their daughters' academic success, which had an impact on the students' performance in the field. Various factors, including classroom dynamics, parental influence, instructional methods, and stereotyping have been recognised as plausible causes of these variations.

In order to create interventions and instructional strategies that support gender equality in Integrated Science education and improve academic achievements for all students, it is imperative that these aspects are understood very well. Addressing the issue of gender in science education is an important task for science teachers. Three duties are necessary for a scientific teacher to fulfil, (Levi, 2000). More specifically, make sure that in the classroom, there are equal chances and respect for their differences; make sure that boys and girls are treated similarly, so that they have an identical experience; up for the disparities in gender in society. This study addressed the relationship between the brain-based learning strategy and students' learning styles.

2.6. Brain- Based Learning Strategies

According to Silver et al., (2012), learning strategies are any planned actions that a teacher uses to accomplish specific goals. To put it succinctly, learning strategies are methods for accomplishing learning objectives. According to Joyce et al., (2009), learning strategies with passive tactics will not further boost conceptual knowledge; instead, strategies that include students actively in the learning process through scientific study will. This point of view emphasises the importance of activities that allow for student response, improvisation, and involvement.

Learning strategies, according to Branch (2009), are arrangements and flows of learning activities. According to Jonassen (2013), learning strategies are defined as learning activities that are organised and carried out during the process of creating learning. The aforementioned two viewpoints demonstrate that learning strategies are planned, systematic actions that are meant to occur during the process of learning. According to Dick et al., (2009), learning strategies are applied generally and encompass a range of activities such as selecting multiple delivery systems, organising and classifying content, elucidating learning components, formulating lesson structure, and choosing learning media.

Teachers in Ghana have a lot of options at their disposal to enhance the standard of instruction provided in classrooms. This could be accomplished by applying student-oriented learning strategies, for example, or by choosing the appropriate learning strategies to use. These are learning techniques that are appropriate for the features of the subject matter and the learners themselves. According to Sakdiyah et al., (2018), the use of suitable learning strategies can enhance students' learning outcomes and make it easier to reach specified learning goals.

The teacher has a wide range of tactics at their disposal to use in instructional activities. Important factors that are taken into account when choosing learning techniques include those that are connected to the efficacy of reaching learning objectives as well as those that support psychological theory and learning theories. These two are also related to the process of learning design, which takes into account the requirements for assessment as well as the technological implementation of learning, student characteristics, and learning objectives. When determining which learning methodologies are appropriate for the given application, all of these factors are taken into account. Apart from learning methodologies, the teacher must also take the students' learning styles into account during the teaching and learning process.

The opinions shared clarify the scope of the learning strategy for everything that needs to be taken into account during the learning process. Suarsana et al., (2018), found that applying the Brain Based Learning (BBL) learning approach by teachers can enhance students' conceptual understanding of mathematics learning, which has a favourable impact on learning outcomes. Based on these results, it can be concluded that integrated science learning outcomes can be enhanced by strong student achievement motivation. According to the preceding description of the conditions, senior high school students' integrated science learning results heavily rely on the teaching tactics used by the instructor while taking the students' individual characteristics into account. Students need to be actively involved in applying their critical thinking skills to solve scientific problems in order for integrated science learning to take place.

These qualities align with the principles of the Brain Based Learning (BBL) learning approach, which stresses the active construction of concepts by pupils (Ulger, 2018). The release of research-based tactics that educators employ nowadays makes the principle of brain-based learning increasingly clear. Educators can identify a specific theory to support their classroom instruction by using this type of learning. The 12 principles listed below are those that Caine and Caine (1994) developed in 1989 and suggest for brain-based learning. According to Connell (2009), these principles enable teachers to work with a wider range of students by validating the idea that different students have different learning preferences and providing them with a variety of teaching methods based on those preferences.

(1). The brain is a parallel processor: The brain performs many tasks simultaneously, including thinking and feeling.

(2). Learning engages the entire physiology: The brain and the body are engaged in learning.

(3). The search for meaning is innate: The brain's/mind's search for meaning is very personal. "The greater the extent to which what we learn is tied to personal, meaningful experiences, the greater and deeper our learning will be" (Caine & Caine 1994, p. 96).

(4). The search for meaning occurs through patterning: "The brain is designed to perceive and generate patterns, and it resists having meaningless patterns imposed on it" (Caine & Caine 1994, p. 88).

(5). Emotions are critical to patterning: Our emotions are brain based; they play an important role in making decisions.

(6). The brain processes parts and wholes simultaneously: The left and the right hemisphere have different functions, but they are designed to work together.

(7). Learning involves both focused attention and peripheral perception: People hold general perceptions of the environment and pay selective attention to various parts of it.

(8). Learning always involves conscious and unconscious processes: There is interplay between our conscious and our unconscious. “One primary task of educators is to help students take charge of their conscious and unconscious processing” (Caine & Caine 1994, p. 157).

(9). We have at least two different types of memory: spatial (autobiographical) and rote learning (taxon memory). The taxon or rote memory systems consist of “facts and skills that are stored by practice and rehearsal” (Caine and Caine 1994, p.169). Spatial, or autobiographical, memory “builds relationships among facts, events, and experiences” (Caine & Caine 1994, p.170).

(10). Learning is developmental: Children and their brains benefit from enriched home and school environments.

(11). Learning is enhanced by challenge and inhibited by threat: Students optimally benefit when their assignments are challenging and the classroom environment feels safe and supportive. The brain learns optimally and makes maximum connections when appropriately challenged. But the brain "downshifts", becomes less flexible and reverts to primitive attitudes and procedures if under perceived threat.

(12). Every brain is unique: This looks at learning styles and unique ways of patterning. We have many things in common, but we also are very, very different. We need to understand how we learn and how we perceive the world and to know that men and women see the world differently.

The following three brain-based teaching approaches can be used to group all 12 concepts (Caine & Caine, 1994). Learning becomes persistent and meaningful when it goes through these stages of brain-based learning (Hasra, 2007, p. 40). BBL strategy phases consist of three steps: coordinated immersion, active processing, and relaxed alertness.

Establishing an environment for learning that requires pupils to think critically (orchestrated immersion): Making the material more significant and long-lasting in the pupils' recollections is the main goal of the phase-by-phase planned immersion. In order to ensure that the knowledge students acquire is retained longer in their memories, this phase assists students in creating patterns and associations in their brains when they are presented with challenges that are rich in learning experiences. It is imperative that all learning activities include topic-specific questions that support students' critical thinking abilities. In order to help students get used to strengthening their thinking abilities in the context of unlocking their brain potential, the lesson questions are designed to be as engaging and useful as possible. Examples of this include using puzzles and simulation games (Tigadi, 2020).

In the phase of relaxed alertness, pupils are tasked with solving a problem well while minimising the threats that may arise if they are unable to do so. This is because learning outcomes are higher when individuals are at ease and do not take unnecessary risks. Different approaches to learning can be taken, such as arranging for students to study outside of the classroom at specific times, selecting music for educational activities based on the needs of the classroom, incorporating lively games into group discussions, and taking other steps to ensure that students are not uncomfortable. A second meaning of relaxed alertness is to establish the ideal emotional and social environment for learning. (Gülpınar, 2005) Providing a demanding learning environment with few hazards is important.

A person is receptive to learning when they are engaged in something, and vice versa. Learning comes more naturally to a calm and an open brain. Results indicate that while learning is suppressed when feeling weary or threatened, it is positively influenced in a relaxed setting (Combs & Suygg, 1959 as referenced in Caine et al.,1999). The learner can assimilate information as effectively as possible when their emotional brain is in a condition of high difficulty but no threat or negative stress. For the pupils, they are constructing real and significant learning environments (active processing).

At the active processing phase, students are grouped together in study groups to help them assimilate the material more easily. Despite subpar performance, students still need to receive prizes. Learning activities provide students with the motivation to actively create their own knowledge through self-directed learning. Provide an environment in the classroom where every student can move as best as they can. For instance, students can use their hands and legs to write, their mouths to actively ask questions and engage in discussion, their eyes to read and observe, and their other limbs to engage in productive activities. An active brain is one that is processing information while learning. For example, memory responds naturally to new things that are incompatible with the prior maps in order to give the experience meaning.

Consequently, experiences that defy the known are tested by the brain (Duman, 2007). It has been discovered that learning, memory, and emotion are strongly connected with neural growth. Reduced stress, regular exercise, and a healthy diet can all help with development. Schools have the ability to alter these factors in order to improve learning procedures and results (Jensen, 2008). Improved blood circulation and cognitive function are two benefits of physical activity.

Brain Gym is one body-movement which is based on a brain-based learning technique that is revolutionising education today. It entails a set of easy motions designed to improve whole-brain learning by highlighting the connection between academic success and physical growth (Dennison & Dennison, 1989). Students can reach brain regions that were previously unutilised to support learning and repatterning through body motions. According to McEwen and Wingfield (2003), chronic stress results in a modified metabolic state known as "allostasis," which modifies the stress threshold. Since they can seriously affect behaviour, learning, and health, staff and students need to regulate these pathogenic allostatic stress loads in the brains. There are broader ramifications for educational procedures from the brain's capacity to rewire and remodel itself through neuroplasticity. By teaching students in the arts, vocational education, reading, meditation, and skill development, schools can enhance the neuroplasticity processes (Jensen, 2008).

Positive and substantial alterations in the minds can be quickly achieved when these tactics are used effectively. The events and social environments we are exposed to also inevitably shape our brains. Our daily experiences shape our brains and altering our experiences will also modify our brains according to a wealth of data. Because school behaviours are very social in nature, they are ingrained in our long-term memory through feelings of stress, reward, acceptance, and suffering. It is implied by this idea that teachers actively control the social setting of the classroom and improve the learning environment.

The amount of rote memorisation that is necessary can be decreased by using brain-based procedures, which assist students in accessing and utilising more efficient memory storage and retrieval techniques. These techniques support students in seeing patterns and drawing connections between previously learned material and newly acquired information to be incorporated into the long-term memory storage regions of the brain. Creating positive neural circuits through positive emotional experiences that evoke a sense of accomplishment, acknowledgment, and praise are just a few of the brain-based learning strategies that Willis (2006) suggests. Other strategies include making curriculum more thematic and multidisciplinary and giving students' opportunities to visualise mental models of the concepts they are studying. In order to create instructions for brain-based learning, educators must have a thorough understanding of how the brain functions (Stevens & Goldberg, 2001).

2.6.1. Training for BBL strategies

An essential first step in implementing BBL techniques in the classroom and facilitating effective teaching was to train instructors in their use. According to Jenson (2008) and Tokuhama-Espinosa (2014), they would be used in all subject areas to satisfy the needs of the students. There were various BBT strategy trainings, and each had unique applications and efficaciousness. In Lavis et al. (2016), for example, the researchers looked at a group of elementary school teachers and devised a 20-month training program to teach instructors how to use brain-based teaching techniques in the classroom.

Along with pre- and post-program surveys given to teachers and a qualitative survey administered to a subset of all participants, the training program's components included yearly teaching, learning workshops, reading and discussion groups based on the lessons teachers had learned during the training. The training and the insights, varied teaching experiences, and talents of their other instructors proved beneficial to the participating teachers, as the findings shown. According to Lavis et al. (2016), the findings indicated that when children performed below expectations in reading and learning, it was imperative to use BBL tactics in the classroom environment.

Furthermore, the findings indicated that in order to meet the needs of today's students and achieve the best learning outcomes for their students, elementary teachers should be trained in BBL strategies. This is especially important for new and inexperienced teachers who may be reluctant to adopt and apply BBL strategies in the classroom (Jensen, 2014; Sprenger, 2015). Nunly (2002) is a biology teacher who does research at the University of Utah on curriculum creation and brain-based learning. But to date, no meta-analytical study has been conducted in our nation or any other nation to demonstrate the impact of brain-based learning on academic accomplishment from a more comprehensive angle.

Reading fluency is a key component of the overall learning process and a predictor of future academic achievement, according to experts and proponents of BBL (Gardner, 2014). This is especially true for struggling children. The BBL approach centered on understanding how the brain works during learning. It may not be the last word in education, though, as Chall (1967) noted that it ignored some social and cultural factors that have been shown to impede learning. But the notion could be a useful starting point for a successful educational plan if combined with other tried-and-true teaching techniques. BBL has significantly increased the chances of academic success by utilising the most recent research on brain processes.

Realising that BBT methods were the keys to success and that the discoveries made by the forerunners in BBL scientific research had a major influence on learning achievement was important (Sousa, 2014). The brain has an infinite capacity to integrate information, create patterns, and draw conclusions from learning experiences, regardless of age, gender, or cultural background (Caine & Caine, 1994). Twelve principles, as outlined by Caine and Caine (2014), were used to introduce BBL to elementary pupils with varying learning styles, including those with difficulties reading and other learning obstacles. The principles highlighted the significance of learning patterns.

According to Jensen (2005), BBL is an engagement technique built on ideas from our understanding of the brain. Brain-based learning maximises the emotional, social, cognitive, physical, and reflective learning spaces in students' brains to support their learning (Sesmiarni, 2016). Environment, Brain Fitness, Choice, Difference, Emotion, Fun, Purpose, High Hope, Interest, Just Like Home, Kinaesthetic, Lighting, Music, Nutrition, Online Learning, Patterns, Questions and Answers, Gifts, Seating, Technology, Water, and Sleep are all factors that the BBL application must consider (Kommer et al, 2008).

In order to enhance learning results, teachers are supposed to select material that can elevate mood, perseverance, and brain chemistry (Jensen, 2009). Often known as educational neuroscience, brain-based learning (BBL) explores learning as a biological process. To improve learning, BBL applies three key components: active processing, relaxation and alertness, and immersion in complex environments. These elements combine neuroscience knowledge with educational practices (Rodgers, 2015). Brain research appears to have a long way to go in terms of learning and teaching. There will undoubtedly be significant changes when it is made evident how knowledge is created, arranged, and retained in the brain (Soylu, 2004, p.175). "To what extent does brain-based learning influence students' academic achievement?" was the primary research question that guided the analysis of the 31 research studies (42 impacts) that were discovered in order to examine the impact of brain-based learning.

In order to better understand how to teach Physics to a group of one hundred high-achieving students in the northern states of Peninsular Malaysia, Saleh (2012) performed a study. The findings demonstrated that the Brain-Based Teaching Approach is successful in raising conceptual comprehension of Physics and learning motivation among the research samples. It accomplishes this by incorporating brain-based teaching strategies through the seven-brain compatible instructional phases. Similar findings were also made by Rehman and Bokhari (2011) in their investigation of the efficacy of the Brain-Based Teaching Method (BBTM) on the mathematical achievement of ninth-grade pupils. It has been discovered that the Brain-Based Learning Principles, when implemented through an enriched environment and cognitive practices such as playing gentle music, using appropriate language, praising, and soothing colours will help students learn effectively. Other cognitive practices include creating a safe and welcoming environment, exploring real-life problems, cracking jokes, encouraging smiles and laughter, encouraging critical thinking, and providing nutritional advice.

2.6.2. The Relationship between Academic Achievement and Brain-Based Learning Theory

Hart (1969) explored and understood how learners' brain functions interfered with education, emphasising the need for educational reform in the classroom. With an emphasis on the consequences of children's brain development for instructional practices in education, Hart created the BBL theory in order to achieve this. Given the current understanding of the neurophysiology of the learning process, Hart provided a number of teaching strategies (Jensen, 2000; Sulayman, 2014; Willis, 2009) to help educators and teachers comprehend the critical relationship between brain-based teaching tactics and students' cognitive functioning. Hart outlined a unique teaching style that is wholly based on a knowledge of brain-based education (Chawat et al., 2016; Degen, 2014).

Hart (1983) pushed educators to monitor their pupils' progress in learning by having them use BBL tactics under supervision. Teachers' ought to be cognisant of their kids' brains, says BBL. The brain is an apparatus to be marvelled at and approached with awe and reverence because it is an effective learning tool and because it helps recognise the brain's supremacy as it evolved in skulls (Sulayman, 2014). Students' rates of brain growth can vary greatly, and the learning environment has an impact on each stage of growth, according to Hart (1983) and Caine & Caine (2010). According to BBL theory, educators must create gradual but specific learning objectives and be prepared with brain-based strategies to engage brain processes in order to promote brain growth.

According to Diamond and Hopson (1998), there is a critical stage of brain maturation that is related to reading performance, and the majority of struggling readers exhibit a poor or inadequate stage of brain development. However, as per Chall (1967), research on the nervous system demonstrated that a "molecular" emphasis strategy at the onset of reading is better than the holistic approach. For pupils to do better when reading, teachers had to provide a learning environment where their brains could expand and mature to their maximum potential (Chall, 1967; Fletcher, 2014; Kayalar & Turkan, 2016). Others have dabbed a combination of brain research and common sense imagined to bring forth efficacy in learning. Richardi (2023) had dubbed his proposed teaching style a brain-compatible approach.

Neuroscience studies have been conducted in the medical domain, but recent findings from educators are perceived to have implications for learning, motivation, and growth (Schunk, 1996). According to Jensen (2005), the brain connection that forms, becomes stronger, and is used to link to other people, is the basis for the learning viewpoint in neuroscience. This connection carries a change in cell reception. The study of how the neural system affects behaviour and learning is known as learning neuroscience.

