EFFECT OF BRAIN-BASED LEARNING ON CRITICAL THINKING AND ACADEMIC ACHIEVEMENT OF GENERAL SCIENCE STUDENTS AT ELEMENTARY LEVEL

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(2025)

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A thesis submitted in partial fulfilment of the requirement for the degree of PhD Education.

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SUPERVISOR'S CERTIFICATE

The thesis titled "EFFECT OF BRAIN-BASED LEARNING ON CRITICAL THINKING AND ACADEMIC ACHIEVEMENT OF GENERAL SCIENCE STUDENTS AT ELEMENTARY LEVEL" submitted by Mr. Nauman Saeed Reg. No. 183-FSS/PHDEDU/F20 in partial fulfilment of PhD degree in Education has been completed under my guidance and supervision. I am satisfied with the quality of the student's research work and allow her to submit this for further process as per IIUI rules and regulations.

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APPROVAL SHEET

EFFECT OF BRAIN-BASED LEARNING ON CRITICAL THINKING AND ACADEMIC ACHIEVEMENT OF GENERAL SCIENCE STUDENTS AT ELEMENTARY LEVEL

By

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Author's Declaration

I, Mr. Nauman Saeed Reg. No. 183-FSS/PHDEDU/F20 as a student of PhD Education at International Islamic University, Islamabad do hereby declare that the thesis entitled "EFFECT OF BRAIN-BASED LEARNING ON CRITICAL THINKING AND ACADEMIC ACHIEVEMENT OF GENERAL SCIENCE STUDENTS AT ELEMENTARY LEVEL", submitted for the partial fulfillment of PhD Education is my original work, and has not been submitted or published earlier. I also solemnly declare that it shall not, in future, be submitted by the researcher for obtaining any degree from this or any other university or institutions.

_____

Nauman Saeed

Dedication

To my father Muhammad Saeed Malik

whose nature of commitment and determination

is a source of inspiration for me and my family.

My mother my brother and my sisters without them none of this would have been possible.

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Abstract

The purpose of this study was to evaluate the effect of brain-based learning on critical thinking and academic achievement of General Science students. The study was experimental and used a pretest-posttest equivalent group design. The population the study was sixty students at Government Boys Secondary School Panag Sharif Kotli Azad Jammu and Kashmir, Pakistan. The research was conducted by using two groups such as experimental and control group. Thirty students in each group were randomly selected. Four units (9,10, 11, and 12) were selected from the General Science textbook of the 8th class. The study includes three variables i.e., teaching methods, critical thinking, and academic achievement. Teaching methods including brain-based method and traditional method were the independent variable whereas critical thinking and academic achievement were the dependent variables. The researcher developed 32 lesson plans from these selected units to treat the control and experimental groups. To develop lesson plans, expert opinion was taken and changes and improvements were made as per experts' suggestions and guidelines. The researcher made the Subject Achievement Test and critical thinking test as research instruments and applied before and after intervention as pretest and post-test respectively. Furthermore, the researcher used the split-half method to check the reliability of the research instrument. After this teacher made a subject achievement pretest given to all the students and results were collected. Then control group of students was taught through the traditional method and the experimental group of students was taught through the brain-based method for eight weeks. After the last session of intervention same pretest was administered as the posttest. The difference between the pretest and post-test scores of each selected student was considered as the academic achievement of the concerned student. The critical thinking test developed by Alison King in 2017 at Brown University USA was adapted to measure the critical thinking of students. Collected data were analyzed by using SPSS version 23. The researcher used paired sample t-test and ANOVA for testing the research hypotheses. The findings confirmed that the brain-based method was effective in improving critical thinking and academic achievement of students in General Science subject. It was concluded that using brain-based method to teach General Science subject has significantly better results in improving critical thinking and academic achievement of students than traditional method. Moreover, critical thinking and academic achievement of students can be improved in General Science subject at elementary level if teachers apply brain-based method in classrooms. It is recommended that BBL may be used at elementary level in teaching General Science to improve critical thinking and academic achievement of students.

Keywords: Brain-based method, Traditional method, Critical thinking, and Academic achievement, Elementary level.

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Abbreviations

AA	Academic Achievement
AJK	Azad Jammu and Kashmir
ANOVA	Analysis of Variance
AP	Active Processing
ASD	Autism Spectrum Disorder
BBL	Brain-Based Learning
BBM	Brain Based Method
EFL	English as a Foreign Language
ELL	English Language Learners
KWL	Know Wanted Learning
OI	Orchestrated Immersion
SHR	Sensory Hyper Responsiveness
SL	Significant Level
SOR	Sensory Overreaction
USA	United States of America

CHAPTER 1

INTRODUCTION

Brain-based instruction uses teaching strategies that enhance or improve the abilities of learners to integrate and process the information in meaningful ways. Brain-based learning also focuses on how the learner's brain processes information in a meaningful way full of his /her in-depth and thoughtful understanding of concepts. In such type of instruction, teachers are suggested not to match the characteristics of learners with their learning styles or with the subject matter or presentation method. Teachers are suggested to get maximum information about students learning as well as their study needs. If we examine instruction theories through the utilization of brain-based learning theory, it will improve our instructional strategies and fulfill the needs of each child. As a teacher, we need a more complete understanding of how the brain processes information and which type of strategies make it easier to retain that information.

1.1 Background of the Study

In the most primitive sense learning is considered as survival if not the highest form of pleasure-seeking behavior. Humans remain the most advanced species on earth because they successfully find ways to cope with the paradoxes and ambiguities of their everyday lives. In recent years, the use of imaging methods, neuropsychological tests, and electrophysiological studies has provided researchers with opportunities to study the function and structure of the human brain, which may provide clues to major changes in the field of education.

According to Awolola, (2011) in any education system, teaching without understanding the function of the human brain is like designing a glove without understanding the hand structure and movement. Carolyn, 1997; Gozuyesil & Dikic, 2014). As a result, the human brain continues to evolve and adapt according to needs and challenges.

A learning process is defined as interdisciplinary and the use of brain-based instruction can be focused to answer the question what is the most efficient way for the brain learning mechanisms?" Brain-based learning aims to enhance learning potential and provides educators with a pedagogical framework compared to traditional methods

and models. Applying brain-based instruction to learning may improve academic performance. (Duman, 2006) The brain sustainably reorganizes itself through experiences that shape neural routes that will determine how our brain learns (Sousa, 2012). According to Sousa (2012), the brain is continuously involved in processes that transfer information from its temporary to long-term memory.

According to Suparta (2018), teachers guide, promote, counsel, and instruct their students in their learning, growth, and development simply by providing relevant content and methods based on their intellectual abilities. Any intellectually compatible environment enables students to construct their ideas about the meanings of the concept and demonstrate their knowledge through tactful, creative, and advanced methods; students' intrinsic motivation, positive self-perception, and sense of responsibility develop as they interact, cooperate, and collaborate in learning situations to become more active participants in the educational process. Additionally, the curriculum must reflect on natural connections to the real-life experiences of students. Furthermore, the curriculum must be purposeful, comprehensive, and meaningful and also based on any particular theme that involves such strategies to fulfill learners' educational needs for their better understanding.

Brain-based learning is often considered an educational strategy derived from the field of neurological and cognitive sciences which aims to maximize the learning of a child in a safe but challenging way, hence, the brain-based method used by the teachers allows students to have brain-based learning which ultimately improves students learning in a safe environment without any fear Sor hesitation. The human brain continually pursues to execute incoming stimuli in a direction and generate models that promote adaptive behavior among learners to generate useful and purposeful predictions (Koban., Gianaros, Kober, & Wager 2021).

According to Suparta et. al. (2018), the concept of brain-based teaching has been used for so many years in the field of education and still demand further fruitful research. The brain-based strategy involves the teaching method that a teacher uses in classroom instruction. What makes unique to this strategy is the way the lessons are delivered, which differs from traditional direct instruction learning. In "brain-based" teaching, a teacher makes a lot of effort in teaching to connect information to prior knowledge or experience. Brain-based methods exploit the concept that irrelevant

information is lost or discarded by the brain's unconscious process. If the brain considers this information unimportant then discards it. If teachers apply these strategies in the classroom, it will enable learners to retain maximum information that they learn (Al Balushi & Al Balushi, 2018).

Darling et al. (2019) emphasized the crucial role of the brain in human thought, memory, emotions, and development, asserting that managing these aspects is key to success across various life domains. They highlighted education as fundamental to societal progress globally, with advancements continually expanding human knowledge and learning processes.

Saleh and Neamah (2020) remarked that brain-based instruction emphasized on how the brain learns better rather than what to learn. In a meaningful way, the brain receives information, but insignificance forces may inhibit the brain functions in processing that information. The brain is considered as the center of intelligence which includes different components like memory, perception, cognition, emotion and attention.

Brain-based instruction, as Jensen (2008) described, is an educational approach centered on aligning learning with the brain's natural style. It's a perspective on the entire teaching-learning process, not a singular solution, technique, or fleeting trend. Instead, it's a basically values system and a knowledge foundation and skills for making more informed educational choices. Jensen (2008) further characterized BBL as an approach to understanding learning, providing guidelines and a basis for informed judgments about the learning process, encompassing intellectual reasoning.

In brain-based learning our brain tries to link our learning in such a style that it connects or works and claiming that performance and function of a brain improves continually which effect positively on learning. Hence, it could be said that learning always promotes the development of the brain. Much research in the field of neuroscience examines the connections and associations with human brain and its neural functions, behavior, attitude and learning., Brain-based learning has always become an important by the neuroscience discoveries and technological advancements and always defined and promoted (Hansen & Monk, 2002).

According to Caine and Caine (1994), in any Brain-Based Learning (BBL) meaningful learning needs an in-depth understanding of principles that govern brain

function and designing instruction based on these principles. They supported the concept of enhancing teaching and learning processes by recognizing cognitive frameworks through expressive knowledge and adapting instruction according to Brain Based Learning principles within educational settings. After all, it can be argued that every individual's brain is a precise object that functions by a particular set of brain principles. Because the human brain's functions are determined by a person's genetics, growth, familiarity, cultural context, and emotions, it is constantly stimulated to change (Gardner, 1983).

Brain-based learning is a technique in education that is based on the way the brain functions. The conservative education technique, which emphasizes the conditional, is entirely different (Lee, 2003). It is considered as the combination of various concepts and aspects for instance cooperative and experiential learning, mastery learning, multiple intelligences, different learning patterns, peer teaching, and the theory of the triune brain. These fit well with existing teaching methods in different educational fields such as natural and social sciences, languages and literature, etc. This approach works in a brain supportive, friendly and non-threatening environment of the classroom to maximize students learning as well as to minimize traditional methods that only promote rote learning (Rehman, 2011).

Brain-based learning enables teachers to identify specific theories that they can use to underpin classroom instruction. Caine and Caine (1995) illustrated how this learning can be applied for learning and teaching process. They both focused on learning in a meaningful way rather than more traditional methods of memorizing facts. This type of learning not only focus on how our brain receives information but also highlights the different methods and process that involved in learning and emphases on the role of each and every part of the brain. This whole process allows students to make connections between their learning and the way they receive, perceive and take account on their learning (Jensen, 2008). He also highlighted the various sequences of the brain where the brain goes during the learning process and introduced the idea of the best time for students to study. He elaborated on this concept that teachers' instruction should be helpful for their students to realize the better time for study, and emphasize students' needs that may be supportive for themselves. Theoretically, students may better grasp

who they are as learners and how to effectively advocate for themselves with the support of the theory of brain-based learning.

This research was conducted in the AJK region to enable the researcher to generalize the results to a larger population. AJK has a sizable population that shares similar cultural and educational norms, making it an ideal setting for studying cognitive and brain-based processes. The homogeneity in these factors allows for the extrapolation of findings to broader populations with similar socio-cultural and educational backgrounds, increasing the relevance and applicability of the study's outcomes. This approach ensures that the research findings are not only specific to AJK but can also apply to other regions with comparable demographics and cultural contexts.

1.2 Statement of the Problem

The traditional teaching method, which relies heavily on textbook-based learning is commonly practiced at the elementary school level. It only promotes rote memorization of facts and often leads students to focus on memorizing and reproducing content word by word. General Science is included as a compulsory subject in the curriculum at the elementary level. The major objective of teaching General Science is to enhance the critical thinking of students about scientific knowledge. In General Science subject, lack of laboratory work is reported at elementary school level. The General Science textbook is a practical subject that demands innovative techniques for teaching and learning for content understanding. Students learn General Science only through traditional method and there is no practical work. In present scenario, practical task accomplished by the students either note taking or verbally answer to their teacher. It is the core problem at elementary level which results less critical thinking and students' low academic achievement in General Science subject. Therefore, to address this issue, the brain-based method is proposed as an alternative, focusing on replacing rote memorization with concept-based teaching and learning, thereby promoting meaningful understanding. The aim of this study was to examine the effect of brain-based method on enhancing critical thinking and academic achievement among elementary level students in General Science.

1.3 Significance of the Study

This study can be helpful for General Science teachers working at elementary level to make them aware about which teaching method could be more appropriate and valuable for elementary level General Science students. This study can also be supportive for General Science teachers to plan, organize and implement their instructional methodologies which may activate the learning of their students through this method. In the light of this study elementary General Science teachers may be able to improve their teaching strategies. This study can be significant for teachers and students to address the lacks in critical thinking skills. The findings of this study can be important to improve the vision of school administration to promote interactive enviornment in the classrooms to improve critical thinking of students. The findings of the study maybe fruitful in revising the General Science curriculum. The practicak work may be inculcative in General Science textbook in view of the finding of the study.

1.4 Objectives of the study

Following were the objectives of this study:

1. To determine the effect of brain-based method on students critical thinking in General Science at elementary level.
2. To investigate the effect of traditional method on students critical thinking in General Science at elementary level.
3. To compare the effect of brain-based method and traditional method on students' critical thinking.
4. To examine the effect of brain-based method on students' academic achievement.
5. To explore the effect of traditional method on students' academic achievement.
6. To compare the effect of brain-based method and traditional method regarding students' academic achievement.
7. To compare the effect of brain-based method on students critical thinking and academic achievement.

1.5 Research Hypotheses

Following were the research hypotheses of this study:

H_o1: There is no significant difference in the mean score of students critical thinking taught through brain-based method.

H_o2: There is no significant difference in the mean score of students critical thinking taught through traditional method.

H_o3: There is no significant difference between the mean score of students critical thinking taught through brain-based method and traditional method.

H_o4: There is no significant difference in the mean score of students' academic achievement taught through brain-based method.

H_o5: There is no significant difference in the mean score of students' academic achievement taught through traditional method.

H_o6: There is no significant difference between the mean score of students' academic achievement taught through brain-based method and traditional method.

H_o7: There is no significant difference between the mean score of students' critical thinking and academic achievement taught through brain-based method.

1.6 Delimitation of the Study

The current study was delimited to the students of 8th grade from District Kotli Azad Jammu and Kashmir, Pakistan. Through purposive sampling study was delimited to 60 elementary school students at Government Boys High School Panag Sharif district Kotli. The study was delimited to four chapters from the textbook of General Science, including i). Reflection and Refraction of Light ii). Electricity and Magnetism iii). Technology in Everyday Life and last one was iv). Our Solar System.

1.7 Operational Definitions

Academic Achievement: It is the measurable success of a student in educational activities, typically assessed through grades, test scores, and the ability of the learner to apply new knowledge or skills in academic settings, reflecting the student's overall educational progress and performance.

Brain-Based Learning (BBL): Brain-based learning involves an instruction that takes into account teaching concepts based in brain anatomy and physiology, focusing on the associations and the mechanisms of information processing of the brain. It also encompasses resources and techniques developed based on these principles for various

learning processes. Learning always takes place in a natural setting as the brain is ready to carry out its basic and regular functions. It is basically a collection of different exercises that are founded and based on research about the brain. It contains of all required learning goals, required resources, and different techniques based on the idea regarding brain-based learning and for use in diverse learning situations and processes.

Critical Thinking: The practice of assessing claims, incidents, viewpoints, and arguments is known as critical thinking. It evaluates the legitimacy, authenticity, and correctness of data. It is the evaluation of claims using recognized standards. It evaluates the significance and veracity of an existence. It requires exact, persistent, and impartial analyses.

Lecture Method: The lecture method refers to a traditional teaching approach in which the teacher delivers information or instructional content verbally to students in a structured manner, typically without active participation from the students.

1.8 Conceptual Framework of the Study

In this study the conceptual framework shows that the researcher followed Caine and Caine's (1991) three basic Brain-based Learning principles. The researcher used three brain-based learning strategies such as Formal or perceptive regulator, Brainstorming strategy and Strategies of KWL and three BBL teaching techniques such as Indulgement, Relaxation and Active processing to measure critical thinking and academic achievement of General Science students. The main variable of this research study was the brain-based method. Above discussed three basic principles were measured through subject achievement and critical thinking tests. The researcher determines the effects of brain-based learning on critical thinking and academic achievement of students in the subject of General Science at elementary level.