Establishing a setting that maximises teaching ability was one of the most crucial components of BBL. BBL philosophy required teachers to involve students fully in the learning process and have them actively participate in it, as opposed to having them observe it passively (Gulpinar, 2005). During the teaching and learning process, a further brain-based requirement for the pupils was eased. According to neurophysiological research, the specific brain wave frequencies associated with the relaxed state are the most conducive to attention, learning, and memory (Byrnes & Vu, 2015; Darling-Kuria, 2010). With the students' complete cooperation, BBL presented a constructivist approach in the classroom.

Every facet of knowledge ought to provide pupils with worthwhile challenges rather than just required rote memorisation exercises (Coffman & Klinger, 2014). BBL also encouraged teachers to inspire their students by posing difficult questions and difficulties to them. Many educational institutions have created curricula that aim to include the neurobiology of learning into the classroom, and BBL is currently an acknowledged theory in education research and practice (Doolen & Cates, 2014). Scholars have broadened their understanding of BBL to include both conventional classrooms and special education settings (Edelenbosch et al., 2015). Hart's BBL theory of learning was widely acknowledged, and new developments in neuroscience and learning psychology have reinforced its influence (Edelenbosch et al., 2015; Saleh, 2011).

New discoveries regarding the brain and their potential applications in educational settings have been made possible by BBL research. Caine and Caine, who added a list of twelve "brain/mind learning principles" to Hart's theory of brain-compatible learning, or BBL, were among the academics who made a significant contribution to the implementation of BBL (Caine & Caine, 1991; 1997). As per Le-Mar and Burgess (2015), the Caines' concepts have effectively integrated neuroscience research with learning applications, so making a significant theoretical contribution to the field of brain-based education. Over time, numerous educational environments have used the well-researched and perceptive brain-compatible learning concepts developed by Caines as a framework and set of practical guidelines (Wiznia et al., 2012).

In the modern era, BBL theory has grown and adjusted to fit a variety of educational settings (Jensen, 2000). Jensen (1995) focused on integrating the practical applications of Caines' brain/mind learning concepts with Hart's BBL theory. Caine and Caine (2013) assert that this kind of integration approach enhanced learning results. Jensen (2013) urged educators to hold students to a high standard of intellectual rigour in order to improve reading achievement. He also identified five strategies that have been shown to maximise reading performance: (i) upholding high standards; (ii) teaching in a variety of learning styles; (iii) using alternative forms of assessment for students who learn differently; (iv) fostering a respectful environment for students; and (v) utilising multi-status, multi-age, and multi-ability teamwork (Jensen, 2013).

According to a number of studies (Connell & VanStelten, 2013; Liu & Huang, 2014; McCall, 2012; Tokuhama-Espinosa, 2015), applying brain-based knowledge to teaching has a significant impact on student learning outcomes. Neuroscience has been shown to have a unique role in this transformation of education. To enhance their instructional strategies and support students' learning objectives, Özgül & Necdet (2012) investigated a group of elementary school instructors using mind mapping. A qualitative research design was employed to conduct the study, which involved 24 elementary school instructors from multiple elementary schools (18 females and 6 males).

The researchers gave the instructors detailed examples of mind maps and requested them to create their own mind maps in which they presented themselves individually in order to learn more about the opinions of the participating teachers on mind mapping as a teaching tool. Six open-ended questions were used to allow the participants to share their own methodologies and studies related to mind mapping, allowing them to analyse each other's mind maps. As per the findings of the study, mind maps were a useful tool for instructors to enhance their planning, assessment, and instruction. They also helped teachers teach more effectively.

Students gained a more effective education as a consequence. Teachers found it easy to become lost in their instruction and struggled to maintain mental organisation and use instructional strategies in the absence of mind mapping. Learning outcomes for pupils were subpar as a result of teaching without mind mapping becoming less effective. According to Özgül and Necdet (2012), the researchers' findings are closely tied to the study because they demonstrate how the mind mapping technique is a brain-based teaching strategy that helps students and teachers remember information and identify connections between various ideas and viewpoints. Consequently, mind mapping served as a brain-based educational tool that emphasised the significance of neuroscience in the classroom (Malekzadeh & Bayat, 2015; Saleh & Salmiza, 2011).

Gehris et al., (2015) investigated the views of 37 primary school teachers about kids' movement and learning in early childhood education in Allentown, Easton, and Bethlehem, Pennsylvania. The study used a qualitative research design with the goal of learning more about the teaching environments and exploring the depth, richness, and complexity that are intrinsic to the phenomenon. The utilisation of a qualitative design enabled the researchers to concentrate on the comprehensive, subjective interviews, conversation, and observation that stem from the fundamentals of knowledge, enabling participants to uncover their individuality and provide significance.

With the assistance of lead teachers (20 lead) and assistant teachers (17 assistants), the researchers split up the participating teachers into six small focus groups. In order to explore teachers' perceptions about the following subthemes, each focus group discussion lasted approximately 70 minutes. The data were generated through interactive group processes such as interviews, discussion, and open-ended prompting questions. The sub themes included (a) how teachers' teaching movement experiences influence students' learning results, (b) what kinds of BBL teaching experiences are most beneficial for students, and (c) what challenges exist related to supporting students' learning and what BBL strategies might be used to overcome those challenges. Written informed consent was supplied by the participants, and no data was gathered without a signed consent form.

To analyse the survey, the teachers' answers regarding their knowledge and experiences with the subject were totalled. The researchers found that 21 teachers who used movement activities, their understanding of BBL methods, and their own experiences with them made a significant difference in their students' ability to learn more effectively. Sixteen educators who were less knowledgeable and experienced in using BBL tactics in the classroom resulted in their students achieving less learning objectives that were effective. As the findings showed, it was critical to draw the conclusion that neuroscience offered a special opportunity for teaching because BBL, which drew perspectives and insights from neuroscience, required educators to fully participate in the process of helping students improve their academic performance and self-efficacy (Liu, & Huang, 2015; McCall, 2012). One of the main objectives of educational neuroscience was to close the achievement gap between instruction and learning by utilizing instructional strategies that emphasized key features of brain activity (Connell & VanStelten, 2013).

The 12 BBL principles, which combined the body, brain, and mind into a dynamic unity, were unique and holistic approaches to teaching and learning for educators, teachers, and students. Caine and Caine (2010) extended these principles and applied them to a variety of learning environments to enhance effective teaching and learning outcomes. The aim of the Caines was to provide principles and a framework for teaching and learning by utilising the theoretical underpinnings of BBL in the classroom with the involvement of teachers. The Caines employed a qualitative approach to their study, gathering and analysing data using questionnaires, in-person observations, and interviews with a group of participating teachers from various school settings. According to the findings, attention, emotion, and the senses, all crucial components of cognitive processes could not be divorced from teaching and learning. The brain has an innate ability to learn and teach. Since the brain is a social organ, instructors have a special responsibility to use their social brains to teach and stimulate students' cognitive processes through class activities. Teaching and learning abilities and their functionality depend on all aspects of the brain (Caine & Caine, 2010).

Research has also indicated that the field of educational neuroscience has made significant contributions to the practice of brain-based education in recent years, providing new opportunities for teachers and struggling students (Caine & Caine, 2012). Numerous aspects of the neuroscience research on BBL were revealed, and each of these aspects supported the idea that BBL is changing schooling (Hughes, & Baylin, 2012; McCandliss, 2003).

Theoretical and practical approaches in education that affected both teaching and learning have undergone substantial modifications as a result of the diverse impacts of BBL's neuroscience research on enhancing reading.

By polling 217 elementary school teachers in Greece (155 females and 62 males) from a variety of primary school education programs, Deligiannidi and Howard-Jones (2014) investigated how neuroscience studies of BBL affected teaching and learning. The purpose of this study was to lower the frequency of neuromyths in education by applying the results of neuroscience research on BBL. According to analysis, Greek school teachers had a number of false beliefs about the brain that affected their perspectives on teaching and the relationship between students' minds and brains. Because neuromyths were common among Greek teachers, they frequently failed to give their students the learning experiences they needed, which resulted in inadequate theoretical and practical approaches to education.

According to the findings, the vast majority of Greek primary school teachers (87%) thought that neuromyths had detrimental effects on the brain and hampered instruction. The results of BBL neuroscience research greatly aided Greek instructors in understanding the value of precise brain information that enhanced instruction and learning. Because they significantly altered instruction, the BBL researchers' findings were therefore vital to the study. The findings were crucial in lowering the frequency of neuromyths in education, which were frequently linked to subpar or unevaluated methods of instruction and classroom management (Deligiannidi & Howard-Jones, 2014).

Teachers that use BBL tactics to improve their students' reading skills are nevertheless impacted by brain studies on learning. Recently, the field of neuroscience has made significant advancements in the biological and physiological understanding of how the human brain develops to its full potential and learns to read. These discoveries have had a profound impact on teaching and learning, necessitating the use of new BBL strategies in the classroom by educators and teachers (Becattini et al., (2015); Sprenger, 2002).

Through the use of various standards-based mathematics curricula, teachers' instructional methodologies, and a group of first and second grade pupils were tested by Price et al., (2016) for their numerical and mathematical competency. The investigators measured the ways in which children developed arithmetic abilities through imitation, active engagement, and inquiry, and they observed how teachers taught and implemented their BBL tactics in the classroom. According to the findings, teachers who used BBL techniques had a greater impact on students' development of mathematical and numerical concepts and applications, as well as their success in acquiring these abilities. Both reading comprehension and other learning skills improved for the students.

According to Yildiz et al., (2015), the impact of brain research on instruction therefore aimed to fulfil learners' requirements rather than changing and revising education. There was a growing demand in elementary schools to help second-grade struggling readers, and teachers needed to know how vital it is for students to explore and learn about neuroscience through second-grade students' brain responses to visual and auditory stimuli (Marzano et al., 2001). By combining the visual and auditory teaching modalities of their teachers in the classroom, Mitchell et al., (2016) conducted a study on 42 second-graders from multiple elementary schools. Children were exposed to a great deal of visual, aural, and kinaesthetic information from birth through touching, feeling, and experiencing the subject matter.

The findings demonstrated that 42 second-grade students were able to learn more quickly and efficiently and read more proficiently than to the visual and auditory teaching modalities used by their teachers. The findings also showed that repeated reading significantly improved reading fluency and helped struggling second-grade readers improve their vocabulary, grammar, and syntax (Mitchell et al., 2016). It was crucial that teachers involve their children in both visual and auditory literacy exercises as a result. Effective educators understood how to set up lessons using obvious, hands-on teaching techniques to excite students' minds (Fischer et al., 2007). For their teaching methods to be relevant and adaptable to the requirements of struggling readers, teachers also have to be structured in their use of and implementation of BBL strategies (Battro et al., 2008).

2.6.3. The functioning of the brain (BBL- Principles)

The best learning activities are determined in large part by how the brain functions. Teachers must assist students in making the most of their experiences and obtaining relevant experiences. Teachers can design a learning environment that increases the likelihood that a student will succeed by understanding how the brain functions best. Your pupils' performance in the classroom can be enhanced by implementing the following brain-based learning principles:

i. Speaking: By speaking, individuals assimilate what they have discovered. After giving the kids a few facts, let them "turn and talk," when they can discuss what they've learned. It works and is adored by them.

ii. Emotions: powerful emotional experiences have both positive and negative implications and they are strongly associated with powerful memories. Feeling good about yourself makes the brain function better. Before the brain is prepared for learning, students need to feel emotionally and physically protected. By supporting and recognising the work of their pupils, teachers may foster a good atmosphere.

iii. Visuals: Of all the senses, vision is the strongest. To aid in the children's learning, use photos, films, posters, drawings, and even guided imagery. Roughly half of students learn best visually, favouring written text, charts, and pictures over lectures. Thirty percent of students learn best through touch and movement; therefore, they require more tactile, hands-on experiences. Twenty percent learn best by talking about what they are learning since they are auditory learners.

iv. Chunking: This refers to the requirement for a little information and a chance to process it in some way. This is where you can write, draw, or even dance, and also where "turn and talk" works. New information is processed by the brain in pieces. Brain research states that children between the ages of 5 and 13 learn best when given chunks of 2 to 4 pieces of information. Children ages 14 and older can learn up to 7 chunks at a time. Teachers should plan for these limits and teach material in small chunks.

v. Movement: Learning combined with movement practically always results in stronger learning.

vi. Change things up: Your brain tunes out when you do the same thing over and over again because it gets monotonous. Have a backwards day by rearranging the seating, reversing the entire schedule, and carrying out one aspect of the day entirely differently.

vii. The brain requires oxygen: It is estimated that the brain uses 20% of the oxygen consumed by the body. This implies that we must constantly encourage the pupils to get up from their seats and move around. Pupils require a little break from an assignment to "rest their brain." A student's attentiveness is frequently increased when they are given time off between lesson parts. For example, allow students to take time to stand up and stretch, provide a 2-minute talk break, Brain Gym exercises, etc. By providing these moments, the brain will be more ready to stay on task and store information.

viii. Brain Breaks: The human brain is limited in its capacity to process information. If you visualise the brain as a cup, everything that tries to fit within it eventually spills out the side. In order for the cup to be filled again, you must empty it. Similarities exist in the brain. To make space for more, students need time to assimilate new information. Make sure your pupils take mental breaks every five to ten minutes. A think-share-pair, a movement exercise, or a well-timed joke could all be examples of this. Have imagination.

ix. Form Links: The brain depends on connections. It is not capable of storing random data. There must be an existing connection made between it and another entity. You can make connections through your own experience and stories. Children learn best when teachers teach new material first and review previously learned material at the end of instruction.

x. Feedback: Except in the case of accuracy, practice does not improve anything. It is important for students to hear that they are headed in the correct direction. Additionally, motivation is also somewhat enhanced by it. Teaching in brief units, one or two at a time and allowing students to lead an activity period afterward is the ideal approach for educators. For the skills they are learning, students require time to practise.

xi. Music: A musical instrument has great potential. Through music, we can understand the challenging elements.

xii. Acronyms: Make up your own acronyms or use the ones your pupils come up with.

xiii. Encourage pupils to stay hydrated by providing water during class. Excessive blood salt levels due to dehydration have been linked to elevated blood pressure and stress, according to research. Dehydration also causes a loss in attentiveness and lethargy. Ideally, students should drink 6 to 8 glasses of water a day to be properly hydrated.

xiv. Reflection time: The brain follows a temporal timetable as well. It is preferable for kids (5–13 years old) to learn in 5-to 10-minute blocks. Youngsters fourteen years old and up learn in 10- to 20-minute blocks. Instructors may occasionally use positive reinforcement to expand time limitations. After a class, give students some time to reflect and have a discussion about the subject. It's possible that understanding will come to pass later. The learning environment depends heavily on processing time and reflection.

xv. Energy Level: Make good use of the most of kids' periods of high energy. A cycle of high and low energy levels happens during the school day. For instance, most students, particularly those in their adolescence, are less energetic in the morning and more energetic after lunch. A higher energy level correlates to an increased level of attention. Teachers should take advantage of the times during the day when the students' energy levels are higher by teaching the most important material during these times.

xvi. Space: Give the learner enough room to be alone. A learner who has more personal space feels less stressed.

xvii. Location: This is another simple concept to put into practice. Memory is heavily location-dependent. When introducing new material to your class, you can change up your position and the students' positions as well.

xviii. Positive Environment: Establishing a helpful and upbeat classroom atmosphere is crucial. Under stress, the brain is not able to learn well. Higher order cognitive processes are diverted to primary survival requirements. Our brains' mirror neurons make us experience stress in the same ways as people around us, which impairs the class's capacity to learn. Make sure the atmosphere is conducive to learning.

xix. Optimism: Every day, one should exemplify an optimistic outlook. A student's teacher can be the only person in their lives who is upbeat. Their future might depend on it, so be careful to practise and model positivity.

xx. Choice: Making a choice is another crucial and simple tactic. Pupils adore having options. When people feel invested in the work at hand, their brains are more active. Here are some solutions you could use if your district restricts you from offering specific content, book, or subject choices: Where to sit, whether to stand, A crayon, coloured pencil, or pencil Lesson sequence.

xxi. Anticipation: Provide pupils with specific material to listen to prior to starting a class. Alternatively, let them know they will need to retell some information to a fellow student. They will pay close attention and retain more.

xxii. Meaningful learning: Information that is relevant and meaningful is more likely to be retained by the brain. It is imperative that students understand the significance of the material they are studying. This is especially important for students who struggle academically.

2.6.4. The relationship between BBL and Kolb's experiential learning theory (ELT)

According to the BBL approach, students should share their experiences and the lessons they have gained from them with one another during class discussions. In order to improve learning, BBL principles like patterning, parallel processing, and challenges are applied in experimental learning (Phillips, 2005).

As seen in Figure 3, the process of experiential learning is connected to the way the brain functions. Put more simply, the graphic shows that the frontal integrative cortex creates new abstract notions, the sensory cortex processes concrete experiences, the motor brain is involved in active testing, and the integrative cortex at the back is involved in reflective observation.