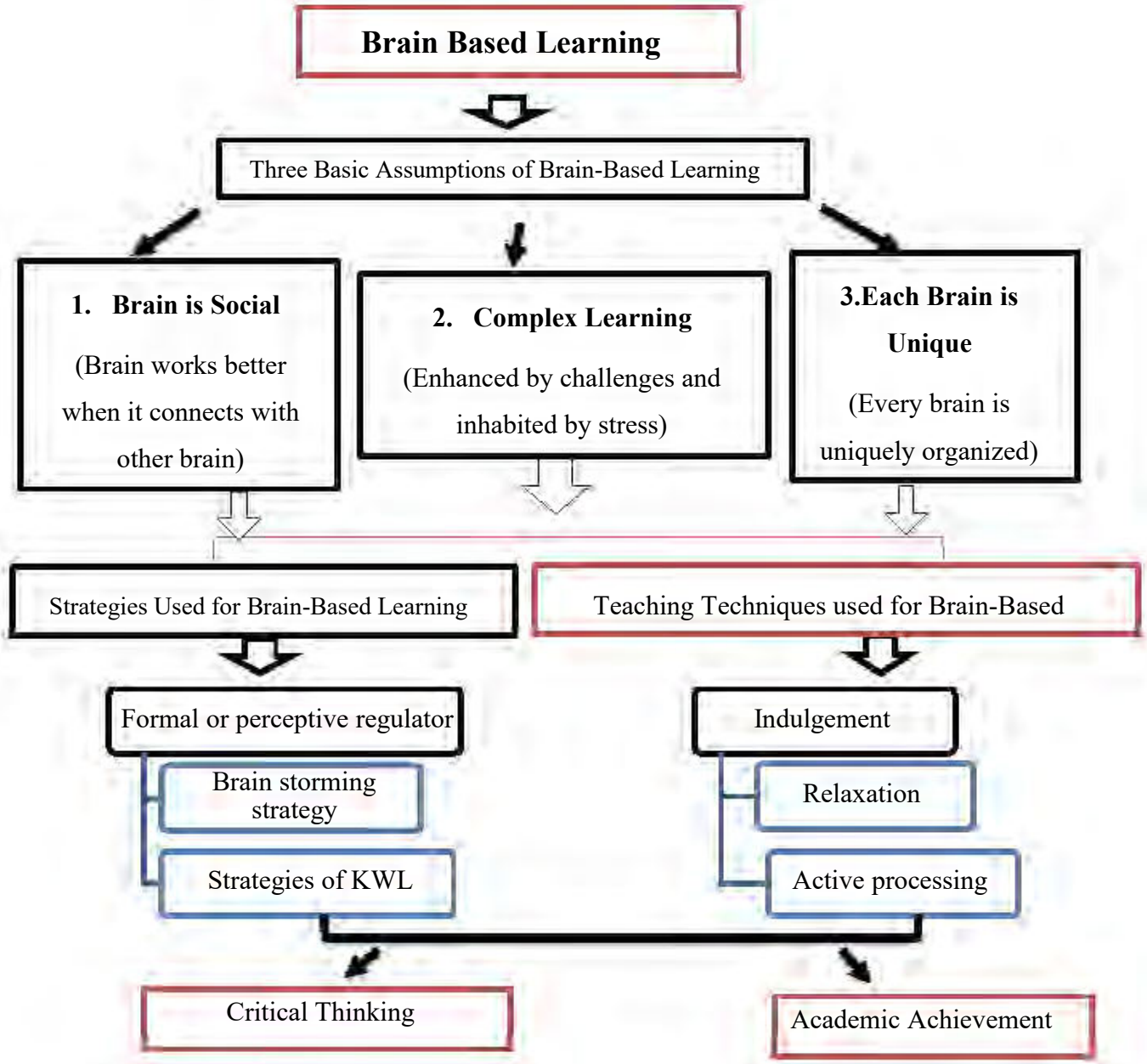

Figure 1.1: Conceptual Framework of the Study

CHAPTER 2

LITERATURE REVIEW

A literature review is a study or survey of scholarly resources on any specific topic, and it provide help to the researchers for searching relevant topics or familiarizing with such research as well as identifying problems and exploring gaps in any particular area. It may provide a review of latest and current knowledge and data for the identification of various methods, approaches, theories, and gaps in existing research in order to increase and enhance knowledge of current research in any field before undertaking new research or investigation. It allows researcher to explore what has already been conducted and find out what is unidentified about the topic.

2.1 Concept of Brain-based Learning

The natural functionalities of any brain can be unstated through the main components of brain-based theory. The concept of this theory has been elaborated and defined in various ways by the thought-provoking efforts of many educational psychologists (Vosskuhl et al. (2018). According to Deepa and Seth (2013), education can only occur if the brain does not hinder its normal functioning and proper development. Education is constructed with the correct formation and convenience of the brain. Duman (2010) stated that each learner can be taught through a specific teaching process that facilitate them to revolve around in a natural way for the collection of evidence.

2.1.1 Defining Brain-based Learning

Brain-based teaching learning is a process that considers how individuals' brain processes information in a meaningful way and makes connections (Duman 2007). This concept was defined by the various researcher such as Bonomo (2017), Jensen (2008), Ozden and Gultekin (2008), as teaching learning process of everyone must be based on the physiology of their brain, the natural environment, and collective intelligence, personal, common sense, part of various learning techniques, approaches and styles, and variations in authentic learning, complexity and reinforcement considered as balanced learning.

Pennington (2010) defined brain-based learning as a comprehensive and balanced approach rooted in current neuroscience research on natural brain learning. This teaching-learning process emphasizes obtaining meaningful information through idea exploration. Individual conceptual understanding is vital for cognitive development, and this learning integrates brain skills with individual common sense.

Karen (2005) defined this type of learning as utilizing diverse learning methods to stimulate the brain, encouraging better learning strategies for individual improvement. It's considered an effective method that maximizes the natural functions and resources to strengthen and improve the spatial retention ability to improve and promote knowledge and required skills. Essentially, it's applying key principles to deepen our understanding of how the brain functions in educational settings.

Recognizing the brain as social, possessing the intelligence, and thriving in collaborative learning environments, brain-based learning focuses on planning such instructional techniques or strategies that align with the environment and students need, to stimulate attention, emotion, and memory areas (Schonert-Reichl, 2017). Implementing a brain-based approach in teaching learning is a multifaceted process requiring the adoption of various strategies that foster natural learning, allowing learners to gather information organically. Erlauer (2003) noted that brain-based teaching strategies or techniques are always effective because they align with practicality and empower pupils to learn without fear.

Murniati et al. (2023) stated that possibility of education is rely only when the brain's normal development is not hindered and is shaped appropriately, a development termed brain-based learning. Similarly, other researchers view BBL as an inclusive teaching that based on the brain's natural learning mechanisms, not just a simple program. As per Purwati & Handayani, (2022) found in their research study that different teaching methods are beneficial for different students and they can learn better through theses method and enhance learning processes that based on natural functions of their brain for the purpose of improvement in learning.

Erlauer (2003) also proposed BBL as a friendly educational skill achieved by stimulating the collective intelligence of peers and mentors within a supportive environment. Furthermore, BBL, as defined by Craig (2003), encompasses the accurate

philosophical and neuro-scientific foundations that compatible with brain teaching. Craig (2003) argued that brain-based teaching and learning techniques overcome the limitations of traditional education, where rote memorization often prevails over brain-aligned learning activities, a practice favored by some teachers due to its perceived ease.

Banner and Cannon (2017) described traditional teaching methods as often relying on verbal encouragement with minimal learner involvement in preparing classroom activities or presenting new concepts and lacking connection between new and higher-level concepts. Concept based learning as a form of brain-based learning, helps to restore different learned knowledge by offering a hands-on method that leverages the brain's natural abilities, strengthening memory and skills (Davis, 2023).

BBL also found to be an evocative collection of key ideas that represent our common sense understanding of perspective construction (Karen, 2005). Wiklund-Hörnqvist (2014) defined brain-based learning as the basis for regulating true learning complexity, enhancing and adapting understanding; on this basis, learners can understand questions easily and extract the meaning of other concepts; such explanation is largely derived his research work on brain-based education.

2.2 Theoretical Review about Brain Based Learning

Brain learning is based on normal functionalities and activity of brain. It differs from the traditional educational approach, which focuses on memorization only. Brain based learning emphasizes on conceptual and meaningful learning that involves learners in decision making, applying knowledge and building collaborative groups in a meaningful way. Caine and Caine (1995) used descriptions, figures, and demonstrations to describe active tolerance and uncertainty of ambiguity, questioning, problem solving, and forming relationships, and some of the brain’s features in the terms of learning.

2.3 Origin of Brain-based Learning

As the non-unification of the brain-based education as a single concept (which would appear in all references under the same name) indicated that, it is difficult to establish the concrete country and a year when brain-based learning was born. According to Reiner (1990) BBL term was first time used by Paul MacLean in 1970. One of the most influential was the book by Tony Buzan: Use Both Sides of Your Brain

(1983). In 1990's Leslie Hart published the book "Human Brain and Human Learning (1998)" which recognized the important connections among functionalities of brain and conventional practices in education (Jensen, 2008). It is also important to mention Geoffrey Caine and Renate Caine whose works such as "Making Connections: Teaching and The Human Brain (1991)" deeply marked brain-based education.

2.4 Brain-Based Learning and Neuroscience

In simpler terms, Bear et al. (2007) explained neuroscience as the scientific study of the nervous system. "It is a natural fact that human nature is curious about what and how we see or hear, why some belongings hurt us or hurt others, how we move forward, how and why we reason, learn new things, remember something or forget an important thing sometime, the nature and reason of our anger and madness. These are most probably some mysteries which are initial to be discovered and might be the focused area of basic neuroscience research". Neuroscience highlighting its interdisciplinary nature, requiring insights from the field of medicines, biology, psychology, chemistry, physics, and mathematics to understand the nervous system.

Neuroscience is considered as a distinct and new field of study. In the field of experimental biology the largest professional scientist's association, named "The Society for Neuroscience" which was founded in 1970 (Bear, et al., 2007). However, the neuroscience was the sub field, which have deep impact on brain-based learning. Cooke and Bear (2010) indicated that neuroscience has a broad scope, with research into reasoning, learning, remembering, and forgetting being particularly significant for brain-based learning. Cognitive neuroscience is the sub area that encompasses these aspects of the human brain. Cognition, involving every action and process of mind in receiving or understanding of meaningful information through self-experience and intelligences, is studied by the cognitive neuroscience in a biological perspective.

Social neuroscience is another branch incorporated into education through brain-based learning, examining how biological process influence social and emotional behavior (Siegel and Sapru, 2006). Louis Cozolino (2013) research on the social neuroscience of education, noting that brain-based learning uses different findings from cognitive neuroscience to education. From his viewpoint, social neuroscience that is not adequately measured by the brain-based education.

The human brain must be recognized as a social organ of adaptation which is unfortunately not properly discussed. If brain is considered as adaptation organ it means that the brain must interact to learn how to navigate its natural settings for the purpose of learning and its survival. If brain is considered as social organ, which simply reflect that humans interact with other in order to establish a strong connection and also make a strong link with other brain to create emotionally significant relationships. He might have missed the fact, that brain-based learning strategies highlight socialization and cooperative learning (Fratangelo, 2015). Kagan's (2014) principle for brain-friendly teaching which is called "Social" and which "promotes social cognition" in the class. The second example might, from the first sight, support Siegel's idea. It is true that Jensen did not devote any chapter uniquely to how socialization has an impact on human brain and learning. However, he concerned the role of a teacher. One whole chapter was dedicated to "Teacher Communication" (Jensen, 2008).

According to Doyle (2023) our learning ability is mostly controlled and planned by how our teachers treated us. If we considered this statement it highlights to "emotional atonement between teachers and learners" is considered, Jensen's contribution to brain-based learning does not forget to imply social neuroscience too. Also, Jensen (2008) admits that all brain-based education has one basic principle: "the brain is designed for survival" which correlates to some extent with Siegel and Sapru's (2006) citation that "the brain has progressed to learn that how we can navigate the environment for the purpose of our survival".

To summarize the content, the definition of brain-based learning can be discussed and its origin and the disciplines serving as principal sources for its principles. This type of learning is learning with a brain in mind which incorporates the strategies based on principles from neuroscience to make best decisions regarding the learning process. It has become to emerge in the 1980's and the country in which this educational approach has the strongest foundation is the United States (Davis, 2023).

According to Škrhová (2017) Neuroscience, especially its sub disciplines represented by cognitive neuroscience and social neuroscience by Kagan's and Jensen's approach demonstrates that social neuroscience also plays an influential role in brain-

based learning) bring such knowledge and findings for brain-based learning so it may be claimed that this educational concept is scientifically based.

Dehaene (2021) research “how we learn” explored that the brain's mechanisms of knowledge acquisition, focusing on four key principles such as attention, active engagement, repetition and feedback. He argued that learning is a dynamic process driven by the brain's neuroplasticity, which allows it to adapt to new challenges throughout life. Dehaene emphasized the importance of the prefrontal cortex for cognitive control and explains how sleep, emotions and motivation are essential for memory consolidation and learning effectiveness. His work also emphasized the value of active, deliberate practice and spaced repetition in skill acquisition. By aligning educational practices with these cognitive principles, Dehaene advocated a more evidence-based approach to teaching that promotes long-term learning and development.

The concept of preparing the brain for learning is a fundamental aspect of brain-based education, which focuses on optimizing brain function to improve the learning process (Jensen 2005). Dehaene (2021) pointed out that there are several key factors that help prepare the brain for effective learning:

Hydration: The brain is extremely sensitive to dehydration. Even mild dehydration can impair cognitive and reasoning functions like attention, memorization, and problem solving. Ensuring that students are adequately hydrated before studying can significantly improve the ability to concentrate and process information.

Proper Nutrition: A balanced diet plays a vital and important role in functions of brain. Necessary nutrients, like omega-3, acids, antioxidants, and different vitamins are supportive for the brain's cognitive abilities and help improve focus and memory. Eating a nutritious meal before studying can ensure your brain has the energy and building blocks it needs to function optimally.

Adequate Sleep: Sleep is considered very crucial for memory strengthening, learning, and overall brain health. For elementary school students especially, adequate, quality sleep is important for improving attention, memory, and problem-solving skills. Sleep

helps "consolidate" knowledge gained throughout the day, and lack of sleep can impair cognitive performance.

Exercise: Physical exercise, especially aerobic exercise such as running, swimming, and cycling, have a significant effect on intellectual and reasoning functions. Aerobic exercise has a wide range of cognitive benefits that directly enhance the learning process. By improving blood flow to the brain, stimulating neurogenesis, releasing beneficial neurotransmitters, and reducing stress, aerobic exercise can improve attention, memory, and complete function of brain, make it a valuable tool for enhancing learning, both in children and adults. Regular exercise increases blood pressure that is beneficial for the brain and can also promote the growth of new nervous connections and improve memory and learning. Physical activity before studying can improve attention, focus, and memory, helping students perform better in class (Donnelly, et al., 2016).

Overall, priming the brain through proper hydration, nutrition, sleep, and exercise is essential to creating an optimal learning environment. These practices support brain health and cognitive function, making it easier for students to absorb, retain, and apply new information. This approach is particularly important in brain-based education, which integrates neuroscience findings to improve educational practice and outcomes (Dehaene, 2021).

2.5 Components of Brain

According to Tanaka et al. (2020) the brain is divided into three main parts and these parts of brain are responsible to control the body functions.

2.5.1 The Forebrain

In vertebrate brain anatomy, the forebrain is the rostral (most frontal) and largest part of a brain. The Forebrain is basically responsible for regulating body temperature, reproductive function, diet, sleep, and emotional expression. During early nervous system development, the forebrain, along with the mesencephalon (midbrain) and hindbrain vesicles, constitutes the three primary brain vesicles. By the five-vesicle stage, the forebrain differentiates into the diencephalon, which includes structures such as the thalamus, hypothalamus, and epitheliums, and the telencephalon, which develops into the cerebrum (Davis, 2023).

The cerebrum is composed of the cerebral cortex, underlying white matter, and the basal ganglia. In human embryos, at approximately 5 weeks' gestation, a distinct portion of the forebrain can be observed. During the eighth week in utero, the forebrain divides into left and right cerebral hemispheres. The average brain size is just a quarter in fetus at their birth to the average adult size. At the age of 25 to 30 brain complete their development. The development of brain is called neurogenesis. It is first process of brain development and completed before baby birth. Holoprosencephaly occurs when the embryonic forebrain does not properly divide into two hemispheres. This condition results in the incomplete separation of the brain's lobes during early development, leading to a range of neurological and structural abnormalities. The parts present in the forebrain are the cerebrum, thalamus and hypothalamus (Swanson, 2000). The forebrain further divided in the following parts:

2.5.1.1 Thalamus

Thalamus is a small structure of brain located on right side of brain. It carries sensory information from limbic system and cerebrum. It carries visual, auditory and tactile sensory information. This part of the brain helps to organize the outward display of emotions as it involves selective choices. It has further divided into two parts and these parts perform different functions such as the right part provide assistances to focus on the essential image and on the other hand the left part is responsible to guides the mind to interpret different phenomena, structures and things into understandable words (Cozolino 2013).

2.5.1.2 Hypothalamus

It is the smallest and most important part of brain. It is an almond sized part of brain. In human it is present at the center of the human body. It controls maximum body functions. It is present just below the thalamus. This part of the brain responsible to regulates body temperature and other biological simulators such as thirst, hunger, sleeping. It also controls secretion of hormones and menstrual cycle. It helps in balancing water in body (Cozolino 2013).

2.5.1.3 Peripheral

This is also an important part of brain that processes and control the emotions and emotional involvements. This part of brain is located outside of central region of brain (Fratangelo 2015).

2.5.1.4 Cerebrum

According to Kagan (2014) cerebrum is the large part of our brain which contains various nerve centers involved in sensation, movement, and responsible to perform major operations such as memory and thinking. The brain has some curvature (bending) on its surface called convolutions and further divided into further two different halves. The two hemispheres of the brain operate in a complementary manner: for example, the left hemisphere is responsible to controls the functions of the body on the right side, won the other hand, the right hemisphere of the brain is responsible to controls the functions of the body on left side. The bands of axons that helps in communication of these two halves are known as carpus callosum.

There are 10 billion of neurons are presents in this part. These neurons communicate with each other through large axons bands. The outer part of cerebrum is cerebral cortex. Cerebral cortex is in folded form which is called convolution and have large surface area. Cerebral cortex plays an important role in control of sensory information and process on it and respond them. It involved in control of reasoning, judgment intelligence sutures between the convolutions of the brain divide each hemisphere of the brain into lobes, like connected skulls. These lobes are known as follows: the temporal lobe that contains functional areas such as the auditory cortex, the parietal lobe that is involved in processing sensory information and integrating various sensations; and the occipital lobe, which is primarily responsible for visual functions (Kagan 2014).