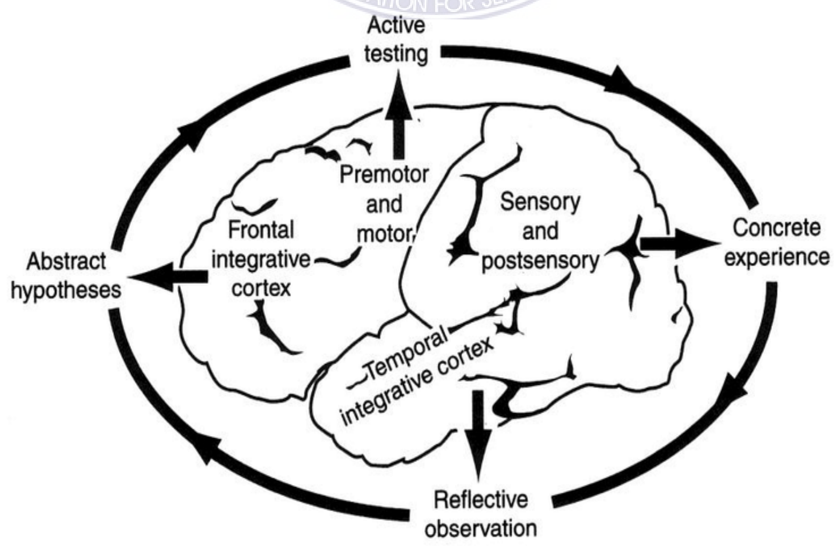


Fig.3: The Experiential Learning Cycle and Regions of the Cerebral Cortex (Zull, 2002) Kolb's learning cycle mode

Students' internal realisations of their preferred modes of learning are taken into consideration by Kolb's learning cycle model. Students can reinforce the connections between neurons by engaging in experiences and physical activities. The brain is physically altered by experiences via both internal and external inputs (Roberts, 2002). Zull (2002) asserts that learning is change. Experiences are the means through which learning takes place. The relationship between BBL and Kolb's experiential learning model can be summed up as follows. Experience is the most significant idea that both ELT and BBL share.

Based on learning principles and the lobes of the brain, the BBL and ELT models describe how learning occurs. Each person has a unique circadian rhythm and circulation, according to BBL theory (Jensen, 2008). Previous research on BBL and learning styles is also reviewed in this paper. Academic accomplishment is enhanced when learning activities and learning styles are coherent, according to a meta-analysis research on learning styles that analysed 42 separate studies (Hein & Budny, 2000; Bayraktar, 2000; Sünbül, 2004). Research has shown that learning-centred instruction that takes learning styles into account has a favourable impact on students' academic achievement, motivation, and creative intelligence (Bajraktarevic et al., 2003; Butler, 1987; Demirbas & Demirkan, 2007; Felder, 1996; Kolb, 1984; McCarthy, 2000; Scales, 2000). According to Gagne et al., (1992), distinct learning objectives call for varied instructional pedagogies. No single learning-teaching theory is sufficient on its own, and teaching should take into account the variances in styles of pupils (Gardner, 1993). Therefore, integration of several models based on brain-compatible learning conditions is required.

2.7. Learning Styles

According to Felder and Brent (2005), learning styles define a learner's psychological, cognitive, and affective behaviours as well as how they optimally perceive and process information from their surroundings and outside sources. Studies have demonstrated that students do, in fact, have different learning styles. While some learn best by actively participating in physical activities and experiencing new things, others learn best by visualizing and conceptualising data that is presented to them (Kolb & Kolb, 2018). Every person learns in a different way (Abdul-Wahab, 2015). Learning style preferences can help to understand how pupils learn and have an impact on academic accomplishment (Yazici, 2016). Depending on the student's inclination, learning styles can differ from one another (Nor et al., 2014).

According to Adnan et al. (2013), this is because people differ in their personalities and because each student has a different set of values when it comes to learning. According to Willingham et al., (2015), it is best defined as an individual's way of thinking and learning because the learning approach used is unique to each person (Ahmad et al., 2014). Individual thought processes are also perceived in various ways. Every potential teacher is perceived to have a different learning style based on their unique personal attributes (Katranci & Bozkuş, 2014). According to McDonough and Ramirez (2018), student motivation may vary depending on their individual variances in self-concept.

According to Özgen et al., (2011), pre-service teachers have a tendency for acquiring abstract conceptualisations and more active experimentation in processing knowledge, as indicated by their dominating mental preferences from Kolb's learning styles assessment. According to Valley (2016), a person's tendency for processing information in a specific way during a learning activity is known as their learning style. According to Duff and Duffy (2002), learning styles are the result of a person's interaction with and reaction to their learning environment, including cognitive, emotional, and psychological elements. A person's method of thinking, processing, and comprehending information is referred to as their learning style. According to Muwardi (2013), there are three types of learning styles among students: visual, auditory, and kinaesthetic.

The relationship between integrated science learning and gender studies has garnered more attention in the modern period. It is necessary to determine the learning styles of males and females in order to provide a tangible connection between the learning process and the genetic makeup of the brains. Research indicates that there are several neurological and anatomical variations in the cognitive structures of men and women (Kaiser et al., 2009), which has an impact on both genders' cognitive capacities and perceptions of the sciences.

According to Kolb (1984), learning styles come from a combination of genetic predispositions, prior experiences, and current environmental demands that create unique orientations that place varying emphasis on the four fundamental learning modes proposed by experiential learning theory. For integrated science students, whose learning preferences are probably shaped by their prior educational experiences, this definition is pertinent. Their approach to learning science will probably be influenced by the kind of instruction they have received. Was their experience of the classroom more teacher-centred or more learner-centred? Were they encouraged to raise their hands when they knew the answer to a question? Were they encouraged to engage in independent or small group work? When paired work and games are introduced to learners accustomed to a more traditional whole class method, they may at first be reluctant to participate, but if a safe and encouraging environment is created, they will eventually warm up to them. Different learning styles will impact how students approach every subject, including integrated science. While some students like to read and write, others would rather analyse texts or study with the aid of visual aids. But the majority of students have a combination of learning styles.

Furthermore, while learning style differentiates between individuals who prefer to focus on the details and those who would rather focus on the wider picture, it is dependent on brain activity. While some people are comfortable with both, most people tend to lean toward one or the other.

Understanding how the brain functions is crucial to comprehending learning methods. The two halves of our brain are separated by a fold that extends from the front to the rear. The purpose of the nerves that connect these components is to synchronise their functions and send information from one to the other. Although both sides of the brain are capable of reasoning, they do it in different ways, and frequently one side is dominant. The majority of scientists and researchers concur that the functions of each hemisphere of the brain differ significantly from one another. It is believed that the right brain is holistic, convergent, and capable of seeing the broad picture. It addresses feelings, creativity, intuition, and emotions. The left brain is singularly focused, divergent, and linear. It covers topics that make more sense, including speaking and mathematics. Learning in a step-by-step sequential manner, starting with minor detail and working their way up to a conceptual knowledge of a skill, is preferred by leftbrained individuals. Right-brained individuals prefer to begin with the broad idea before moving on to the details.

2.7.1. Main characteristics of learning style

Learning styles are characterised by how each student starts to focus, process, and remember new and challenging knowledge, (Rita & Dunn, 1993). They hold the opinion that each student experiences interaction in the classroom in a unique way. Their concept proposed five areas in which each person's strength and references might be classified:

(i). Environmental factors: these comprise temperature, sound, light, and design. Some people enjoy studying in silence, while others would rather listen to peaceful background music. While some people might want to lie on a sofa or sit on the floor, others might prefer to sit on a chair with a straight back. While some people like dim or natural lighting, others prefer bright light when working. Although it would be challenging to imagine a classroom setting that works for everyone, Dunn and Dunn (1978) propose that a classroom can be divided into distinct sections, each with a unique climate. Lighting is an important factor to take into account when working with dyslexic learners since poor lighting can make it very difficult for a student to focus, read, or listen. Similarly, dyslexic learners may find it difficult to filter out background noise and will therefore need the environment to be very quiet when trying to concentrate on challenging tasks.

(ii). Sociology: While some students learn better when they study alongside a buddy or colleague, others prefer to study alone. More help is needed for certain students than for others. Most people find that learning is much simpler when they can do it with another person. They begin to feel more confident and capable of handling the new information as a result. Talking about the subject with a family member, teacher, or other student will improve their comprehension, perception, and recall of the material. Group and pair work are natural fits for science education.

(iii). Emotional: These comprise drive, tenacity, accountability, and organising abilities. It can be challenging for us to persevere in our learning. They struggle with time management and finishing assignments on schedule. They frequently understand what has to be done but struggle to articulate the specific actions required to finish a task. For students, a lack of drive might be an issue. Finding engaging and understandable ways to deliver instructional materials is the duty of the instructor.

(iv). Physical: These include the time of day that is most likely to yield positive learning outcomes. While some people can work for extended periods of time without taking breaks, others prefer to walk around and take frequent pauses while learning. When learning is divided into little, digestible chunks and regularly spaced out, people learn more efficiently. This might also be the case for recently enrolled integrated science students who must work hard to grasp both the classroom language and science principles. Just 28% of elementary school pupils are active in the early hours of the morning, per a study conducted in 1992. For the majority of primary school students, the best time for learning and working is between 10;30am and 2 pm. As students get older, the percentage of so-called “larks” rises to about 40%, but the majority of students still work/learn more effectively in the afternoon/evening. Only 13% can be classed as nocturnally active.

(v). Psychological: This category covers individual traits including aptitude, drive, disposition, and thought processes. Some people have a global perspective, and many dyslexic persons are among them. They consider the big picture first, then go into the specifics. To put together the big picture, others with analytical minds need to know the specifics. It is crucial for learning to be successful that there be a good, courteous rapport between students and that the environment be accepting and encouraging.

2.8. Empirical Evidence of the Study

LSI has been used in numerous research to evaluate learning styles across a range of subject areas, including integrated science. For example, Ghaffari et al., (2013) found no significant correlation between students' academic performance and their learning styles in their study on the association between learning styles and academic achievement of medical students. Assimilation and convergence were the most common learning styles, though.

The four learning styles and graduate students' attitudes about the four learning techniques (lecture, paper writing, pair learning, and students' attitudes toward cooperation) were measured by Gardner and Korth (1998) using the Learning Styles Inventory (LSI).

The study discovered that although accommodating students favoured pair and group learning, assimilation students preferred to attend lectures and write papers. In comparing the graduation rate of students based on their preferred learning styles, Terrell (2002) found that the majority of students exhibited either an absorbing or a converging learning style.

The learning styles of two samples of undergraduate marketing students from the United States and Bulgaria were compared by Budeva et al., (2015). According to the findings, learners from the two nations appeared to have distinct learning styles, with the majority of them favouring absorbing and converging methods. Only one of the four learning style modes, nevertheless, varies between the two samples. Akkoyunlu and Soylu (2008) looked into how students perceived their learning styles in a mixed learning setting. In a business school, Goorha and Mohan (2009) looked at the connections between course content, teaching methods, and learning preferences. The results showed that business students were becoming more alike and integrating.

As a student participates in the learning process, learning styles and demographic traits like age, gender, and culture are linked in education literature (Boström, 2012; Bosman & Schulze, 2018). Numerous empirical research has provided evidence for this link. For example, Kiwanuka et al., (2015) found that there was gender-based differences in the mathematics performance of first-year high school students in Central Uganda. Thus, it was discovered that while age was not a major predictor of mathematical success, gender was. When compared to male students, female students dramatically underperformed in mathematical achievement.

In a mathematics course at a large university in South Africa, Cho (2016) investigates the interaction between teaching and learning styles. In mathematics class, he discovered that male students were independent (meaning they did not need their professors' supervision to learn), while female students tended to be more reliant on them. However, most lecturers did not agree with this conclusion. The results of the same study indicated that male students preferred visual and intuitive methods of detecting and absorbing information, whereas female students tended to be sensory and verbal learners.

The relationship between learning style preferences and gender disparities among undergraduate medical students was examined by Wehrwein et al., (2007). The results showed that although the majority of females had unimodal learning styles, the majority of males displayed multimodal learning styles. But the results of a related study by Slater et al., (2007), which revealed no significant differences in gender or learning styles, do not support this claim. Furthermore, while both genders (males and females) showed preferences for multimodal learning styles, it was found that female students showed a greater degree of diversity (10 of the 11 options) within multimodal preferences, whereas male students were more closely associated with a smaller subgroup or subunit (6 of the 11 options). First, second, and fourth-year optometry students at the University of the Free State in South Africa identified converging and assimilating as their two preferred learning styles, according to Kempen and Kruger's (2019) study on learning styles of optometry students using Kolb's LSI. The converger learning style was most preferred by third-year students, and then the accommodator learning style. There were no discernible correlations between learning styles, gender, age, ethnicity, or academic year according to the study. The results of the study on first-year students are in contrast to those of a different study carried out in 2005 at the Faculty of Health Sciences at Nelson Mandela Metropolitan University by Vawda. That study indicated that nursing students' preferred learning styles were diverger, accommodator, and assimilator, in that order.

Another study (Ghazivakili et al. 2014) that looked into the relationship between learning styles and critical thinking among Iranian undergraduate students found a statistically significant relationship between learning styles and age, gender, employment, and semester of study. Other demographic factors that education literature ties to learning styles are nationality and the high school that students attended before enrolling in higher education institutions. Budeva et al. (2015) used Kolb's LSI to compare the preferred learning styles of marketing students in the

United States and Bulgaria. There were notable distinctions found in the learning preferences of the kids from these two nations. The converger learning style was found to be the most preferred by Bulgarian marketing students, while the diverger learning style was recognized as the least preferred. Among the United State marketing students, assimilation was the most common learning technique, whereas accommodation was the least preferred.

Adenuga (1989) examined adult learners' readiness for self-directed learning and their preferred learning styles at Iowa University. The results showed that learning style preferences and nationality groups did not differ significantly, which is in contrast to the previously mentioned findings (Marriott, 2002; Budeva et al., 2015).

In order to ascertain the impact of brain-based learning on students with varying learning styles' academic achievement, Bilal et al. (2010) conducted an experiment. The assimilating learning style was found to be the most prevalent among students in both the control and experimental groups, while the accommodating learning style was found to be the least prevalent when the study's distribution learning style sample groups were analysed. This result is in line with the findings of earlier studies (Aşkar & Akkoyunlu, 1993; Duman, 2006; Güven, 2004; Hasırcı, 2006; Kılıç, 2002; Stice, 1991) that used Kolb learning styles.

Aşkar & Akkoyunlu, 1993; Kolb, Boyatzis & Mainemelis, 2001) found that learning styles differ depending on an individual's major (social sciences, natural sciences, etc.) and occupation. These findings are consistent with research done using the Kolb Learning Style Inventory. Learning styles can vary depending on the discipline, according to Kolb, Wolfe, Fry, Bushe, and Gish (1981). Additionally, according to Kolb, personal experiences gradually mould learning preferences. Aşkar and

Akkoyunlu, 1993; Ergür, 1998; Hasırcı, 2006) note that the majority of persons in the teaching profession have an integrating learning style. Assimilation is the primary learning style exhibited by the student instructors, according to the current study.

The following protocol was used in order to evaluate academic attainment. Comparisons were made between the experimental group and control group students' post-test results on their academic success. In comparison to traditional teaching methods, BBL led to a greater rise in students' academic achievement. This result is consistent with previous research (Bowman, 2003; Brodnax, 2004; Caine & Caine, 1994; Caine, 2000; Caulfield, Kidd & Kocher 2000; Cengelci, 2005; Erlauer, 2003; Getz, 2003; Jeffrey, 2004; Jensen & Dabney, 2000; Özden & Gültekin, 2008; Wagmeister & Shifrin, 2000; Wortock, 2002).

According to several studies (Godwin, 2000; Jensen, 2008; Kotulak, 1997; Sousa, 2006; Wolfe, 2002; Zadina, 2004; Zull, 2002), students' motivation, attitudes, and academic achievement can all improve when the lesson's design, delivery, and outcomes align with the principles of the brain. When the academic achievements of students with different learning styles were compared within the group, no discernible differences were discovered between the students with different learning styles in the same group. This suggests that variations in learning styles may not necessarily translate into considerable variations in academic performance.

Other research has found that learning styles-based instruction improves student achievement, but the degree of this gain is independent of learning style (Bielaczyc & Collins, 1999; Whicker, 2001; Williams, 1990, Gencel, 2008). Certain research indicates that there is no meaningful connection between academic success and learning styles. When Williams (1999) examined the usefulness of mind maps vs traditional note taking, she discovered no statistically significant correlation between the participants' performance and hemisphere dominance or learning styles. According to a study by Somyürek and Yalın (2007), there is no discernible difference in the academic outcomes of field-dependent and field-independent learners in computer-assisted learning.

The academic achievement levels of the students with diverging, converging, and assimilating learning styles were compared between the groups, and the results indicated that, aside from the accommodating learning style, there were significant differences favouring the experimental group. This research bolsters the notion that BBL improves student academic performance in the classroom when used appropriately. We can contend that for students with varying learning styles, the BBL model employed in this study offered an environment and procedure based on "the natural learning conditions of the brain." BBL, according to Carbo, Dunn, and Dunn (1986), is a novel strategy for teaching applications connected to learning styles. There are many studies demonstrating that matching teaching styles with learning styles has positive impacts on student achievement (Scales, 2000).