2.5.2 Midbrain

This is the middle part of brain. It presents between forebrain and hindbrain. It contains of relay center of auditory and reflexes of eyes. It has reticular structure means screening of sensory information. This part is responsible for the activation of brain reflexes, basic processes of attention and control, such as eyes blink and sudden head

movements. So many problems of understanding and problems and difficulties in learning are addressed by this part of brain (Doyle 2023).

2.5.3 Hindbrain

According to Doyle (2023) hindbrain is an important component of brain and further divided into three parts. It controls all the functions that are important for survival. These are breathing, heartbeat, sleep, wake and motor learning.

2.5.3.1 Cerebellum

Cerebellum in brain is always located behind the arch. This part is responsible to receives incoming messages or information about the state of the body and limbs. The brain part also receives messages about the required state of these limbs and sends coordinated messages to the spinal cord. All of such process effects on the contraction and relaxation of skeletal muscles. Cerebellar damage can cause reflex muscle contractions and uncontrolled voluntary muscle movements in addition to loss of balance (Swanson, 2000).

2.5.3.2 Arch

Arch consists of various centers that work in coordination with medulla oblongata in order to regulate the rate and complexity of breathing (Swanson, 2000).

2.5.3.3 Medulla Oblongata

The medulla oblongata is a critical part of the brain responsible for regulating vital functions, such as blood circulation and breathing. Damage to this area can be life-threatening. The brain is based on two main types of cells such as neurons and glial cells. Neurons, which account for about 10% of brain cells, are crucial for learning and cognitive functions. The remaining 90% of brain cells are glial cells, which support and protect neurons. Gluteal cell plays a supporting role in expelling dead cells, regulating immune system function and providing better protection for the brain, transferring nutrients and forming the blood-brain barrier (Doyle 2023).

2.6 Basic Functions of a Brain

The human brain is made up of parts that work independently and collectively. Many research studies have shown that when extra zones of brain are implicated in learning, the chances of forming long-term memories are greater (Bender and Waller,

2011). There are no clear managerial profiles for students with autism spectrum disorder (ASD). However, failing groups prevail (Posick, 2016). Nevertheless, of performance, whether low or high performance, memory is constantly changing (Chantiluke, 2015). Arousal, sensory modulation, and attention have all been implicated in ASD (Schoen, 2009). The major factor in designing appropriate instruction is understanding how to regulate memory and recollect are organize information in meaningful way.

2.6.1 Memory

The long-term storage in the brain is called memory and temporary processing of information together in a work is called the workload of memory. Brain load includes what actually needs to be learned, while load involves the brain's inherent ability to understand how the parts fit together to form larger ideas and concepts (Kalyuga, 2011). Practice and repetition strengthen the brain's abilities due to increased access.

The use of media enhances the delivery of certain messages. Van Merrienboer and Sweller (2005) suggest that the average person can retain approximately seven items, with only about four pieces of information being actively utilized and processed. This limitation in memory capacity affects both conscious and unconscious thinking and reactions. According to Merrienboer and Sweller (2005), long-term memory does not have strict limits on the amount of information it can encode. By reducing cognitive load—both extraneous (external) and intrinsic (internal) demands—working memory capacity can be increased, which in turn improves the ability to retain more information as the long-term memory and when more information is reserved in the long-term memory that can reduces the amount of space needed for new information.

Different studies pointed out that biological organisms to environmental stimuli (Bakker, et al., 2015; Scarpa, 2015). Reactions to known events are more conservative than planned responses, whereas conceptual responses require formative thinking. According to Porter, et al. (2013) one brain task may influence responses to another activity or task. This develops an understanding about the intrinsic memory formulation. Without using conscious thoughts different activities such as coughing, eating and walking are different aspects of long-term memory.

Kessler (2020) remarked that when brain load increase it reduces or prevents the learning of new responses acquired through instruction, while responses resulting from activation of stimulus response types remain unchanged. When the brain is under more stress, learning that is based on stimulus reaction is irreversible.

Memories that are not easily recalled, cannot be searched, or do not fit into a larger picture of information fall under the category of direct access memory. This information is typically incorporated into the plan through practice, although this is not always the case. The more the brain exercises these responses in each target, the faster the response retrieval time, resulting in increased long-term memory for correctly accessed memories. Although direct access memory has limitations, it cannot be activated long-term (Campoy 2017; Liefooghe, 2013). Increased coupling and usage mean less direct access memory. The amount of information one attempts to convey depends upon the amount of training and the person's focus in teaching.

During periods of high cognitive demand, active long-term memory is less susceptible to loss, which reduces overall effort and allow the brain to manage other tasks (Leifoghe, 2013). To achieve appropriate memory capacity and effectiveness, it is crucial to understand the inner workings of memory.

2.6.2 Arousal

Arousal which linked with behavior and alertness is a basically physical structure (Kleberg, 2015). Understanding how our brain achieves and recovers from specific states, and how related behaviors influence learning, is crucial for establishing effective educational practices. The brain’s autonomic nervous system can play a key and vital role in sustaining and adjusting states of arousal (Cavazzi, 2014). This system acts as a natural defense mechanism, where the perception of a negative stimulus or a particular set of stimuli triggers an automatic response.

Gerber (2005) remarked that educational institutions must identify students' needs which must be based upon their ability to respond effectively to stimuli that align with the expectations of the school is crucial. in the classroom and tolerate with school staff. Social conditions commonly include verbal, visual and physical stimulation. Orekhova and Stroganova (2014) discussed in their research and linking arousal and social cues. Emotions often play a role when it comes to socialization. Changing the

nature of social contact requires arousal and its role in changing emotions and moods**.** (Scarpa, 2015).

Reactivity simply refers to a one's response to emotional stimuli, while moderation refers to how a person changes responses to changing situations (Scarpa, 2015). Social anxiety involves students' instinctive reactions to social connections. In this case, students act autonomously in social situations when their socially motivation and interaction is low and want to comply with social norms (Melnyk, Carrillat, & Melnyk, 2022). This personality state often leads to increased levels of victimization due to harassment, a creative force that enhances nervousness to responses (Scarpa 2015).

If, over time, anger creates and eradicates negative stimuli than the stimulus responses become generalized or habit-forming. Sensory Overreaction (SOR) and Sensory Hyper responsiveness (SHR) present a dual problem for students in that they are naturally at risk of overreacting to the initial stimulus, but they are also at risk of overreacting to the stimulus, and in most cases, high on depression and anxiety (Brindle, 2015). To learn and learn the material, students must also deal with shortcomings that impact available study effort.

2.7 Philosophical Foundation of Brain Based Learning

It is observed that from ancient times, humans were interested in unraveling the mysteries and anonymities of the brain. From that time philosophers such as Socrates, Plato, and Aristotle and many others were not considered the brain as the central body part of human and their cognitive processes (Fatima and Ali, 2020). Many research studies explored that both mind and body are complete and complex entities, whereas the ancient Greeks philosophers believed that these all soul, mind, and spirit were not only complete separate but independent as well (Bakhurst, 2008).

The two renowned philosophies of 'realism' and 'idealism' proposed by Aristotle and Plato in the Greek era combined to explain the true concept of things. Sensory signals can come from thoughts we already have in our heads. This means that the functions of the brain help to recognize facts and actual images of all things that are related directly with us or with our affairs. These both mind philosophies clarified the

role of brain in individuals' life. The concept of individual body and brain was discovered from past ancient times, they were not regarded as a separate field or subject and considered an individual as a whole. All these schools of thought discussed about the brain through the work of Descartes, gave birth to another philosophy of mind called Interactive Dualism." The ultimate connection between the physical and mental problems of everyone were discussed in this school of thought and all of these were directly related to each other (Eberwein, 2001).

Many research studies highlighted that Descartes accepted that the idea of oneself is straightforwardly connected with mental factors and proposed the magical idea of dualism, which comprehend the body as something separate from the brain (Hattie, 1999). Descartes also observed that the brain was analogous to a machine that perform specific and special functions that could be explained only through scientific laws of behavior. On the other hand, feelings and emotions were ignored because they were not relevant to life and were thought to be pointless (Damasio , 1999; Honey, Dwyer & Iliescu, 2020).

After point-by-point hypothetical investigations of soul body connection in the twentieth hundred years; in view of perceptions, the issue of body-mind cooperation can be additionally made sense of through the accompanying two parts of reasoning of brain:

1. Materialistic attitude toward individual body and mind

2. The dualism of individual mind and body (Dossey, 2013).

Nonetheless, the above philosophical components of the brain do not exactly describe the role of the brain in human existence, accordingly, creating numerous inconsistencies and debates with respect to the communication of each brain and body. As a result, these arguments have been around for a long time in cognitive philosophy.

1. The mind-body problem of "Russian monism"

2. Voluntary Theory on the Phenomenology of Consciousness and Passion

3. On the concept of consciousness (Kriegel, 2023).

These current and well-established debated in way of thinking of brain have laid out that the issue of brain body association has really been addressed through the force of realist and dualistic ways to deal with individual brain connections. Research has found that there are species whose brains have been exposed to our world, and if physical matter did not have species of its own, our world would not have species with brains (Kriegel, 2023).

This can be explained by the idea that we would be able to comprehend the value of anything if we could only recognize its physical appearance. This idea is called realism; however, it is the inverse; one more idea arose in the way of thinking of psyche called the idea of dualism. Clearly, the underlying physical characteristics of a particular brain structure determine the personality of that structure (Gottlieb, 2023).

Kriegel (2023) remarked that the actual presence of different things that show up in a particular brain is not what is completed on the grounds that there are numerous things or thoughts to us that don't have an actual presence, however we feel their excellence and presence. Grasping, creative mind, feelings, and sentiments are connected directly with different brain parts; however, all have no actual appearance. These are the reasons that the existence of person's imagination cannot deny by dualism and considered feelings, emotions, and emphasizes the many characteristics of the mind that, although they do not exist in the body, are directly related to the mind and body of everyone.

Therefore, it can be said that whether it is the complexity of conceptual materialism or dualism, the profundity and difficulty of its complexity can be seen. These constrained associations among possessiveness and separation have disappointed psychological scholars, who committed themselves late to finding new and creative procedures for mind-body connections between people (Kriegel, 2023).

It was found that in many studies that devising a materialistic perspective that describes the difference between knowledge and matter. It has been also observed that dualism can help to overcome causal thinking relative to matter. Therefore, from a sociological point of view, one supreme and effective strategy can be emphasized, that is "Russian monism" (Kriegel, 2023). If we considered this idea, the universe contains some very special properties. To be sure, the concept of "Russell's monism" has the

original spirit and original properties of physical objects. Understandably, the previous aspect described the gap between two different dimensions of the philosophy of mind, while the lateral aspect addresses the complexities of individual's brain inactivity (Kriegel, 2023).

It turns out that philosophy of mind was not easily understood until the end of the 20th century, because here long discussions of the complexity of mind-body interactions generated many questions related to personal intention and consciousness. (Uriah Kriegel, 2023). It was observed that in the tracking approach to intentionality, there is a relationship between the physical part of the brain and its environment. Direct physical link. It consists of three levels of understanding, the first of which concerns the nature of purely materialistic "naturalistic" intentions. Intentionality or "representational" theories of consciousness for subsequent and third-level understanding involve reductive articulations of perceptual knowledge. The cooperation of intention and consciousness could be directly associated to the materialism. Thus, these both are balanced with materialism on mind-body issues (Giustina & Kriegel, 2024).

Research has found that the nature of emotional experience is a key aspect of our consciousness. Our temperament is seen as an important test of consciousness, many of the senses seem less objective. The Greek philosopher Hippocrates developed the concept of human genius as a mixture of four complexities. As per Greek philosophers, individuals have this tendency determined by their passions and may base on their mood.

1. People with enthusiasm and positive personality are called optimistic.

2. Sad people were considered as melancholic people.

3. Aggressive and angry people were called choleric.

4. Phlegmatic people are calm, cool and passive (Kriegel, 2023).

The phenomenology of our complexity is based on the single entities of body and brain, interconnected in ways that they subjectively affect us. A largely scientifically inspired doctrine known as "naturalism" explains important ideas about

the brain and mind as terrestrial phenomena. It attempts to describe the essential structure or functionalities of the human brain (Tennant & Musolesi, 2024). This naturalistic approach to the brain helps to analyze physical and mental stress states through path-based methods that sense the brain's intentions in an individual's life. It has been observed that contemplation without judgment is not tolerated and when it is found that thought always has a direction and always has its absolute, such a concept is termed as personal thought process (Schaafsma, et al., 2015).

It was noticed that there are different philosophies of reasoning that are directly connected with the design and capability of the brain, for example, induction and natural selection hypotheses that concentrate on the mind were directly connected with brain-based learning. It was additionally seen that information about the climate and self-discernment is created using the five faculties and the perspective, which is delineated in the cerebrum during human learning (Porter et al. 2013).

This concept is directly related to the theory of empirical psychology that Locke worked to develop in the 19th century. Likewise, another psychological concept has been proposed to explain the continued development of individuals as dependent on environmental adaptation, a thought-provoking concept that directly fits Darwinian survival (Masten, 2012).

Similarly, the concepts of unconsciousness and consciousness appear in modern brain research because it clearly describes the role of the brain in individual thinking and learning processes. These two intellectual qualities of man were demonstrated in the 19th century. This is the explanation that Freud's theory of the "unconscious" is viewed to act as an illustration of the steadily growing light between the mental and cognizant parts of a singular's insight and understanding. This unconscious idea the occasionally confuses our profound life, which likewise straightforwardly connected with our feelings and brain capabilities. The consciousness or its value can be understood and discussed from several perspectives, such as the concepts of consciousness and unconsciousness in relation to ethical and moral considerations of our life. From a social perspective, it makes our lives interesting and valuable (Kriegel, 2023).

Therefore, the cognitive significance of this knowledge is more important than not only from personal perceptual knowledge but also from self-knowledge. From this it can be concluded that consciousness, awareness and pseudo consciousness is directly related to materialist philosophy as all these aspects of the brain confirm the physical properties of the brain as an individual. Research has also found relatively small physical differences between unconscious and pseudo-conscious mental states. Therefore, this aspect of the brain plays a neural role in explaining materialism and dualism (Shahzadi, et al., 2024)

Kant's constructivism philosophy is another important philosophy of mind considered as the backbone of the unique learning or teaching process. According to this philosophy, understanding and learning occurs through daily life experiences, where the human brain acts as a filter, processing some information from the five senses in the form of input and then organizing and developing it into a structure. Through these structures, humans understand a certain body of knowledge about their environment. All these types of structures change over time in human life (Kriegel, 2023). Finally, the philosophical basis of brain-based learning could be concluded as all the philosophical ideas, such as idealism, realism, dualism, materialism, naturalism, consciousness, the unconscious and conscious aspects of the brain that constructivism are related with brain-based learning.

2.8 Psychological Foundation of BBL Theory

The researchers focused on the practical arguments regarding the structure and functions of brain in everyday life, starting with the existence of evil spirits in the human personality. It was seen that in antiquated times they accepted that individual malicious spirits straightforwardly connected to the empty nerves of the cerebrum. This way of thinking about bad spirits likewise embraced Descartes' dualism theory (Hatfield, 2017).

It was found that million years ago, people suffering from this psychological problem were treated with a stone tool that punched holes in the human skull, as these people believed that the brain was compressed in the holes that were formed. After removing the skull, various evil spirits will escape from the human brain. This treatment provoked psychologists' curiosity about how these skulls related to human personality

and gave birth to a field of research that directly interprets skulls and explains people's different natures directly to different parts of the brain (Hari & Kujala, 2009).

Phrenology is a branch of psychology that grew out of researchers' fascination with the human skull. This field makes sense of the state of the skull that is straightforwardly connected with various cerebrum capabilities, as well as the normal mind segments that are straightforwardly connected with run of the mill mind capabilities (Hassan, 2013). Growing curiosity about the brain's structure and its functions has led to the following various psychological theories about the brain:

i. Structuralism

ii. Functionalism

iii. Behaviorism

iv. Cognitivism

v. Constructivism

vi. Multiple intelligence theory

Functionalism and structuralism were used to explain the concepts of consciousness, unconsciousness, and pseudo-consciousness because each of these aspects of the individual brain is directly related to the brain's structure and function. On the other side, there is another psychological dimension of the brain called behaviorism that considered to be a systematic system of behaviors of individuals (Hassan, 2013).

This is why each person’s actions and behavior are directly related to wise practices, personal inducements and responses (Kriegel, 2023). All this also explained that before a clear and systematic stimulus-response association occurs, the psychological process does not have significant existence, because with this association, individual behavior is directly linked. The behavioral concept differs from structuralism or functionalism in that it has four perspectives of recognition or understanding and treats the brain of any individual as a hollow box or black box. These four intellectual perspectives are related to the four rules of Gestalt. These rules tend to negate the

meaning of actions associated with structuralism. Therefore, the following rules play an important role in the behavior.

1. Rule of stability

2. Act of conclusions

3. Rule of closeness

4. The law of similarity (Hassan, 2013).

Researchers view perception and behavior as a whole and this was the reason for psychologists to evaluate brain characteristics. Over time, various learning mechanisms have been understood through scientific revolutions in psychological field. These revolutions changed the way researchers think about the human brain, moving from a behavioral approach to a cognitive approach. This change can be achieved through Gestalt psychology and cognitive awareness. Complex learning mechanisms can be easily understood through brain mapping technology because science has verified that the influence of certain thoughts on learning already exists in the brain. It was noted that the brain-based learning concept was not originated directly from practice, as many psychology theories are used as the basis for teaching and learning (Hassan, 2013). The brain has been studied by different trained psychologists and the results show that following schools of thought is directly related to human learning.