Numerous researches have demonstrated the connection between university students' learning styles and their academic achievement. In their investigation on the relationship between students' learning styles and academic achievement, Arıpın et al. (2008) discovered that learning style has a major role in predicting academic performance. Matthews (1996) discovered that high school pupils' learning habits have an impact on their academic performance. The study conducted by Pyryt et al. (1995) revealed a noteworthy distinction in the learning methods of talented and special needs kids.

McCarthy's (1987) research indicates that students who possess diverse and adaptable learning styles do not achieve sufficient success. Research conducted by McCarthy (1987), Currie (1995), Bilgin and Durmus (2003), Uzuntiryaki, Bilgin and Geban (2003), Kvan and Yunyan (2005), Demirbas and Demirkan (2007), and others demonstrated that learning styles have an impact on academic accomplishment. Kolb (1984) asserts that it is crucial to provide pupils with activities that fit their individual learning preferences. Students can engage in both intellectual and physical participation in the educational process in this way. Organising suitable training to enable more effective learning can improve student achievement (Sims & Sims, 1995).

During the BBL approach-aligned exercises, the researcher in this study noted that the pupils were in a state of "physiologic security" and "psychological relaxation." In fact, because the BBL model is based on "multiple models and preferences," it can be argued to promote "relaxed alertness" (Caine & Caine, 1994) and metacognition (Jensen, 2008). Diverse learners require diversified techniques to support a range of learning styles for reading and learning, according to recent BBL research (Green, 1999; Goswami, 2004; Pool, 1997; Slavkin, 2002; Sousa, 2006). The pupils were able to identify their learning styles and brain characteristics because of BBL. Pupils who are aware of their learning styles are able to fully engage with the material. They can process the learning according to their understanding and construct meaning.

Learning style awareness helps students feel more at ease both emotionally and cognitively. Students' motivation is increased and their self-concept is improved as a result of this awareness and relaxation (Bandura, 1997). Accordingly, Goleman (1995) highlights the role that a pleasant psychological state plays as an effective learning facilitator. Examining the results of this study, one may claim that while learning styles-based instruction and the BBL approach helped students succeed more academically, academic achievement within a group does not significantly differ based on learning styles.

Whether or not there is a meaningful relationship between learning styles and academic achievement is a contentious question, but employing brain-compatible and integrated teaching strategies that can make learning a fundamental need is undoubtedly a smart move if we want our students to succeed. Thus, the most significant implications of this research are that students with varying learning styles experienced similar good effects from BBL on their academic accomplishment. The use of BBL in the aforementioned study improved student performance in both integrated whole-class activities and customised teaching activities for various learning styles. The design of the learning-teaching environments and processes should be based on BBL in order to improve the academic achievement levels of students with varying learning styles at the same level.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0. Overview

The general technique utilised to carry out the study was covered in this chapter. The study's demographic, study area, sampling strategies, sample size, and research design were all highlighted. The chapter also covered the data collection tools, data collection process (pre-intervention activities, intervention activities, and post-intervention activities), validity and reliability of the instruments, and data analysis methods.

3.1. Research Design

A research design is the investigator's plan for conducting the study, according to Bogdan and Biklen (1992). The research design is the overarching structure or strategy that guides the collection, handling, and analysis of data for a project. Researchers use certain steps and procedures to try to answer their research questions or goals. The research design influences the conclusions of the study in terms of validity and reliability. The study used a quasi-experimental approach since its goal was to find out how senior high school students with various learning styles performed academically in integrated science when they were using brain-based learning approach. The natural environment in which I find myself frequently influences this type of design. This research was designed to estimate the causal influence of an intervention (brain-based learning) on a target population (students in COMSEC) without using random assignment, and this empirical interventional study is called a quasi-experiment. Also, because the treatment (brain-based learning) and control (lecture method) groups could not be comparable at baseline, there are internal validity issues with quasi-experiments. Nevertheless, random assignment ensures that each study participant has an equal chance of being assigned to either the comparison group or the intervention group. Hence, rather than being caused by a systematic component associated with therapy, disparities across groups on both observed and unobserved traits would be the consequence of chance. Because they optimise both internal and external validity, quasi-experiments are typically selected by experimenters (DeRue & Scott, 2012). The principal limitation of quasi-experimental designs is their inability to completely eradicate the potential for confounding bias, which might impede the capacity to make causal inferences. Quasi-experimental results are frequently dismissed on the grounds of this limitation. If the confounding variable(s) can be located and measured, however, such bias can be adjusted for using a variety of statistical methods, including multiple regression. By modelling and partially removing the impact of confounding variables, these strategies can increase the accuracy of the findings from quasi-experiments.

3.2. Research Approach

Quantitative research methodology was used in this study because, this study seeks to investigates the effect of an intervention by manipulating an independent variable (brain-based learning approach) to measure its effect on the dependent variable (academic achievement). Measurement of numerical data objectively is emphasised by quantitative research methodologies (Creswell, 2014). According to Cohen et al., (2018), the generalisation of mathematical facts across populations or the elucidation of specific phenomena are the main goals of quantitative research. I created the teaching and learning process using the three fundamentals of brain-based learning, since the goal of the study was to collect quantitative data to explain the effect of brain-based learning on the academic achievement of students with different learning styles in integrated science. These are orchestrated immersion, relaxed alertness, and active processing whiles the diagram designed according to Kolb's (1984) Experiential Learning Theory was used to determine the learning styles of the students in the experimental group. An academic achievement test and the Kolb's learning styles inventory (LSI) were used in this research.

3.3. Study Area

College of Music Senior High School and Mozano Senior High School, both situated in the Gomoa West Municipality in Ghana's Central Region, served as the research study schools. Both schools serve students from a variety of socioeconomic backgrounds and are public, second-cycle, mixed-sex educational establishments. In 1983, Mozano Senior High School was founded by Prophet Moses Jehu-Appiah, the late leader of the Mozama Disco Christo Church. The school provides a wide range of academic subjects, such as business, home economics, agriculture science, general science, and the visual arts.

The same Church also founded College of Music in 2012, and the Minister of Education, Prof. Jane Naana Opoku-Agyemang, later authorised the college to teach Ghana's Senior High School second cycle curriculum. The school provides General Arts, Business, and Home Economics as its three academic offerings. The selection of these two colleges was based on their existing academic programs. Furthermore, the student body at the institutions are diverse, which will improve the study's external validity. Additionally, the researcher will find it easy to gather data and carry out the study because the designated study locations are easily accessible and conveniently positioned.

3.4. Research Population

When samples are obtained for measurement, the group of people is referred to as the population (Creswell, 2014). To answer research questions and to whom the study's findings may be generalised, the target population for every given study is the entire membership of a group defined by the researcher's particular area of interest. The Gomoa West Municipality of Ghana's senior high school students at Mozano and College of Music served as the study's population. Students enrolled in both SHS 3 classes were the target demographic; however, SHS 3 General Arts students from the aforementioned schools were the accessible population.

3.5. Sample and Sampling Techniques

A sample is a portion of individuals, things, or occasions from a broader community that the researcher gathers and examines in order to draw conclusions (Creswell, 2014). Sampling procedure is the process by which the study's sample is chosen. To choose the two schools, purposive sampling procedure was used. Two complete form-three General Arts classes were selected for the study using the basic randomised sampling procedure. The sample of the study consisted of thirty-one (31) students in one class and thirty-seven (37) students in the other intact class at Mozano Senior High School. The students at College of Music Senior High School were divided into two groups. Twenty-eight (28) students were in one class (3 Arts 1) and thirty-four (34) students were also in the other class (3 Arts 3). Due to the experiences teaching such classes and the sufficient knowledge of the students' work, I and a fellow teacher from both schools were able to justify the sample technique selection.

Additionally, in order to minimise disruptions to regular class schedules, I and the colleague teacher in both schools readily selected General Arts classes using simple randomised sampling technique. Of which sixty-eight (68) students were chosen from MOSEC, twenty-seven (27) were males and forty-one (41) were females. Also, the sixty-two (62) students chosen from COMSEC, twenty-seven (27) were males and thirty-five (35) were females. The age range of the pupils was sixteen to twenty.

3.6. Research Instruments

The "Integrated Science Achievement Tests (ISAT)" and the "Kolb's Learning Style Inventory Personal Information Form (KLSIPIF)" questionnaire served as the study's instruments for gathering data. These research instruments were meant to directly impact the quality of data collected for the research and validity of the research outcomes. Therefore, to ascertain the distribution of learning styles among the students in the experimental group, I modified the KLSIPIF to help classify learners into accommodators, assimilators, convergers and divergers. Additionally, the ISAT (pre- and post-tests) for an academic achievement test were given to the experimental and control groups to assess student achievement based on both traditional and brain-based learning methods of instruction. The Integrated Science Achievement Tests (ISAT) and Kolb's Learning Style Inventory Personal Information Form (KLSIPIF) were chosen based on the type of data that needed to be gathered, the amount of time available, and the study's goals.

3.6.1. Achievement Tests

According to Gronlund and Linn (1990), a test is a tool or a methodical process used to measure a sample of behaviour. Data were gathered both before and after the study by the researcher using the Integrated Science Achievement Tests [ISAT]. These assessments were utilised to compare the performance of the 130 research subjects that made up the sample before and after the intervention in the two study schools.

Data on participants' achievement following the intervention was gathered one week later using a rearranged version of the ISAT. The concepts of the excretory system and soil and water conservation from the SHS Integrated Science syllabus were covered in the test items. The test items were also created using a specification table that took into account each of the six cognitive domains identified by Bloom (Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation). Twenty (20) multiple-choice items totalling twenty (20) marks and nine essay-style questions totalling thirty (30) marks made up the ISAT. For every item, four different possibilities were offered. Both the experimental group and the control group took an accomplishment test consisting of multiple-choice questions and an essay format to gauge their prior knowledge. In terms of quantity and complexity, the pre-ISAT and post-ISAT were comparable. But in the post-ISAT, questions were rearranged.

3.6.2. Questionnaire

A questionnaire is a set of written questions that are typically answered in order to gather information from the participants, according to Cohen et al (2018). Using the diagram created in accordance with Kolb's (1984) Experiential Learning Theory, data regarding the students' academic successes in relation to their learning styles and learning style distribution in the experimental areas were gathered. The Learning Style Inventory Personal Information Form (LSIPIF), developed by Kolb, was used to gather information from research participants on their different learning styles related to the teaching and learning of integrated science. Twenty (20) closed-ended, dichotomous scale (give respondents a binary choice to choose from) made respondents check the correct response or leave the box blank if they were unsure of their response comprised the questionnaire. In order to indicate that they disagree more than they agree with a statement, the respondents were asked to leave the box to the left of the question blank and also to tick in the box when they agree (□). The study's primary goal served as the foundation for the questionnaire. Additionally, the questionnaire asked about the respondents' age, gender, school, and class.

3.7 Validity of Research Instruments

Validity was defined by Nitko (2005) as the accuracy of the interpretations and applications of the findings of student assessments. The degree to which an instrument measures the validity that it is designed to measure is known as the instrument's validity. To ensure there was no bias or ambiguity, the researcher's supervisor and fellow educators evaluated and carefully examined the data collection instruments. In order to accommodate the goals of the study, the test items were also modified as needed. West African Examinations Council test components were standardised and deemed legitimate in terms of content, coverage, and syllabus. This led to the development of the Integrated Science Achievement Test (ISAT), which was meant to equipe students with the necessary skills to remember, identify, rationalise, and analyse information. The validity of the instruments was initially confirmed during the study's pilot conducted with Home Economics students from both institutions. Logical validity of the instruments was determined by the experts' rating following observation, revisions, and final thought. I adjusted the tools to better suit the study by taking into consideration the recommendations and guidance provided by assessors. The instruments were subjected to an item analysis so as to find out its item difficulty and item discrimination index.

3.8 Reliability of the Research Instruments

The degree to which a measuring device produces consistent results when used repeatedly is referred to as reliability (Durrheim, 1999). It refers to the level of measurement devices' dependability (Hackman, 2002). The test items' reliability coefficient [ISAT] was ascertained using the test-retest reliability approach. The Twenty-one (21) students from home economics classes at the same schools participated in a pilot test of the ISAT to ensure the instrument's reliability prior to the intervention. For two weeks, the students were taught an integrated science curriculum. The students took the ISAT again when the two weeks were up, and this time the scripts were recorded and marked. Following Tuckman's recommendation, the instrument was given again to the same set of students who underwent a two-week break for the pilot test. Pearson Product Moment Correlation (PPMC) was used to analyse the outcome.

A correlation coefficient of 0.89 was found for Pearson's Product Moment. According to Creswell (2014), a reliability coefficient of 0.8 or above in a study would indicate that the results were quite dependable. Reliability and validity test requirements have been demonstrated to be satisfactorily met by the LSI questionnaire (Kolb & Kolb, 2005; D'Amore, et al, 2012). Cronbach's Alpha statistical method was employed to assess the internal consistency of the KLSIPIF questionnaire. The KLSIPIF instrument's reliability coefficient was 0.77. According to Graham (2006), an alpha value of 0.70 or higher is deemed appropriate for drawing sufficiently accurate group conclusions. This shows that the measure has positive reliability and can accurately identify students' preferred learning modes. The validity of the LSI as a research instrument has been demonstrated by factor analysis and correlation analysis (Kolb & Kolb, 2005).

3.9 Data Collection Procedure

To acquire accurate and trustworthy data, a methodical approach to data collecting is used. A pre-intervention, an intervention, and a post-intervention phase were all included in the process because of this. I conducted the investigation using a six-week period. Pre-intervention took one week, intervention four weeks, and post-intervention one week. An introductory letter to conduct the study was presented to the Headmasters of the Mozano senior high school and the College of Music senior high school by the Department of Science Education, University of Education, Winneba, starting the data collection process.

Data was collected through the administration of Integrated Science Performance Tests (pre-test and post-test) and Learning Style Inventory (LSI) Questionnaire to the respondents.

3.9.1 Pre-Intervention phase

In order to conduct the study, I requested permission from the headmasters and heads of the science and general arts departments of the two schools during the first week of the study. A letter of consent outlining the goals and intentions of my research came next. The pre-test was given to students in both schools by myself and a colleague teacher after obtaining consent. Students' preparedness and entering behaviours were pre-assessed using the pre-test. The gathered data was utilised to assess the pupils past knowledge. There were forty (40) minutes in the pre-test. I assessed, marked, and kept track of the pre-test.

3.9.2 Intervention phase

Four weeks were allotted for the four-week intervention phase, which began one week immediately following the pre-intervention phase. Using brain-based learning's effect on senior high school students' academic performance in integrated science who have varying learning styles was the chosen intervention. Water and soil conservation as well as the excretory system were the chosen topics. The two-weeks course, which included two classes per week, covered the excretory system as its first topic. Subsequently, an additional two weeks of instruction (two courses per week) focused on soil and water conservation. All of the chosen themes were covered in a total of eight distinct lessons.

During the four weeks of active teaching and learning, the three fundamentals of brain- based learning approach (Relaxed alertness, Orchestrated immersion, Active processing and) were followed to meet the needs of the students in the experimental group whiles the traditional learning approach (lecture method) was also used for the control group. With regards to the relaxed alertness phase, the lessons began with music, low threats, interest motivation and students were encouraged to drink water throughout the several brief breaks. Opportunities for cooperation and group activity were offered to improve emotional awareness and relaxation. In order to brainstorm and have open discussions, students were also permitted to move about the classroom. To improve the amount of subject knowledge acquired, Orchestrated Immersion was on individual experiences, enhanced environments, collaboration, and meaningful information. Pictures, graphics, and multimedia related to the topics being treated were shown in the classroom during the teaching and learning process for the enhanced surroundings. Active processing phase involves critical thinking and questioning, as well as internalising and rearranging the knowledge to improve meaning internalisation. The fundamental prerequisite for demanding that a pupil think is asking questions. Therefore, students were allowed to always ask questions in class to foster internalisation of meaning.

Formative assessments were used in each learning unit to give the students feedback. By modifying the learning objectives and expectations to account for pertinent student differences, I established minimal goals for every student and articulated distinct expectations for students with varying abilities. The investigator facilitated adaptable grouping arrangements and guaranteed that educational resources were tailored to the proficiency and growth of every student. In order to give the above-average students more depth and challenge during instruction, the researcher gave the below-average students more structure and extra instructional support while allowing all students to work at their own pace. This way, the learning content was processed to account for relevant student differences. Based on the students' progress during the session as shown by ongoing assessments, I also gave them extra help or challenges. Finally, I assessed the students' learning outcome using the following lesson plans for the experimental group. The details of each lesson are presented as follows:

LESSON ONE

Week ending: 09/ 02/2024	**Duration:** 60 minutes	**Subject:** Integrated Science
Day: Tuesday	**Class:** SHS 3	**Topic:** Soil and water conservation
Time: (7:00 – 8:00am)	**Class size:** 34	**Sub-topic:** Moisture conservation
Reference: Ministry of Education (2010). *Teaching Syllabus for Integrated Science (Senior High School).* Accra. Kusi-Aidoo, P. A. (2019). *Integrated Science Revision Guide for Senior High Schools, Supporting Free SHS*. Kumasi: Elite Publishing Company. Oddoye, E. O., Taale, K. D., Ngman-Wara, E., Samlafo, V., & Ofori, D. O. (2011). *Integrated Science for Senior High Schools, Student's Book.* Accra: Sam-Woode Ltd.		