1. Behavioral training: Model learning research proposed by Ivan Pavlov in 1904.

2. The connection between induced and premeditated responses was first suggested by Thorndike in the 1920s.

3 Reinforcement: Introduced by BF Skinner in the 1940 added incentives to respond to stimulus interactions (Kriegel, 2023).

From this it can be concluded that all three learning methods involve behavioral concepts, induction and refutation interactions are core parts of behavior. The study highlighted that this correlation only held true if individuals exercised regularly, otherwise the world would not function properly. Ivan Pavlov also demonstrated the concept of individual intelligence that is directly related to this connection. He explains

that in this type of process, countless links are created in the chain between constructs, and the intelligence of each link depends on the number of constructs (Hassan, 2013).

Additionally, another researcher B.F Skinner, also proposed the reinforcement concept in the form of desires learning connection. Such reinforcement can be in the form of praise, ratings, and rewards etc and it can be in both forms positive as well as negative. Therefore, it recommends the addition of small data, thus shaping and enhancing responses (Woolfolk, 2007).

According to Erneling (2014) another important school of thought proposed by Piaget was cognitivist. Through constructivist, it was believed that learning is directly related to a person's stage of development. He described learning in terms of meaningful connections and specific stages of development. He takes the whole person through the developmental stages of his pre-operational, sensorimotor, concrete and formal operations. He also said that these four stages of development, which he thought are well-developed and well-structured for the process of personal knowledge, are linked to other psychological aspects of a person, like intelligence. Because of this, the theory continues to have a significant impact on curriculum development and teaching practice.

However, this theory has some flaws, as they fail to account for the social and cultural aspects of personal values. Likewise, this school of thought cannot account for individual differences based on individual thinking processes, norms, and culture (Hassan 2013). So, the conclusion about this theory is determined for teachers to obtain knowledge from students. It also showed that teachers play a key role in learning and also responsible for imparting knowledge to students. Although later scientists or researchers believed that children must have intelligence that play a very important role in their learning (Kriegel, 2023).

These observations based on the development of new theories, incorporating new concepts just like individual interaction, self-concept, and intelligence through frameworks like social cognitive theory, self-efficacy, and multiple intelligences (Kriegel, 2023). Consequently, the focus of learning shifts toward the students themselves. Teaching is no longer solely about stimulus-response interactions but also involves understanding and addressing the individual's metacognition. This is best explained by Gardner's research on multiple intelligences in individuals, in which he

stated: "It seems to me that the brain has the ability to process different types of content, but it also has the ability to process one type of content." In short, intelligence (not to mention normal esteem) is probably a special kind of content that humans are designed to display multiple intelligences and to make use of one, but flexible intelligence changes are taking place.

2.9 Three Basic Assumptions of Brain-based Learning

According to Westlin (2023) this learning is basically based on latest research and focus on the question how the brain learns? According to Caine and Caine's (1991) there are three basic principles of BBL which are as under: -

1. Brain is social. (Brain works better when it connects with other brain)
2. Complex learning (This learning enhanced by challenges and inhabited by stress)
3. Each Brain is Unique (Every brain is uniquely organized)

2.10 Brain-Based Learning Principles Proposed by Caine and Caine

According to Nwoye and Temitayo (2022), Caine and Caine proposed following principles:

1. The brain is parallel processor.
2. Learning engages the entire physiology.
3. The search for meaning is innate.
4. The search of meaning occurs through "patterrning ".
5. Emotions are critical to patterning.
6. The brain processes parts and wholes simultaneously.
7. Learning involves both focused attention and peripheral perception..
8. Learning always involves conscious and unconscious processes.
9. We have at least two different types of memory: a spatial memory system and a set of system for rote learning.

10. We understand and remember best when facts and skills are embedded in natural spatial memory.

11. Learning is enhanc by challenges and inhibited by threats.

12. Every brain is unique.

2.11 Educational Implications of Brain-Based Learning Principles

Educational implications of these principles proposed by Caine and Caine (1991), as follow;

2.11.1 The Brain is Parallel Processor

The brain of human is skilled to perform various activities simultaneously. Different thoughts, imaginations, emotions, and presuppositions interact with different methods of information processing and shared social and cultural knowledge.

2.11.1.1 Educational Implications

Productive teaching therefore "orchestrates" the learning experience, addressing all these aspects of brain function. Therefore, teaching process should base on theory and method so that teachers can make overall arrangements. No method or technology can fully capture the human brain diversity. However, teachers provide the necessary framework for this relationship, drawn from the vast array of methods, techniques and approaches available.

2.11.2 Learning Engages the Entire Physiology

The interaction between different parts of our mind is importance to human physiology as a whole. The brain is a physiological organ that follows physiological laws. Learning resembles regular conscious; however, it tends to be obstructed or controlled. The perception and interpretation of experiences are fundamentally influenced by neuronal development, new discoveries, and interactions (Ceylan & Saka, 2022). The brain responds differently to threat, stress, challenge, boredom, happiness, and self-control. In point of fact, education and experience have an effect on brain.

2.11.2.1 Educational Implications

Each and everything that affects work affects the physiological and biological ability to learn. Management of stress, exercise, nutrition and relaxation, as well as other satisfying approaches, should be fully integrated into cognitive processes. As many drugs, both prescription and "recreational", can hinder learning, their use and effectiveness must also be reduced. They understand that attitudes and beliefs, once they become part of the personality, are also physiologically narrow, resistant, or slow to change (Hamre, 2013). Additionally, the suitable study time must be determined on the basis of natural development of the individual body and the brain as well as personal and natural cycles. Two children of the same age may differ in maturity by five years. Therefore, it would be inappropriate to expect an equation for chronological age.

2.11.3. The Search for Meaning is Innate

The search for important and subsequent need to act inside our current circumstance are planned. The human brain's foundation is organized search consciousness. The brain requires and naturally passes commonality while at the same time searching out and answering on to new stimuli (Bada, & Jita 2022). This dual process occurs every waking moment (and, some believe, while they sleep). Other studies corroborate the idea that people are important artists. The formation of inquiry only guided and focused but cannot be stopped.

2.11.3.1 Educational Implications

The training must relate to classroom behavior and the functioning of daily procedures. At the same time, we must ensure that learner curiosity and desire for discovery, and challenge are satisfied. The curriculum as a whole need to be stimulating and meaningful in order to provide students with ample choice. The more such teachings are put into practice, the better. Many programs for gifted children combine rich environments with complex and meaningful challenges, taking these effects for granted. We believe that it is most important that students should be taught in creative ways (Bada & Jita, 2022).

2.11.4. The Search of Meaning Occurs Through " Patterrning "

According to Saleh Al Rasheed and Hanafy (2023) patterning simply refers to the meaningful and thoughtful association and classification of different information in

such style the brain acts like an illustrator and a researcher at the same time as it tries to find and understand patterns that turn into and express its own creative patterns. The brain is liable for seeing and producing examples, and it opposes the burden of invalid examples. The "self-importance" model breaks snippets of data into content that is significant to understudies. At the point the brain's innate capacity to coordinate data is perceived and pretended, a lot of at first irrelevant or apparently irregular data and exercises can be introduced and used.

2.11.4.1 Educational Implications

Students receive information and create meaning in different ways all the time. We cannot stop students from learning, but we can change direction. Daydreaming does not exist in this model as problem solving and critical thinking of students is enhanced throughout the teaching learning process. Although there is still much work to be completed in terms of student learning, the ideal purpose is to present and integrate meaningful information in such way that permits the brain to draw the model they are trying to impose on them. Completion of in time task is not a good model because students are actually doing busy work while their minds are somewhere else. Learners must learn to be effective and create relevant forms through reading approaches, subject-based teaching, curriculum, and other suitable learning approaches (Lagoudakis, et al., 2022).

2.11.5. Emotions are Critical to Patterning

We cannot learn by any means and anything we learn is impacted and organized by feelings and contemplations. As per expectations, individual predispositions and generalizations, levels of confidence are the necessities of social collaboration. Mental and emotional states cannot be separated. Because they aid in the storage and recall of information, emotions are also essential to memory. Moreover, many passions sometimes simply cannot be extinguished. They work on many levels, such as weather. The permanent or emotional impact of any lesson can continue to have an impact on specific events (Olofin & Olojo, 2022).

2.11.5.1 Educational Implications

Teachers are suggested to understand students' feelings and attitudes and make decisions about learning. It might be impossible to escape from the emotional cognitive zone, it is necessary to continuously monitor the emotional climate of schools and classrooms, use effective communication strategies, and allow students and teachers to engage in reflection and metacognitive processes. In general, both on and off estate, the environment should be supportive and characterized through respect and acceptance. Probably the most significant encounters in a substitute's life are transient "critical proceedings," like an opportunity experience in the lobby with a somewhat obscure educator or a "far off" executive. Frequently, these brief exchanges occur spontaneously. The color of a movement depends on “authentic” and deeper support among teachers, administrators, and students (Olofin & Olojo, 2022).