Objective/RPK	**Teacher-Learner Activities**	**Teacher - Learner Resources**	**Core points**	**Evaluation & Remarks**
Objectives By the ned of the lesson, the students will be able to: (1). Define soil conservation (2). Explain at least four (4) principles of soil and water	**Introduction** The teacher initiates the lesson by taking students to the school farm for observation. On return, Teacher plays music for students to dance for two minutes. He then engages students in a small group discussion to share their views on their observations and existing knowledge about soil and its importance to human. **Activities** 1. Teacher brainstorms with students to come with the meaning of soil conservation. 2. With the help of the teacher and observations made at the school farm, students were provided with a rich array of learning resources to assist in explaining the principles of soil and water conservation. 3. Students were grouped to undertake the following activities at the school farm to conserve soil and water. Examples; mulching and irrigation. 4. Teacher introduces creative avenues (visits to the farm) for	Whiteboard, Maker, textbook, soil, cutlass, rake, weeds, water, watering can.  	Soil conservation refers to the protection of soil against erosion or deterioration or loss of nutrients. The principles of soil and soil moisture conservation involves maintaining soil fertility and conserving soil moisture. These are: Afforestation, crop rotation, application of manure, step farming, cover cropping, application of fertiliser, practising bush fallowing.	**Evaluation** (1). Define the following terms as used in soil conservation; (i) soil (ii) soil conservation (2). State three (3) principles of soil and water conservation.

conservation. **RPK** Students' have been taken through the definition of soil and its components.	students to express their understanding of soil conservation and its principles. 5. Teacher observes students' progress informally by assessing their grasp of soil conservation. 6. Conducts a whole class discussion where students answer questions and receive feedbacks to strengthen their confidence in answering questions. 7. Teaching and learning occurred in chunks, brain breaks, forming acronyms, reflection time and anticipation. **Closure** Teacher ends the lesson by summarising the pivotal aspects of soil and assigns students' exercise.		**Application** Students can apply their understanding of soil conservation to various situations, such as effects of bush burning and overgrazing.	**Remark** Lesson was taught successfully.

LESSON TWO

Week ending: 09/02/2024	**Duration:** 60 minutes	**Subject:** Integrated Science
Day: Thursday	**Class:** SHS 3	**Topic:** Soil and water conservation
Time: (11:30 – 12:30 pm)	**Class size:** 34	**Sub-topic:** Essential soil nutrients and soil fertility.
Reference: Ministry of Education (2010). *Teaching Syllabus for Integrated Science (Senior High School).* Accra. Kusi-Aidoo, P. A. (2019). *Integrated Science Revision Guide for Senior High Schools, Supporting Free SHS*. Kumasi: Elite Publishing Company. Kwarteng, C., Antwi, I. B., & Gyamfi, A.-J. (2013). *Integrated Science Workbook 2*. Kumasi: Unijay Publications.		

Objective/RPK	Teacher-Learner Activities	Teacher -Learner Resources	Core points	Evaluation & Remarks
Objectives By the ned of the lesson, the students will be able to; (1). Define essential soil nutrients. (2). Distinguish	**Introduction** Teacher starts the lesson by reviewing the concept of soil conservation and the principles of soil conservation. Teacher clearly outlines the primary lesson objectives: to understand the meaning of soil nutrients and difference between macro and micro nutrients. Teacher then allows students to drink water so as to hydrate their bodies for the lesson to commence. **Activities** 1. Teaching and learning occurred in chunks, brain breaks, forming acronyms, reflection time and anticipation. 2. Teacher allows students to turn and talk to each other by discussing the meaning of soil nutrients based on previous lesson taught. 3. Divide the class into small groups and assign them to set of	Whiteboard, maker, textbook, pictures of soil nutrients, poultry waste, cow dunk.  	1. Essential plant nutrients are chemical elements and substances which are very important for plant growth and development. 2. macro nutrients are nutrients required by plants in large amount. Examples: potassium, calcium, magnesium, sulphur, nitrogen, phosphorus.	**Evaluation** (1). Define the following terms as used in soil conservation; (i) soil nutrients. (ii) soil fertility. (2). Classify the following into macro

between macro and micro nutrients and give at least three (3) examples each. (3). State at least three (3) ways of improving soil fertility. **RPK** Students already know the importance of soil conservation and nutrients they obtain from foods they eat.	cards with the following information: potassium, calcium, boron, nitrogen, copper, magnesium and instruct the students to categorise them into macro and micro nutrients. 4. Each group shared their work with the class fostering discussion about the quantities of nutrients required by plants. 5. Teacher gives the learners enough room to be alone so as to feel less stressed, followed by a collective discussion of answers to ensure understanding. 6. Task students to write the meaning of fertile soil and ways of improving soil fertility. 7. Review their write-up to assess their understanding of the concepts. **Closure** Teacher ends the lesson by summarising the key points of the lesson and encouraging students to seek clarification on the topic.		Micro nutrients are required by plants in small quantities and hence in trace amounts. Examples: manganese, copper, zinc, iron, cobalt, boron, chlorine. Ways of improving soil fertility Cover cropping, crop rotation, irrigation, terracing, mixed cropping, bush fallowing. **Application** Students can apply their understanding of soil nutrients to the various nutrients they get from foods they eat after digestion has occurred.	and micro nutrients; copper, magnesium, potassium, boron, nitrogen, iron, zinc, phosphorus. (3). State three ways of improving soil fertility. **Remark** Lesson was taught successfully.

LESSON THREE

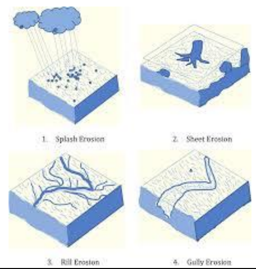
Week ending: 16/02/2024	**Duration:** 60 minutes	**Subject:** Integrated Science
Day: Tuesday	**Class:** SHS 3	**Topic:** Soil and water conservation
Time: (7:00- 8:00am)	**Class size:** 34	**Sub-topic:** Fertiliser
Reference: Ministry of Education (2010). *Teaching Syllabus for Integrated Science (Senior High School).* Accra. Oddoye, E. O., Taale, K. D., Ngman-Wara, E., Samlafo, V., & Ofori, D. O. (2011). *Integrated Science for Senior High Schools, Student's Book.* Accra: Sam-Woode Ltd.		

Objective/RPK	**Teacher-Learner Activities**	**Teacher -Learner Resources**	**Core points**	**Evaluation & Remarks**
Objective By the ned of the lesson, the students will be able to; (1). Define fertilisers (2). Enumerate the types of fertilisers.	**Introduction** Teacher introduces the lesson by using the questioning and answering technique to elicit response from students on soil nutrients. Students were made to clap hands for a short music interlude to activate their brains. Students were then made aware that they will be learning about fertilisers and its implications on crops. **Activities** 1. Teacher takes students to the school farm with a brief overview on soil nutrients, He then ask students what will happen to the soil when nutrient is depleted? 2. In small groups, students discuss and respond accordingly. 3. Teaching and learning occurred in chunks, brain breaks, forming acronyms, reflection time and anticipation. 4. Teacher divides the class into group of three to four students	Whiteboard, maker, textbook, cutlass, rake, hand fork, shovel, knapsack sprayer, manure, pictures of inorganic fertiliser.	1. A fertiliser is any substance (liquid or solid) which can be applied to the soil or plant to supply needed nutrients elements for plants growth and development. Types of fertilizers Organic and inorganic fertilisers Methods of fertiliser application	**Evaluation** (1). Define fertilizer. (2). Differentiate organic and inorganic fertilisers. (3). State three (3) ways of applying

(3). State at least five (5) methods of fertiliser application. **RPK** Students have been taken through soil nutrients.	and assigns each group a method of fertiliser application to be used in their project (compost preparation) at the school farm. 5. He encourages students to ask questions and express their thoughts. 6. Teacher goes round to inspect each groups project and award marks for the work. 7. Teacher gives intermittent breaks for students to drink water, rest their brains from an assignment and also two (2) minutes for students to talk to each other during the lesson. **Closure** Teacher concludes the lesson by summering the salient points of the lesson emphasising the key concepts of fertiliser and its applications.	  	Broadcasting Ring methods Drilling method Side dressing Spraying method **Application** Students can apply their understanding of fertilisers to assist farmers in producing a high crop yield during farming.	fertiliser to plants/ crop. **Remark** Lesson was taught successfully.

LESSON FOUR

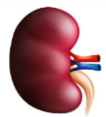
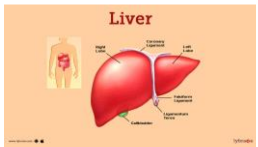
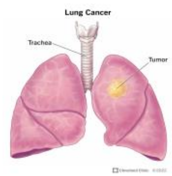
Week ending: 16/02/2024	**Duration:** 60 minutes	**Subject:** Integrated Science
Day: Thursday	**Class:** SHS 3	**Topic:** Soil and water conservation
Time: (11:30 – 12:30pm)	**Class size:** 34	**Sub-topic:** Soil erosion
Reference: Ministry of Education (2010). *Teaching Syllabus for Integrated Science (Senior High School).* Accra. Kusi-Aidoo, P. A. (2019). *Integrated Science Revision Guide for Senior High Schools, Supporting Free SHS*. Kumasi: Elite Publishing Company. Oddoye, E. O., Taale, K. D., Ngman-Wara, E., Samlafo, V., & Ofori, D. O. (2011). *Integrated Science for Senior High Schools, Student's Book.* Accra: Sam-Woode Ltd.		

Objective/RPK	Teacher-Learner Activities	Teacher -Learner Resources	Core points	Evaluation & Remarks
Objectives By the ned of the lesson, the students will be able to; (1). Define soil erosion (2). Enumerate the types of water erosion.	**Introduction** Teacher begins the lesson by asking students what they know about soil erosion. Teacher brainstorm with students to bring forth the definition of soil erosion. Students were then made aware that they will be learning about soil erosion and the various types of water erosion. **Activities** 1. Teacher engages students in a field trip to a site where erosion has taken place. 2. Teaching and learning occurred in chunks, brain breaks, forming acronyms, reflection time and anticipation. 3. The students observe the site and take note of the nature of the land. 4. Base on the pictures that contain the types of erosion and	Whiteboard, maker, textbook, cutlass, pictures of types of water erosion.   	1. Soil erosion is the gradual wearing or washing away of the topsoil and rocks by natural agents such as rain, running water and wind. Types of water erosion Splash erosion Rill erosion Sheet erosion Gully erosion Ways of preventing soil erosion	**Evaluation** (1). Define soil. (2). State three (3) methods of preventing soil erosion. (3). Name the types of water erosion.

(3). State at least four (4) ways we can prevent or check soil erosion. **RPK** Students have been taken through soil erosion in Junior High School.	the observations at the site, the teacher divides the students into small groups and each is tasked to identify the type of erosion they can see at the site. 5. Teacher tasks students to write a report describing the types of erosion and the way to check or prevent soil erosion. 6. Students are assess based on their reports, class presentation and the ability to answer questions. 7. Teacher encourages students to develop their own acronyms to enhance easy absorption of points 8. Teacher encourages students to stay hydrated by providing them with water to drink intermittently as lessons are on-going. **Closure** Teacher summarizes the lesson and provides additional support to those who need it. Teacher encourages advanced students to explore further.		Terracing Strip cropping Afforestation Cover cropping Contour cropping Mulching Avoid overgrazing **Application** Students apply their knowledge in soil erosion by creating channels in crop fields and proper drainage systems in human settlements.	**Remark** Lesson was taught successfully.

LESSON FIVE

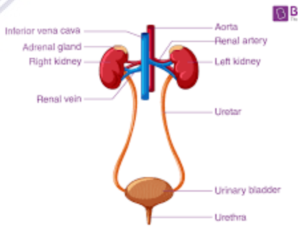
Week ending: 23/02/2024	**Duration:** 60 minutes	**Subject:** Integrated Science
Day: Tuesday	**Class:** SHS 3	**Topic:** Excretory System
Time: (7:00- 8:00am)	**Class size:** 34	**Sub-topic:** The excretory organs in mammals.
Reference: Ministry of Education (2010). *Teaching Syllabus for Integrated Science (Senior High School).* Accra. Kusi-Aidoo, P. A. (2019). *Integrated Science Revision Guide for Senior High Schools, Supporting Free SHS*. Kumasi: Elite Publishing Company. Kwarteng, C., Antwi, I. B., & Gyamfi, A.-J. (2013). *Integrated Science Workbook 2*. Kumasi: Unijay Publications.		

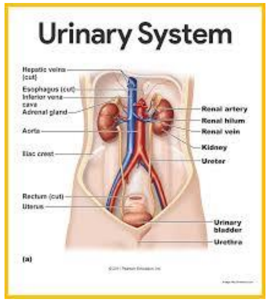
Objective/RPK	Teacher-Learner Activities	Teacher -Learner Resources	Core points	Evaluation & Remarks
Objectives By the ned of the lesson, the students will be able to; (1). Define excretion (2). Mention at least four (4) excretory organs and their associated excretory products.	**Introduction** Teacher plays music for students to dance for three minutes. Teacher then begins the lesson by asking students what happen to their body after a regular exercise. Base on students' response, Teacher assists students to define excretion. **Activities** 1. Teacher observes students' progress informally by assessing their grasp of excretion. 2. Conducts a whole class discussion where students answer questions and receive feedbacks to strengthen their confidence in answering questions. 3. Teaching and learning occurred in chunks, brain breaks, forming acronyms, reflection time and anticipation. 4. The students observe the pictures of the excretory organs and takes note of importance features. 5. Base on the pictures that contain the various excretory organs, the teacher divides the students into small groups and each is tasked to identify the excretory product of the organs they observed in the pictures.	Whiteboard, maker, textbook, pictures of various excretory organs.   	Excretion is the process by which metabolic products are removed from the body or cell of living organisms. Excretory organs and their associated excretory products. 1. Lungs- carbon dioxide 2. Liver- bile pigments 3. Skin- sweat 4. kidney- urine **Application**	**Evaluation** (1). Define excretion. (2). State four (4) excretory organs and their associated excretory products. **Remark**

RPK Students have been exercising and urinating.	6. Students are assess based on their class presentation and the ability to answer questions. 7. Teacher goes round to inspect each groups participation and award marks for the work. 8. Teacher gives intermittent breaks for students to drink water, rest their brains from an assignment and also two (2) minutes for students to talk to each other during the lesson. **Closure** Teacher ends the lesson by summarising the pivotal aspects of excretion and assigns students' exercise.		Students can apply their knowledge of the excretory system by understanding how each organs functions and how they work together to facilitate the removal of waste from the body.	Lesson was taught successfully.

LESSON SIX

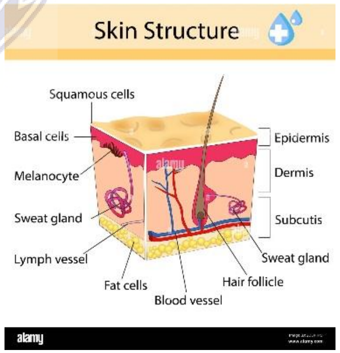
Week ending: 23/02/2024	**Duration:** 60 minutes	**Subject:** Integrated Science
Day: Thursday	**Class:** SHS 3	**Topic:** Excretory System
Time: (11:30- 12:30pm)	**Class size:** 34	**Sub-topic:** Urinary system disorders and their remedies.
Reference: Ministry of Education (2010). *Teaching Syllabus for Integrated Science (Senior High School).* Accra. Kusi-Aidoo, P. A. (2019). *Integrated Science Revision Guide for Senior High Schools, Supporting Free SHS*. Kumasi: Elite Publishing Company.		

Objective/RPK	Teacher-Learner Activities	Teacher -Learner Resources	Core points	Evaluation & Remarks
Objectives By the ned of the lesson, the students will be able to; (1). Differentiate between excretion and egestion. (2). Mention at least five (5) disorders of the urinary system in human and their remedies.	**Introduction** Teacher starts the lesson by reviewing the various excretory organs and the product they excrete. Teacher clearly outlines the primary lesson objectives: to understand the differences between excretion and egestion and also to know some disorders of the excretory organs and their remedies. Teacher then allows students to drink water so as to hydrate their bodies for the lesson to commence. **Activities** 1. Teacher observes students' progress informally by assessing their grasp of excretion. 2. Conducts a whole class discussion where students answer questions and receive feedbacks to strengthen their confidence in answering questions. 3. The students observe the pictures of the excretory organs and takes note of importance features. 4. Teaching and learning occurred in chunks, brain breaks, forming acronyms, reflection time and anticipation. 5. Teacher encourages students to develop their own	Whiteboard, maker, textbook, pictures of various excretory organs, human excretory system.  	Excretion is the process by which metabolic products are removed from the body or cell of living organisms whiles egestion is the removal of undigested food through the anus. Some disorders associated with the urinary system are; 1. Kidney stone 2. Urine retention 3. Bed wetting 4. Nephritis 5. Kidney failure	**Evaluation** (1). Differentiate between excretion and egestion. (2). State three (3) urinary system disorder and their remedies.

RPK Students have been taken through the various excretory organs and their functions.	acronyms to enhance easy absorption of points 6. Base on the pictures that contain the various excretory organs, the teacher divides the students into small groups and each is tasked to identify disorders associated with the urinary system. 7. Students are assess based on their class presentation and the ability to answer questions. 8. Teacher goes round to inspect each groups participation and award marks for the work. 9. Teacher gives intermittent breaks for students to drink water, rest their brains from an assignment and also two (2) minutes for students to talk to each other during the lesson. **Closure** Teacher concludes the lesson by summering the salient points of the lesson emphasising the key concepts of the differences between excretion and egestion and its applications.		 **Application** Students can apply their knowledge of the excretory system by drinking more water and fluids like fruit juice to prevent over concentration of urine.	**Remark** Lesson was taught successfully.

LESSON SEVEN

Week ending: 01/ 03 /2024	**Duration:** 60 minutes	**Subject:** Integrated Science
Day: Tuesday	**Class:** SHS 3	**Topic:** Excretory System
Time: (7:00- 8:00am)	**Class size:** 34	**Sub-topic:** The structure of the mammalian skin
Reference: Ministry of Education (2010). *Teaching Syllabus for Integrated Science (Senior High School).* Accra. Kusi-Aidoo, P. A. (2019). *Integrated Science Revision Guide for Senior High Schools, Supporting Free SHS*. Kumasi: Elite Publishing Company. Kwarteng, C., Antwi, I. B., & Gyamfi, A.-J. (2013). *Integrated Science Workbook 2*. Kumasi: Unijay Publications.		

Objective/RPK	Teacher-Learner Activities	Teacher -Learner Resources	Core points	Evaluation & Remarks
Objectives By the ned of the lesson, the students will be able to; (1). Differentiate between the layers of the mammalian skin (2). State at least four (4) functions of the mammalian skin of human.	**Introduction** Teacher introduces the lesson by using the questioning and answering technique to elicit response from students on the mammalian skin. Students were made to clap hands for a short music interlude to activate their brains. Students were then made aware that they will be learning about the mammalian skin and its importance. **Activities** 1. Teacher allows students to turn and talk to each other by discussing what they can observe on their own skin after a short exercise. 2. Divide the class into small groups and assign students to discuss about the diagram of the skin in their textbooks. 3. Each group shared their work with the class fostering discussion about the parts of the skin and their functions. 4. Teacher gives the learners enough room to be alone so as to feel less stressed, followed by a collective discussion of answers to ensure understanding. 5. Task students to draw the mammalian skin and label the	Whiteboard, maker, textbook, diagram of the human skin, 	(a). The mammalian skin is made up of epidermis and dermis. (b). functions of the skin; Protection function, sensory function, excretory function and homoeostatic function.	**Evaluation** (1). Name the layers of the dermis that you know. (2). State three (3) functions of the mammalian skin of human.

RPK Students have been taken through the various excretory organs and their functions.	parts 6. He encourages students to ask questions and express their thoughts. 7. Teaching and learning occurred in chunks, brain breaks, forming acronyms, reflection time and anticipation. 8. Teacher gives intermittent breaks for students to drink water, rest their brains from an assignment and also two (2) minutes for students to talk to each other during the lesson. **Closure** Teacher concludes the lesson by summering the salient points of the lesson emphasising the key concepts of the differences between excretion and egestion and its applications.		**Application** Students can apply their knowledge of the mammalian skin by protecting it against harmful chemicals.	**Remark** Lesson was taught successfully.

LESSON EIGHT

Week ending: 01/03/2024	**Duration:** 60 minutes	**Subject:** Integrated Science
Day: Thursday	**Class:** SHS 3	**Topic:** Excretory System
Time: (11:30-12:30pm)	**Class size:** 34	**Sub-topic:** Excretion in plants
Reference: Ministry of Education (2010). *Teaching Syllabus for Integrated Science (Senior High School).* Accra. Kusi-Aidoo, P. A. (2019). *Integrated Science Revision Guide for Senior High Schools, Supporting Free SHS*. Kumasi: Elite Publishing Company.		

Objective/RPK	Teacher-Learner Activities	Teacher -Learner Resources	Core points	Evaluation & Remarks
Objectives By the ned of the lesson, the students will be able to; (1). Enumerate the main excretory products in plants. (2). State at least three (3) importance of excretion in plants.	**Introduction** Teacher begins the lesson by asking students what they know about excretion in mammals and photosynthesis. Teacher encourages students to share their understanding of the concept and its significance and guides the discussion to establish the main excretory products of plants. **Activities** 1. Teacher brainstorms with students to bring out the main excretory products in plants. 2. Through discussion, the teacher guides students to identify the importance of excretion in plants. 3. The teacher thoughtfully divides the students into three groups based on readiness levels. 4. High readiness group is provided with advanced texts and tasked with researching and presenting pictures of other plant waste products. 5. Teaching and learning occurred in chunks, brain breaks, forming acronyms, reflection time and anticipation.	Whiteboard, maker, textbook, pictures of other excretory products which contain Tannins, resins, lignin, latex, alkaloids. 	(a). The main plant excretory products are water, oxygen and carbon dioxide. (b). importance of excretion in plants. **Application** Students can apply	**Evaluation** (1). Name the three (3) main products plants excrete. (2). State three (3) importance of excretion in plants **Remark**

RPK Students have been taken through excretion in mammals.	6. Medium readiness group receives handouts containing key terms and questions and are encouraged to collaborate in pairs to discuss and clarify concepts 7. Low readiness group receives simplified texts and are by the teacher guided through a fill-in-the-blank activity to scaffold their learning experience. 8. The class reconvenes for a knowledge-sharing session where each group presents their findings and discoveries. 9. Students are assessed based on their completion of their group activity. **Closure** Teacher concludes the lesson by summering the salient points of the lesson emphasising the key concepts of excretion in plants.		their knowledge of the excretion in plants in photosynthesis and respiration.	Lesson was taught successfully.

3.9.3 Post-Intervention Phase

I gave the students a forty-minute (40)-minute post-test with the same standard as the pre-test one week following the intervention phase. In order to assess the effectiveness of the intervention techniques, a comparison of the students' pre- and post-intervention performance was made. I assessed, marked, and kept track of the post-test. Following the post-test, I additionally gave the students Kolb's Learning Style Inventory Personal Information Form (KLSIPIF). The Kolb's Learning Style Inventory Personal Information Form (KLSIPIF) Questionnaire was employed in the teaching and learning of Integrated Science to ascertain the learning styles of the students. Data gathered were subjected to descriptive and inferential statistics using the Statistical Package for the Social Sciences (SPSS) programme version 20.

3.10 Data Analysis Technique

According to Creswell (2014), organising what we have heard, read, and seen helps us make meaning of the knowledge we have learned. This is known as data analysis. Data analysis is described by Cohen et al., (2018) as a methodical procedure that includes handling data, organising it, and dividing it into digestible chunks. The relevant descriptive and inferential statistics from the Statistical Package for the Social Sciences (SPSS) Program version 20 were used to analyse the data that were gathered. The frequency distribution tables were used to show the demographic distribution of students' age in the two schools and the learning style distribution of students in the experimental group. To verify whether there was a significant change between the control group and the experimental group, students pre- and post-intervention test scores were used, t-test was utilised. Moreover, analysis of covariance (AN-COVA) was used to verify the significance difference between the learning styles and preferences in the experimental group (COMSEC) in relation to academic achievements. T-test was also used to check the extent of performance between male and female students exposed to brain- based learning. When required, data analysis involves the use of metrics of central tendency. In order to exhibit the data, frequency tables were used to arrange them into percentages and frequencies.

3.11 Ethical Considerations

According to Burgess (1989), ethical concerns are ideals and principles that delineate what is good and wrong in research projects. Gray (2019) emphasises that when performing research in education, researchers must adhere to ethical principles. The investigator adhered to ethical guidelines while carrying out the investigation. Throughout the study, the researcher remained as objective as possible when discussing and analysing the data. The study included acknowledgments for the works of other writers in all published articles in highly-peer reviewed publications that used the APA referencing style. The authorities of the schools where the research was conducted were consulted prior to the study's start.

A description of the study's objectives and the rights of participants was also provided to potential students. The confidentiality, identity, and dignity of the study participants must all be protected, according to the researcher, who recognised how crucial this is. The investigators additionally made certain that the information obtained from the participants was provided with the utmost discretion. There was no physical or psychological abuse or harm done to the respondents while the research was being conducted.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

This chapter presents the results, analysis, and discussion of the data collected to investigate the effect of Brain-Based Learning (BBL) on the academic achievement of senior high school students with different learning styles in Integrated Science. The data is systematically analysed and discussed in relation to the research objectives outlined in Chapter One.

4.1 Preliminary Analysis of Data

4.1.1 Demographic statistics

The demographic statistics provide an overview of the participants' characteristics, including age, gender, school, and learning styles. This section aims to contextualise the sample population and ensure a comprehensive understanding of the study's participants.

Table 4.1.1: Respondent School, AGE (16-20) and Gender of Students Crosstabulation

GENDER OF STUDENT			AGE (16-20)					Total
			16	**17**	**18**	**19**	**20**	
MALE	Respondent School	COMSEC	3	10	6	7	1	27
		MOSEC	1	3	11	11	1	27
	Total		4	11	17	18	2	54
FEMALE	Respondent School	COMSEC	0	6	13	11	5	35
		MOSEC	11	13	15	1	1	41
	Total		11	19	30	12	6	76
Total	Respondent School	COMSEC	3	14	21	18	6	62
		MOSEC	12	16	26	12	2	68
	Total		15	30	47	30	8	130

Source: Field Data 2024

The cross tabulation in Table 4.1.1 shows a comprehensive breakdown of the respondents based on their school, age, and gender.

The gender distribution indicates a higher number of female respondents (78) compared to male respondents (52). This distribution is critical in examining any gender-specific trends or effects of the Brain-Based Learning approach on their respective academic achievements based on the learning styles of students.

The age distribution spans from 16 to 20 years, with the majority of students falling within the 17 and 18-year age groups. Specifically, 30 students are aged 17, and 47 students are aged 18. This age range is typical for senior high school students, ensuring that the sample is representative of the target population.

The distribution across the two schools, College of Music Senior High School (COMSEC) and Mozano Senior High School (MOSEC), is fairly balanced, with 62 students from COMSEC and 68 from MOSEC. This balance is essential for comparing the effectiveness of the Brain-Based Learning approach between different educational environments.

Male Students: At COMSEC, there are 27 male students, with the highest concentration at ages 17 and 19, At MOSEC, there are 27 male students, with the highest concentration at ages 18 and 19.

Female Students: At COMSEC, there are 35 female students, with 15 of them being at age 18. At MOSEC, there are 41 female students, with the highest concentration at ages 16, 17, and 18. The data reveals that while there are more female students overall, the distribution within each age group varies, with certain ages showing higher enrolment in specific schools. This variation allows for a nuanced analysis of how age and gender might influence the effectiveness of Brain-Based Learning across different educational settings. Overall, the demographic statistics provide a solid foundation for analysing the effect of the Brain-Based Learning approach on the academic achievement of students with diverse learning styles. The interpretation of the results and drawing of meaningful conclusions were assessed on the compositions of the samples used in the study.

4.2. Research Question One

What is the learning style distribution of the students in College of Music Senior High School?

The learning style distribution was assessed using a standardised Kolbs' (1984), learning style inventory. The results are summarised in Table 4.2.

Table 4.2: Learning Style Distribution of Student in the experimental Group

Learning Style		**Respondent School COMSEC Gender of Student Male Count**	**Female Count**
ACCOMODATOR learning style	very low preference	6	4
	Low preference	12	10
	moderate preference	5	8
	Strong preference	4	9
	very strong preference	0	4
ASSIMILATOR learning style	very low preference	4	0
	Low preference	4	7
	moderate preference	10	10
	Strong preference	2	11
	very strong preference	7	7
CONVERGER learning style	very low preference	3	5
	Low preference	12	15
	moderate preference	8	8
	Strong preference	4	4
	very strong preference	0	3
DIVERGER learning style	very low preference	5	1
	Low preference	8	9
	moderate preference	8	14
	Strong preference	6	4
	very strong preference	0	7

Source: Field Data 2024

The analysis of the learning style distribution, as shown in Table 4.2, reveals a varied preference among students for different learning styles, including Accommodator, Assimilator, Converger, and Diverger. This diversity is in line with Kolb's (1984) Experiential Learning Theory, which emphasises that individuals have distinct learning preferences that significantly influence their educational experiences. Understanding these preferences is crucial for tailoring instructional strategies to meet diverse learning needs effectively.

The Accommodator learning style shows a varied distribution among students. Males predominantly showed a low preference (12 students) than females in this category.

Moderate preference is notable among females (8 students) than males. Strong preference is more common among females (9 students). Very strong preference is the least common, with only 4 female students for this preference. The Assimilator learning style is relatively balanced across genders. Very low preference is more common among males (4 students). Low preference is slightly higher among females (7 students) than male (4 students). Moderate preference is equally distributed between males and females. Strong preference is significantly higher among females (11 students) than in males (2 students). Very strong preference is also notable, with equal representation among both genders. The Converger learning style exhibits a high number of students with very low preference, particularly among females (5 students) than males (3 students). Low preference is predominant among females (15 students) than males (12 students). Moderate and strong preferences are balanced, with similar counts among genders in the school. Very strong preference is rare, found only among female students in the school. The Diverger learning style shows a relatively balanced distribution across low preference, with males and females in both schools showing similar counts. Males (5 students) showed very low preference for this learning style than females (1 student). Moderate preference is significantly higher among females (14 students) than males (8 students). Strong preference showed a slight dominance of females in this category than males. Very strong preference is more common among female students.

The distribution of learning styles among students reveals significant insights into their preferences and diversity. **Accommodator:** A prevalent learning style, especially with low and moderate preferences. The gender distribution shows that females have a stronger preference for this style. **Assimilator:** Shows a balanced preference across both genders, with a noticeable inclination towards stronger preferences among females. **Converger:** Characterised by a higher number of low preferences, especially among females. This indicates a tendency towards practical work, hands-on learning. **Diverger:** Displays a balanced distribution but with a higher preference among females, indicating a reflective and observational approach to learning. These findings underscore the importance of recognising and addressing the varied learning preferences in educational settings.

4.3 Research Question Two

To what extent does the Brain-Based Learning approach affect the academic achievement of students?

Table 4.3.1: t-test Analyses of the Pre-test Scores for both Experimental and Control Groups of Students

Group	N	Mean	SD	df	t- value	p-value
Experimental	62	30.77	8.724	128	2.346	.210
Control	68	27.85	5.175			

The comparison between the control and experimental groups in table 4.3.1. shows the pre-test mean score difference of 2.92 points, the t-value of 2.346 with 128 degree of freedom (df) and the significance (2-tailed) value of 0.210 which is greater than 0.05. This indicate that there is no significant difference in the performance of students before the intervention or the application of brain-based learning approach on the students in College of Music Senior High School. Therefore, we fail to reject the null hypothesis.

Table 4.3.2: t-test Analyses of the Post-test Scores for Both Experimental and Control Groups of Students

Group	N	Mean	SD	df	t- value	p-value
Experimental	62	73.52	12.475	128	10.027	.000
Control	68	51.88	12.113			

From Table 4.3.2, the experimental group, consisting of 62 students from COMSEC who were exposed to Brain-Based Learning approach, achieved a mean score of 73.52 with a standard deviation of 12.475 from their post-test scores whiles the control group, consisting of 68 students from MOSEC who received the traditional instruction, achieved a higher mean score of 51.88 with a standard deviation of 12.113 from their post-test scores. The comparison of the performance of students between the control and experimental groups in table 4.3.2. reveals a clear difference in academic performance, with the experimental group (COMSEC) achieving a higher mean score than the control group (MOSEC).

The mean score difference of 21.64 points, the t-value of 10.027 with 128 degree of freedom (df) and the significance (2-tailed) value of 0.000 which is less than 0.05 indicates that there is a significant difference in the performance of students exposed to Brain-Based Learning and traditional instruction. Therefore, the null hypothesis was rejected. The t-value of 10.027 with 128 degrees of freedom and a p-value of 0.000 (less than 0.05) in table 4.3.2. reflects a very strong effect of BBL, suggesting that BBL is not just marginally better but substantially more effective than traditional methods. Similar studies, such as those conducted by Caine and Caine (1994), support this by showing how brain-compatible learning environments can significantly enhance students' academic performance. This finding aligns with the body of literature supporting the effectiveness of Brain-Based Learning. Research by Jensen

(2008) and Caine and Caine (1991) emphasises that Brain-Based Learning strategies, which incorporate active, experiential, and reflective learning, can significantly enhance student engagement and academic performance. Zull (2002) also supports the notion that integrating thinking and doing in the learning process leads to better academic outcomes. Furthermore, studies by Sousa (2011) and Gardner (1983) highlight the importance of catering to diverse cognitive processes and multiple intelligences, which Brain-Based Learning effectively addresses.

Moreover, in a comparative study by Özden and Gültekin (2008) it was found that students taught using Brain-Based Learning strategies performed significantly better on post-tests than those taught through traditional methods. The difference in mean scores and the t-value in their study indicated a statistically significant advantage for the BBL group. Research has consistently shown that Brain-Based Learning approaches can significantly improve student performance compared to traditional instructional methods. A study by Jensen (2008) demonstrated that strategies aligned with how the brain naturally learns, such as incorporating movement, music, and hands-on activities, lead to higher student engagement and better retention of information. The results of the t-test analysis of the post-test scores in table 4.3.2. confirms that the Brain-Based Learning approach significantly enhances academic achievement. The experimental group outperformed the control group by a statistically significant margin, indicating that this innovative instructional strategy effectively supports improved educational outcomes. These results underscore the value of adopting Brain-Based Learning techniques to cater for diverse learning needs and promote academic success for all students.

4.4 Research Question Three

To what extent does different learning styles have effect on academic achievement of the students?

The academic achievement of students with different learning styles was measured using pre-test and post-test scores. The results are presented in Table 4.4.1.

Table 4.4.1: Pre-test and Post-test Scores by Learning Style

Learning Style		PRETEST Mean	POSTTEST Mean
ACCOMODATOR learning style	very low preference	27	61
	Low preference	27	65
	moderate preference	25	60
	Strong preference	25	61
	very strong preference	27	64
ASSIMILATOR learning style	very low preference	25	54
	Low preference	25	62
	moderate preference	27	65
	Strong preference	26	61
	very strong preference	27	63
CONVERGER learning style	very low preference	25	59
	Low preference	26	61
	moderate preference	28	66
	Strong preference	27	70
	very strong preference	30	65
DIVERGER learning style	very low preference	27	62
	Low preference	27	62
	moderate preference	27	65
	Strong preference	24	60
	very strong preference	25	60

The pre-test and post-test scores presented in Table 4.4.1. demonstrate significant improvements across all learning styles, highlighting the efficacy of the Brain-Based Learning approach. For students with the Accommodator learning style, the pre-test and post-test scores show significant improvement across all preference levels.

Students with a very low preference increased their mean score from 27 to 61, while those with a low preference saw an increase from 27 to 65. Moderate preference students improved from 25 to 60, strong preference students from 25 to 61, and very strong preference students from 27 to 64. This suggests that the Brain-Based Learning approach is effective in enhancing academic performance for students with varying degrees of preference for the Accommodator style.

Students with the Assimilator learning style also demonstrated improvement. Those with a very low preference increased their mean score from 25 to 54, and those with a low preference from 25 to 62. Moderate preference students improved from 27 to 65, strong preference students from 26 to 61, and very strong preference students from 27 to 63. This pattern indicates that the Brain-Based Learning approach positively impacts students who favour the Assimilator style, particularly those with moderate and low preferences. The Converger learning style group showed notable progress, especially for students with higher preferences. Very low preference students improved from 25 to 59, while low preference students increased their scores from 26 to 61. Students with a moderate preference had an increase from 28 to 66, those with a strong preference from 27 to 70, and very strong preference students from 30 to 65. The significant gains, particularly for students with moderate and strong preferences, highlight the effectiveness of Brain-Based Learning for Converger learners. For Diverger learners, the pre-test and post-test scores indicate consistent improvements across all preference levels. Very low preference students saw an increase from 27 to 62, low preference from 27 to 62, moderate preference from 27 to 65, strong preference from 24 to 60, and very strong preference from 25 to 60. These results suggest that the Brain-Based Learning approach benefits Diverger learners, providing a balanced improvement regardless of their initial preference level.

Accommodator: Students showed marked improvement across all preference levels, with scores increasing by approximately 34 points on average. **Assimilator:** Students demonstrate substantial gains, particularly those with moderate and low preferences, highlighting the effectiveness of Brain-Based Learning for this style. **Converger:** The highest improvements are observed among students with moderate to very strong preferences, indicating that these students benefit greatly from Brain-Based Learning. **Diverger:** Consistent improvements across all preference levels suggest that Diverger learners respond well to Brain-Based Learning.

Students with the Accommodator learning style, for example, showed notable mean score improvements, indicating that hands-on, experiential learners benefit significantly from this approach. This supports Jensen's (2008) assertion that Brain-Based Learning enhances engagement and retention through active learning strategies. Similarly, Assimilator learners, who favour a theoretical and reflective approach, also demonstrated substantial gains. This aligns with Caine and Caine's (1991) findings that Brain-Based Learning accommodates diverse cognitive processes effectively. Converger learners exhibited the highest improvements, particularly those with moderate to very strong preferences. This supports Zull's (2002) emphasis on integrating thinking and doing in learning. Diverger learners, characterised by reflective and observational preferences, showed consistent improvements, supporting Sousa's (2011) research on the benefits of reflective practices in education. These findings underscore the importance of employing Brain-Based Learning strategies to cater to diverse learning styles, thereby enhancing overall academic performance. The analysis shown in table 4.4.1 shows that Brain-Based Learning positively impacts students across different learning styles, with only slight variations in mean scores.

The academic achievements of the post-test scores of students with different learning styles were compared to determine if any group outperformed the others after being exposed to Brain-Based Learning. The findings are detailed in Table 4.4.2.

Table 4.4.2: The ANCOVA Table of the Pre-test and Post test Scores of the Students in Relation to their Learning Styles and Preference Level

Source of Variance	Sum of Squares	df	Mean Squares	F	p-value
Learning Styles	4.082	3	1.36	0.245	0.863
Preference Level	53.448	4	13.362	2.424	0.113
Pre-Test	60.051	1	60.051	10.802	0.007
Residual	61.149	11	5.559		

The table 4.4.2. indicates that the academic achievement scores are relatively close among the different learning styles and preference levels. The mean square of the learning styles was 1.36 with an F-value of 0.245 and p-value of 0.863 which is greater than 0.05. This indicates that the differences between learning styles are not statistically significant in terms of their impact on post-test scores after being exposed to brain-based learning approach. Therefore, we fail to reject the null hypothesis, suggesting that the Brain-Based Learning approach has a consistent positive impact on students regardless of their learning style.

Moreover, the mean square of their preference levels was 13.362 with F-value of 2.424 and p-value of 0.133 which is greater than 0.05. This shows that there is no significant difference in the academic performance of students who were administered the brain-based learning approach in relation to their preference levels. Therefore, we fail to reject the null hypothesis, indicating that the brain- based learning approach has a uniform impact on students regardless of their preference levels. The covariate (Pre-Test) has an F-value of 10.802 with a p-value of 0.007 which is less than 0.05

indicating a significant effect on the Post-Test scores. Therefore, reject the null hypothesis. This suggests that initial performance (Pre-Test) is a significant predictor of final performance (Post-Test). The analysis in table 4.4.2. shows that while pre-test scores significantly predict post-test scores, the different learning styles do not have a statistically significant impact on academic achievement in this dataset. Similarly, the preference level shows a trend towards significance but does not reach the conventional threshold.

Overall, the approach provides a balanced and effective method of instruction that enhances academic achievement regardless of the learning style. This underscores the adaptability and inclusiveness of Brain-Based Learning in catering to diverse student needs and preferences, ultimately supporting improved academic outcomes for all learners. This finding is supported by Duman (2010), who found that Brain-Based Learning effectively accommodates various learning styles, promoting balanced academic performance. The mean scores for Accommodator, Assimilator, and Diverger learners were all closely aligned, suggesting that Brain-Based Learning is adaptable and beneficial across different learning preferences. This supports Gardner's (1983) theory of multiple intelligences, which advocates for educational practices that recognise and nurture diverse cognitive abilities.

4.5 Research Question Four

What is the extent of performance between male and female students exposed to the Brain-Based Learning approach?

The performance of male and female students exposed to Brain-Based Learning was compared to identify any significant differences. The results are summarised in table 4.5. using a t-test.

Table 4.5: Summary of t-test Analyses of the Post-test Scores of Male and Female Students

GROUP	N	Mean	SD	df	t-value	p-value
Male	27	64	46.51	61	0.249	0.804
Female	35	61	46.51			

The t-test conducted in table 4.5. indicates that the t-value of 0.249 which was observed at a degree of freedom of 61 and p-value of 0.804, which is much greater than the significance level (α=0.05). Therefore, we fail to reject the null hypothesis. This indicates that there is no significant difference in the mean post-test scores between male and female students after being taught with brain-based learning approach. This non-significant result reinforces the idea that brain-based learning strategy is equally effective for both genders in enhancing academic performance. This result also lends strong support to the idea that brain-based learning approach is not only inclusive but also a highly effective strategy for fostering equitable learning outcomes in the realm of science education. The finding aligns with existing literature that emphasises the efficacy of brain-based learning in fostering equitable learning outcomes. The analysis of Table 4.5 reveals that the Brain-Based Learning approach benefits both male and female students, resulting in significant improvements in their academic performance.

This finding is consistent with Gurian and Stevens' (2005) research, which suggests that gender-responsive teaching strategies, like Brain-Based Learning, can enhance learning outcomes for both boys and girls by addressing their unique cognitive and emotional needs. The findings of this study are supported by extensive literature on Brain-Based Learning. Jensen (2008) emphasises the importance of active, experiential learning in enhancing student engagement and retention. Caine and Caine (1991) highlight the need for educational approaches that cater to diverse cognitive processes, supporting the effectiveness of Brain-Based Learning. Zull (2002) advocates for the integration of thinking and doing in learning, aligning with the positive outcomes observed in Converger learners. Gardner (1983) suggests that recognising multiple intelligences in education promotes balanced academic achievement across different learning styles. Gurian and Stevens (2005) stress the benefits of gender-responsive teaching strategies in improving educational outcomes for both boys and girls.

In conclusion, the study demonstrates that Brain-Based Learning significantly improves academic achievement across various learning styles and genders. The approach effectively caters to the diverse cognitive and emotional needs of students, promoting inclusive and balanced educational outcomes. These findings underscore the importance of adopting Brain-Based Learning strategies in educational settings to enhance overall student performance and engagement. This approach provides a robust framework for addressing the unique learning preferences of students, ultimately supporting their academic success.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION, AND RECOMMENDATIONS

5.0 Introduction

This chapter provides a summary of the key findings from the research, conclusions drawn from these findings, and recommendations based on the study. It also discusses policy implications and suggests areas for future research.

5.1 Summary of Findings

This study sought to examine the effect of senior high school students' academic performance in selected Integrated Science concepts through brain-based learning approach. To realise the research purpose, the study was guided by the following specific objectives: to determine the learning style distribution of College of Music SHS students, to determine the outcome of the BBL approach on the academic achievement of students, to ascertain the academic achievement of the students with different learning styles, and know the extent of performance between male and female students exposed to Brain-Based Learning approach. Four research questions were answered: What are the learning style distribution of the students in College of Music Senior High School? To what extent does Brain-Based Learning approach affect the academic achievement of students? To what extent does different learning styles have impact on academic achievement of the students? What is the extent of performance between male and female students exposed to the Brain-Based Learning approach? Further, three null hypotheses: H01: There is no significant effect of Brain-Based Learning approach on the academic achievement of students with different learning styles. H02: There is no significant correlation between students preferred Learning Styles and academic achievement of students in Integrated Science. H03: There is no significant difference in the performance of male and female students exposed to Brain- Based Learning Approach, were tested at 0.05 level of significance. The study adopted a quasi-experimental research design and utilised the purposive sampling technique to choose the two schools for the study. Data were collected using achievement tests and questionnaire. Data collected were analysed using descriptive statistics such as the mean, organised into frequencies and presented through frequency tables. T-tests and analysis of covariance were employed to validate whether or not there were significant differences between the mean scores obtained on the tests.

5.2 Summary of Main Findings

5.2.1 The learning style distribution of College of Music Senior High School students

The descriptive statistics of the learning style distribution indicate that females have a stronger preference for the accommodator learning style than males, Assimilator shows a balanced preference across both genders, converger was characterised by a higher number of low preferences, especially among females, and diverger displays a balanced distribution but with a higher preference among females.

5.2.2 Outcome of the Brain-Based Learning approach on the academic achievement of students

The pre-test mean score difference of 2.92 points, the t-value of 2.346 with 128 degree of freedom (df) and the significance (2-tailed) value of 0.210 were ascertained during the pre-intervention phase (pre-test). Both descriptive and inferential statistics of the pre-test in the control and experimental groups indicates that there was no significant difference in the performance of students before the application of brain-based learning approach on the students in College of Music Senior High School. The mean score difference of 21.64 points, the t-value of 10.027 with 128 degree of freedom (df) and the significance (2-tailed) value of 0.000 were also ascertained during the post-intervention phase (post-test). The p-value is less than 0.05 indicating that there is a significant difference in the performance of students exposed to Brain-Based Learning and traditional instruction. Therefore, the null hypothesis was rejected, suggesting that BBL is not just marginally better but substantially more effective than traditional methods.

5.2.3 Ascertain the academic achievement of the students with different learning styles

The mean square of the learning styles was 1.36 with an F-value of 0.245 and p-value of 0.863 which is greater than 0.05. The mean square of their preference levels was 13.362 with F-value of 2.424 and p-value of 0.133 which is greater than 0.05. This shows that there is no significant difference in the academic performance of students who were administered the brain-based learning approach in relation to their preference levels and learning styles. Therefore, we fail to reject the null hypothesis, indicating that the brain- based learning approach has a uniform impact on students regardless of their learning styles and preference levels. The covariate (Pre-Test) has an F-value of 10.802 with a p-value of 0.007 which is less than 0.05 indicating a significant effect on the Post-Test scores. Therefore, reject the null hypothesis. This suggests that initial performance (Pre-Test) is a significant predictor of final performance (Post-Test).

5.2.4 Know the extent of performance between male and female students exposed to Brain-Based Learning approach

The descriptive and inferential statistics of the post-test scores of the experimental group revealed that brain- based learning had a positive and equitable effect on the academic performance of both male and female SHS students in Integrated Science. The t-test conducted indicates that the t-value of 0.249 which was observed at a degree of freedom of 61 and p-value of 0.804, which is much greater than the significance level ($\alpha=0.05$). Therefore, we fail to reject the null hypothesis. This indicates that there is no significant difference in the mean post-test scores between male and female students after being taught with brain-based learning approach.

5.3 Conclusion

Based on the findings of this novel study, the following main conclusions were drawn: Firstly, the implementation of brain-based learning approach demonstrated a statistically significant improvement in SHS students' academic performance, as evidenced by notable differences between pre-test and post-test scores of students in the experimental group and control group. This affirms that brain-based learning approach has a substantial and positive impact on the academic performance of senior high school students in selected Integrated Science concepts.

Secondly, the gender analysis conducted in this study revealed a noteworthy and equitable benefit of brain-based learning approach for both male and female students. The approach exhibited an equal improvement in academic performance across genders, emphasising its inclusive nature. The absence of a significant difference in impact further supports the notion that differentiated instruction fosters equitable educational outcomes for male and female students alike.

Thirdly, the learning styles and preference levels of students highlight how well brain-based learning approach fosters comprehension, engagement, and an all-around improvement in the quality of learning experiences. This further emphasis the potential of BBL as a valuable and recommended approach in the teaching and learning of various subjects.

In summary, the comprehensive findings of this study collectively support the beneficial effect of BBL on the academic performance of SHS students in selected Integrated Science concepts.

5.4 Recommendations

The findings of this research suggest several important policy implications and recommendations that could enhance the educational landscape. The first recommendation is the integration of Brain-Based Learning strategies into the national curriculum. Given the significant improvements in academic performance observed in both male and female students, educational policymakers should consider embedding these strategies within the existing curriculum framework. This integration could systematically enhance student performance across various subjects and learning environments.

Another critical policy implication is the need for comprehensive teacher training programs. To ensure the effective implementation of Brain-Based Learning techniques, professional development initiatives should be designed to equip teachers with the necessary skills and knowledge. These training programs would enable teachers to understand and apply Brain-Based Learning principles, thus fostering an environment conducive to improved student learning outcomes.

Additionally, the allocation of resources plays a pivotal role in the successful adoption of Brain-Based Learning approaches. Schools must be provided with adequate resources and materials, including technology, teaching aids, and learning environments that support Brain-Based Learning methodologies. Policymakers should prioritise funding and resource allocation to ensure schools are well-equipped to implement these innovative strategies.

Furthermore, the findings underscore the importance of inclusive education policies that address diverse learning styles and gender differences. To ensure all students have equal opportunities to succeed, educational policies should promote strategies that cater to various learning preferences and support both male and female students effectively. Inclusive education policies would help bridge the gap between different learner groups, fostering an equitable learning environment for all students.

The research highlights the potential of Brain-Based Learning to significantly improve academic performance among senior high school students. By integrating these strategies into the national curriculum, providing targeted teacher training, allocating necessary resources, and promoting inclusive education, policymakers can create a robust framework that supports enhanced learning outcomes for all students.

5.5 Suggestions for Further Research

To build upon the promising findings of this study, future research should focus on several key areas. One critical avenue for further investigation is the conduct of longitudinal studies. Such studies would be instrumental in assessing the long-term impact of Brain-Based Learning on both academic performance and student engagement. By tracking students over an extended period, researchers can determine whether the benefits observed in the short term are sustained and continue to contribute to student success over time.

Expanding the research to include a broader range of demographics is another important focus. Current findings are based on senior high school students, but it would be valuable to include different age groups and educational settings. By examining diverse populations, researchers can determine whether the positive effects of Brain-Based Learning are consistent across various contexts. This broader demographic scope would help generalize the findings and ensure that the strategies are applicable and beneficial to a wider audience.

Moreover, investigating the challenges and barriers to implementing Brain-Based Learning in various educational contexts is crucial. Understanding the practical difficulties educators face when trying to adopt these methods can inform the development of strategies to overcome these obstacles. This research could provide insights into the necessary support systems and resources that schools need to effectively integrate Brain-Based Learning approaches, thereby facilitating smoother implementation.

Comparative studies are also essential to determine the relative effectiveness of Brain-Based Learning compared to other innovative educational approaches. By comparing Brain-Based Learning with alternative strategies, researchers can identify the most effective methods for improving student outcomes. These comparative analyses could help educators and policymakers make informed decisions about which approaches to prioritise in their efforts to enhance educational practices.

Addressing these areas, future research can further validate and refine the Brain-Based Learning approach. Longitudinal studies, broader demographic research, implementation challenges, and comparative studies will contribute to a deeper understanding of this educational strategy. Such research efforts will support the broader adoption and implementation of Brain-Based Learning in educational systems, ultimately leading to more effective and inclusive teaching practices.

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APPENDICES

APPENDIX A

INTEGRATED SCIENCE PERFORMANCE TEST

PRE-TEST DURATION: 50 MINS

ANSWER ALL QUESTIONS IN BOTH SECTION A &B

SECTION A

Choose from alternatives lettered A -D to complete the following sentences.

1. Soil fertility can be improved by applying

A. lime

B. Sodium chloride

C. fertilizer

D. pesticides

2. Which of the following is ***not*** found in the soil?

A. Air

B. Ammonia

C. Mineral

D. Water

3. Which of the following component of soil is formed through the activities of microbes?

A. Clay

B. Humus

C. Sand

D. Silt

4. A leguminous crop is selected as one of the crops used in crop rotation in order that

A. soil erosion will be checked

B. the growth of weeds will be suppressed

C. nitrates will be added to the soil

D. grazers will not destroy the crop

5. A farming practice which encourages soil erosion is

A. bush burning

B. contour ploughing

C. strip cropping

D. terracing

6. Soil conservation and the renewal of soil fertility can be achieved through

A. introducing green manure

B. inter-cropping

C. agro-forestry

D. mixed cropping

7. Organic manure is preferred to inorganic fertilizer because

A. manure is less bulky than inorganic fertilizers

B. manure suppresses the growth of weeds whiles inorganic fertilizers do not

C. manure can bind soil particles together whiles inorganic fertilizer does not

D. unlike inorganic fertilizers, organic manure does not spread diseases

8. The type of erosion in which large channels form on the soil surface is referred to as

A. gully erosion

B. sheet erosion

C. rill erosion

D. splash erosion

9. In sheet erosion,

A. topsoil removed is thin and uniform

B. deep channels are created

C. narrow channels are created

D. top soil removed is deposited in heaps

10. Soil aeration could be improved by

A. application of inorganic fertilizers

B. drainage of excess water

C. irrigation

D. mulching

11. Which of the following organs excrete carbon dioxide?

A. Kidney

B. Lungs

C. Liver

D. Skin

12. The kidneys are connected to the urinary bladder by the

A. renal artery

B. sphincter muscle

C. ureter

D. urethra

13. The functional unit of the kidney is known as the

A. Bowman's capsule

B. Nephron

C. Ureter

D. Urethra

14. The body of the mammal cools down when sweat evaporates from the body because

A. the body loses latent heat of vaporisation

B. sweat is made up of water

C. wind blows over the skin

D. relative humidity decreases with evaporation

15. Heat is generated in the human body during

A. defecating

B. expiration

C. shivering

D. sweating

16. Which of the following substance is present in both glomerular filtrate and urine of a healthy person?

A. Amino acid

B. Blood proteins

C. Glucose

D. Urea

17. The excretory product of plants include

A. ammonia, gum and excess salt

B. gum, excess salt and urea

C. ammonia, latex and urea

D. gum, latex and excess salt

18. Which of the following structure of a mammal is not an excretory organ?

A. Colon C. Liver

B. Kidney D. Lung

19. The skin of a mammal excretes

A. salt and water only

B. water and urea only

C. water and carbon dioxide

D. salt, urea and water

20. In humans, urine moves from the kidneys to the urinary bladder through the

A. renal vein

B. collecting duct

C. ureter

D. urethra

SECTION B

1.a. Define fertiliser.

b. Describe briefly ***two*** methods of fertiliser application

2.a. Give ***three*** farming practices that prevent soil erosion

b. State ***three*** qualities of fertile soil

c. State ***three*** conditions under which a fertile soil will not be productive

3.a. Explain the following terms

(i) De-amination.

(ii) Ultra-filtration

(iii) Selective re- absorption

b. Name ***four*** organs in the human body that excrete waste

4.a. Name ***four*** waste excreted by each of the organs named in "3 (a) " (i) above

4.b. Enumerate ***three*** disorders associated with the urinary system in humans.

APPENDIX B

INTEGRATED SCIENCE PERFORMANCE TEST

MARKING SCHEME (PRE-TEST)

TOTAL MARKS WILL BE CONVERTED TO 100%

SECTION A (20 marks)

1. C	**11. B**
2. B	**12. C**
3. B	**13. B**
4. C	**14. A**
5. B	**15. C**
6. A	**16. D**
7. C	**17. D**
8. A	**18. A**
9. A	**19. D**
10. B	**20. D**

SECTION B (30 marks)

1.a. A fertilizer is a substance or material that is applied to plants or soil to supply nutrients.

b. Methods of fertilizer applications are as follows: side dressing, drilling methods, broadcasting methods, foliar application and ring methods.

2.a. farming practices that prevent soil erosion are; contour ploughing, cover cropping, strip cropping, terracing, afforestation, wind breaks and mulching.

b. qualities of fertile soils are; favourable pH, adequate supply of air, low leaching capacity, good soil texture, Rich in humus and adequate moisture.

c. conditions under which a fertile soil will not be productive are; erosion, type of farming method used, water logging, unsuitable temperature, unavailability of oxygen, presence of weeds on the farm and nutrients not available to crops

3.a.i. De-amination is the removal of excess amino acids by the liver in the form of urea.

ii. Ultra- filtration is the filtration of fluids from the blood in the nephron, glomerulus under pressure.

iii. Selective reabsorption is the reabsorption of useful substances from filtrate and unwanted substances remain in the filtrate to form urine.

b. Some excretory organs are; lungs, skin, liver and kidney

4.a.

EXCRETORY ORGANS	**EXCRETORY PRODUCTS**
1. Lungs	Carbon dioxide, water
2. Kidney	Urea, salts, water
3. Liver	Bile pigment
4. Skin	Urea, mineral salts, excess water.

4.b. Some disorders associated with the urinary system are; kidney stone, weak bladder, Enlarged prostrate, Strictures.

APPENDIX C

INTEGRATED SCIENCE PERFORMANCE TEST

POST-TEST DURATION: 50 MINS

ANSWER ALL QUESTIONS IN BOTH SECTION A &B

SECTION A

Choose from alternatives lettered A -D to complete the following sentences.

1. The skin of a mammal excretes

A. salts and water only

B. water and urea only

C. water and carbon dioxide

D. salts, urea and water

2. In humans, urine moves from the kidneys to the urinary bladder through the

A. renal vein

B. collecting duct

C. ureter

D. urethra

3. The excretory product of plants include

A. ammonia, gum and excess salt

B. gum, excess salt and urea

C. ammonia, latex and urea

D. gum, latex and excess salt

4. Which of the following structure of a mammal is not an excretory organ?

A. colon

B. kidney

C. liver

D. lung

5. The type of erosion in which large channels form on the soil surface is referred to as

A. gully erosion

B. sheet erosion

C. rill erosion

D. splash erosion

6. In sheet erosion,

A. topsoil removed is thin and uniform

B. deep channels are created

C. narrow channels are created

D. topsoil removed is deposited in heaps

7. Soil aeration could be improved by

A. application of inorganic fertilisers

B. drainage of excess water

C. irrigation

D. mulching

8. Which of the following organs excrete carbon dioxide?

A. kidney

B. lungs

C. liver

D. skin

9. The kidneys are connected to the urinary bladder by the

A. renal artery

B. sphincter muscle

C. ureter

D. urethra

10. The functional unit of the kidney is known as the

A. bowman's capsule

B. nephron

C. ureter

D. urethra

11. A farming practice which encourages soil erosion is

A. bush burning

B. contour ploughing

C. strip cropping

D. terracing

12. Soil conservation and the renewal of soil fertility can be achieved through

A. introducing green manure

B. inter-cropping

C. agro-forestry

D. mixed cropping

13. The body of the mammal cools down when sweat evaporates from the body because

A. the body loses latent heat of vaporisation

B. sweat is made up of water

C. wind blows over the skin

D. relative humidity decreases with evaporation

14. Which of the following component of soil is formed through the activities of microbes?

A. clay

B. humus

C. sand

D. silt

15. A leguminous crop is selected as one of the crops used in crop rotation in order that

A. soil erosion will be checked

B. the growth of weeds will be suppressed

C. nitrates will be added to the soil

D. grazers will not destroy the crop

16. Heat is generated in the human body during

A. defecating

B. expiration

C. shivering

D. sweating

17. Organic manure is preferred to inorganic fertiliser because

A. manure is less bulky than inorganic fertilisers

B. manure suppresses the growth of weeds whiles inorganic fertilisers do not

C. manure can bind soil particles together whiles inorganic fertiliser does not

D. unlike inorganic fertilisers, organic manure does not spread diseases

18. Which of the following substance is present in both glomerular filtrate and urine of a healthy person?

A. amino acid

B. blood proteins

C. glucose

D. urea

19. Soil fertility can be improved by applying

A. lime

B. sodium chloride

C. fertilizer

D. pesticides

20. Which of the following is not found in the soil?

A. air

B. ammonia

C. mineral

D. water

SECTION B

1.a State three qualities of fertile soil

b. Name ***four*** organs in the human body that excrete waste

2.a. Enumerate ***three*** disorders associated with the urinary system in humans.

b. Define fertiliser?

c. State ***three*** conditions under which a fertile soil will not be productive

3.a. Explain the following terms

(i) De-amination

(ii) Ultra-filtration

(iii) Selective re- absorption

b. Describe briefly ***two*** methods of fertiliser application

4.a. Name ***four*** waste excreted by each of the organs named in "1 (b)''above.

4.b. Name ***three*** farming practices that prevent soil erosion

APPENDIX D

INTEGRATED SCIENCE PERFORMANCE TEST

MARKING SCHEME (PRE-TEST)

TOTAL MARKS WILL BE CONVERTED TO 100%

SECTION A (20marks)

1. D	11. A
2. D	12. C
3. D	13. A
4. A	14. B
5. A	15. C
6. A	16. C
7. B	17. C
8. B	18. D
9. C	19. C
10. B	20. B

SECTION B (30marks)

1.a. Qualities of fertile soils are; favourable pH, adequate supply of air, low leaching capacity, good soil texture, rich in humus and adequate moisture.

b. Some excretory organs are; lungs, skin, liver and kidney

2.a. Some disorders associated with the urinary system are; kidney stone, weak bladder, Enlarged prostrate, Strictures.

b. A fertilizer is a substance or material that is applied to plants or soil to supply nutrients.

c. Conditions under which a fertile soil will not be productive are; erosion, type of farming method used, water logging, unsuitable temperature, unavailability of oxygen, presence of weeds on the farm and nutrients not available to crops

3.a.i. De-amination is the removal of excess amino acids by the liver in the form of urea.

ii. Ultra- filtration is the filtration of fluids from the blood in the nephron, glomerulus under pressure.

iii. Selective reabsorption is the reabsorption of useful substances from filtrate and unwanted substances remain in the filtrate to form urine.

b. Methods of fertilizer applications are as follows: side dressing, drilling methods, broadcasting methods, foliar application and ring methods.

4.a.

EXCRETORY ORGANS	EXCRETORY PRODUCTS
1. Lungs	Carbon dioxide, water
2. Kidney	Urea, salts, water
3. Liver	Bile pigment
4. Skin	Urea, mineral salts, excess water.

4.b. farming practices that prevent soil erosion are; contour ploughing, cover cropping, strip cropping, terracing, afforestation, wind breaks and mulching.

APPENDIX E

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

LEARNING STYLE INVENTORY QUESTIONNAIRE [LSIQ]

Name…………………………………………………………………….
Class………….

School……………………………………………Age……………… Sex: **M / F**

This questionnaire will take you about 15 minutes to complete. How honest you are will determine how accurate your results are. Answers are not correct or incorrect. Tick (√) in the box to the left of the question if you agree with a statement more than you disagree. To indicate that you disagree more than you agree, leave it blank. Do not overthink your response, follow your initial instinct.

QUESTIONS

[ ] 1. I like the sort of work where I have time for thorough preparation and implementation.

[ ] 2. I actively seek out new experiences.

[ ] 3. I take care over how I interpret data and avoid jumping to conclusions.

[ ] 4. I like to reach a decision carefully after weighing up many alternatives

[ ] 5. I accept and stick to laid down procedures and policies so long as I regard them as an efficient way of getting the job done.

[ ] 6. I like to relate my actions to a general principle, standard or belief.

[ ] 7. In discussions, I like to get straight to the point.

[ ] 8. I thrive on the challenge of tackling something new and different.

[ ] 9. I pay careful attention to detail before coming to a conclusion.

[ ] 10. I prefer to have as many sources of information as possible – the more information to think over the better.

[ ] 11. I tend to judge people's ideas on their practical merits.

[ ] 12. I tend to be a perfectionist.

[ ] 13. In meetings, I put forward practical, realistic ideas.

[ ] 14. On balance I talk more than I listen.

[ ] 15. I am keen to try things out to see if they work in practice.

[ ] 16. I am keen to reach answers via a logical approach.

[ ] 17. I enjoy being the one that talks a lot.

[ ] 18. I like to be able to relate current actions to the longer-term bigger picture.

[ ] 19. I quickly get bored with methodical, detailed work.

[ ] 20. I like meetings to be run on methodical lines, sticking to laid down agenda.

Scoring

You score one point for each item you ticked. There are no points for items you crossed. Go back over your responses and simply circle the question number in the table below for each question you ticked. Then add up the number of circled responses in the Totals row.

	QUESTION NUMBERS			
	2	1	6	5
	8	3	12	7
	14	4	16	11
	17	9	18	13
	19	10	20	15
TOTALS	**Activist**	**Reflector**	**Theorist**	**Pragmatist**

Your preferred learning styles

Now circle your total scores for each learning style on the table below to determine the strength of your preference.

ACTIVIST	REFLECTOR	THEORIST	PRAGMATIST	
5	5	5	5	**Very Strong Preference**
4	4	4	4	**Strong Preference**
3	3	3	3	**Moderate Preference**
2	2	2	2	**Low Preference**
1 0	1 0	1 0	1 0	**Very Low Preference**

ADAPTED FROM KOLB'S LEARNING STYLE INVENTORY FORM (1984)

APPENDIX F

Raw Scores of Students

Gender	Pre-test	Post-test
M	14	31
M	6	25
M	11	26
M	19	41
M	22	46
M	25	46
M	9	32
M	14	29
M	13	30
M	9	37
M	23	48
M	13	35
M	9	36
M	11	33
M	16	38
M	14	35
M	19	42
M	16	40
M	23	48
M	16	43
M	15	44
M	13	37
M	19	38
M	14	38
M	12	27
F	14	31
F	13	38
F	21	41
F	15	39
F	8	27
F	10	34
F	23	41
F	20	47
F	13	32
F	14	35
F	22	43
F	7	23
F	17	29
F	14	36
F	13	33

F	18	39
F	12	36
F	19	43
F	11	26
F	16	30
F	15	40
F	16	34
F	12	33
F	14	37
F	8	28
F	18	33
F	15	44
F	17	41
F	21	39
F	15	32
F	16	39
F	19	46
F	16	36
F	21	45
F	20	40
F	16	41
F	20	43
M	13	32
M	19	25
M	10	19
M	19	36
M	12	19
M	15	42
M	24	36
M	18	30
M	9	27
M	9	23
M	15	31
M	21	26
M	17	20
M	23	21
M	8	28
M	14	27
M	12	23
M	10	26
M	20	29
M	14	13
M	11	34
M	12	21
M	13	32
M	15	36

M	15	28
M	20	28
M	16	34
F	19	25
F	16	26
F	18	24
F	15	24
F	14	17
F	13	23
F	16	27
F	19	33
F	13	25
F	18	29
F	17	25
F	14	23
F	14	21
F	11	23
F	9	19
F	3	16
F	17	32
F	13	19
F	22	29
F	24	37
F	14	19
F	18	34
F	21	39
F	19	26
F	13	18
F	9	24
F	14	27
F	11	17
F	13	27
F	20	27
F	9	16
F	14	26
F	17	27
F	12	27
F	16	19
F	17	23
F	15	29
F	8	18
F	8	22
F	10	26
F	9	30