2.11.6. The Brain Processes Parts and Wholes Simultaneously

The brain hemispheres are significantly different. However, the two hemispheres of a healthy person interact inextricably, regardless of whether they speak act, art, music, or mathematics. As a metaphor, the idea of teaching with two brains is most useful because it helps teachers understand that the brain has two distinct but concurrent tendencies to arrange all information. The one is to separate data into parts and the other one is to see or involve it as a progression of all (Harden & Jones, 2022).

2.11.6.1 Educational Implications

When parts or wholes are neglected, it will create a great difficulty for learners in learning. Effective teaching must build understanding regarding different skills progressively over the time, as the learning is collective and incremental. Both the individual components and the overall framework interact and derive meaning from each other (Harden & Jones, 2022). Similarly, equalities and scientific principles must be taught within the context of life sciences to enhance their relevance and application.

2.11.7. Learning Involves both Focused Attention and Peripheral Perception.

The brain receives the message or information and idirectly aware of what the message is and how to address it. It likewise directly ingests data and signs outside the field of consideration. These boosts might be seen as "invisible," like dark and ugly

walls in a homeroom. The peripheral upgrades can likewise incorporate "lights" and downplayed signals, for example, a grin or a slighter body act change that are inside the scope of consideration yet have not yet been intentionally taken note. All of this indicates that when learning or communicating, our brain responds to the integrity of the environment (Khosravany & Amirian, 2023).

The fundamental principle of Lozanov is that every stimulus must be associated, encoded and represented. Therefore, from a single word to a siren, every sound, seen to raise finger, every visual symbol is imbued with multiple meanings. It is intended as a simple question to draw attention to and explore possible meanings. In its context, it refers to the learner's experience and what happened at that time. Therefore, to facilitate learning peripheral information can be organized purposefully (Khosravany & Amirian, 2023).

2.11.7.1 Educational Implications

Teachers may organize material and goes beyond students' attention. Furthermore, to the traditional focus on noise, temperature, etc., they also include visual peripherals such as diagrams, illustrations, project plans, and artwork (including large-scale artworks). Many researchers recommended for teachers to change teaching materials frequently and these changes also reflects in their teaching learning process. Teachers must cater to students' interests and motivations in learning, supervision so that insentient signs are appropriately linked to the importance and value of learning (Johnson, 2015).

One of the reasons is that it's very significant to know what we speak, for example, if we truly compassionate and not pretend to be compassionate, because our intuition is always marked and seen by learners to some extent. Calkin (2009) named "double plane" to describe this inner and outer consistency of people. Likewise, the design and management of schools clearly inform to students that what they are going too learned. In fact, a student life’s every aspect, including community, family, and technology also impacts on student learning.

2.11.8. Learning Always Involves Conscious and Unconscious Processes.

As a student we can advance however much we intentionally grasp (Bada & Jita, 2022). Most incidentally seen signals enter the cerebrum without the student's mindfulness and are totally oblivious. After reaching the brain, this information is delayed in consciousness or affects reasoning and decision-making. So, we try to experience what we experience rather than what we hear. For example, students may learn to sing in key while also learning to hate breathless. Therefore, instruction can be designed to help students primarily from unconscious processes. To some extent, this is completed through peripheral context (as mentioned earlier). All of this is done only through teaching.

2.11.8.1 Educational Implications

Much energy is wasted in teaching and learning because students often do not fully process the experiences while active learning encourages students to take responsibility for both their learning and personal emotional development. This approach involves reflection and metacognitive activities, helping students identify their preferred teaching styles. Additionally, creative elaboration of concepts—such as exploring similarities and reorganizing material—can make learning more individually meaningful as well as valuable.

2.11.9. We Have at-least two Different types of Memory: A Spatial Memory System and a Set of System for Rote Learning

Humans have a naturally special spatial memory system which is not auditory and can "on the fly" remember experiences. The application of memory strategies is not required for remembering where we ate lunch yesterday or what we had for it. In fact, our experiences in the extraordinary three-dimensional space are recorded by at least one memory system. The system is always busy and inexhaustible and it belongs to people of all genders, all nationalities and races. It enriches over time as the things, genres and our styles (Olofin & Olojo, 2022).

2.11.9.1 Educational Implications

Teachers or educators are experts in the types of teaching that involve memorization. Common examples include multiple diagrams at the bottom,

orthographic words and unfamiliar vocabulary for adult learners. Sometimes, information is important and useful to remember, but instruction that focuses solely on memorization often fails to promote or to transfer learning, that can hinder in the development of deeper understanding of concepts. Ignoring the personal capabilities of learners can inhibit the effective functions of brain, limiting the potential for meaningful and lasting learning.

2.11.10. We Understand and Remember Best When Facts and Skills are Embedded in Natural Spatial Memory

As student we can learn numerous intelligent encounters including jargon and syntax in our mom language. It is formed by social interactions and internal processes (Harden & Jones, 2022). This exemplifies the process by which shared experiences can give meaning to any term. Students' abilities can be upgraded when this kind of advancement is utilized in schooling. This is one of the super normal components of the new theory.

2.11.10.1 Educational Implications

It is largely dependent on all the other principles that have been discussed previously, the symbolic process is complex. The learning promotes frequently used to stimulate spatial memory. Teachers need a lot of real-world activities, like classrooms demonstrations, participation, field trips, projects, and visual representations of different experiences as well as the best portfolios, symbols, stories, metaphors, dramas and different types of interactions. Vocabulary may be affected and grammar is learned through stories or writing in this process. Math, history and science subjects can be integrated together. Success in learning relies on engaging all the senses and immersing learners in diverse, interactive experiences. Guidance and analysis should be integral to the learning process, rather than separate, to enhance the overall educational experience. (Harden & Jones, 2022).

2.11.11. Learning can Enhanc by Challenges and, Inhibited by Threats

Our brain works better in a peaceful environment. Different challenges enhanced learning and threat inhibited it. In any threat environment, learner becomes less flexible which decrease his performance. According to Tanaka and Haley (2020), the

hippocampus is an important part in the limbic system and shows to act somewhat as a life center for all brain and it is the most sensitive area of the brain. Certain parts of our brain function optimally in situations of perceived threat.

2.11.11.1 Educational Implications

Teachers are suggested to establish a relaxed and learner centered environment for students to achieve their set goals. This combines overall relaxation with a threatening and challenging atmosphere. This state must immediately run through the classroom and teacher must be present there. All methods used for situation-based learning or castration affect the status of unorganized skills.

2.11.12. Each Brain is Unique

Every brain is different from other and also has a different way of being organized. Even though we all share the same fundamental systems, such as our basic senses and emotions, each part of our brain integrates them differently. Moreover, advancement fundamentally transforms the structure of the mind; as we learn more, we enhance our capabilities and become more exceptional.

2.11.12.1 Educational Implications

Teachers must change their teaching according to the situation and allow every student to participate in classroom discussion to express their ideas or feelings. Teacher must be given importance to individual differences and provide suitable instruction which fulfill the desires and requirements of every student in the classroom. In very short and comprehensive context it could be said that education is needed to improve the brain’s ability to work.

2.12 Brain-Based Learning Principles by Kagan (1994)

Kagan (1994) articulates seven principles of brain-based learning. These seven principles summarize twelve principles which were proposed by Cane and Cane in 1991. The principles were discussed as under:

2.12.1 Nourishment of Brain

An increased supply of oxygen and blood are actively required for the brain's ability to pay attention, behave, and style of learning (Kagan 1994).

2.12.2 Brain is a Social Organ

The brain learns more actively and strongly in a cooperative environment which means learning can be enhanced through cooperation and coordination. The performance of brain decreased in unsocial environment (Kagan 1994).

2.12.3 Safety Need of Brain

This principle recognizes that during any panic situation, the brain fights with this situation, or its flight response is activated, and this anxiety or threat prevents brain from learning (Kagan 1994).

2.12.4 Emotions in Brain

The brain is differently response to any situation which means to express emotions, pain, fear, and happiness the state of brain is varies on situation (Kagan 1994).

2.12.5 Brain and Information Processing

The brain's ability to move from attention to innovation, feedback, parallel processing, and imitate to seek the construct meaning to store, process and retrieve the data for further use as needed (Kagan 1994).

2.12.6 Different Styles of Brain

According to Kagan (1994) cognitive styles of brain vary on different situation and these styles may often changes in the ways such as;

a. Reflective verses Impulsive

b. Auditor verses visual verses kinesthetic

c. Concrete verses Abstract

d. Interpersonal verses Mastery verses Expressive verses Understanding

e. Deductive verses Inductive

f. Simultaneous verses Sequential

g. Avoider verses Stimulation

h. Extrovert verses Introvert

i. Responsible verses Curious verses Harmonious verses Adventures

Likewise, the brain may use all eight multiple intelligences and correspond to different parts or may use the same parts in any different ways. The three different types of brain's memories such as procedural, episodic and semantic memory display the retrieval tendencies of brain in different ways (Kagan 1994).

2.12.7 Development of Brain

According to Kagan (1994) the most common working principle of the brain is "use it or lose it", which leads to the development of the embryonic brain through the continuous formation of new neurons in a significant way.

The earlier mentioned principles by Kagan (1994) are slightly unique in relation to one another, however the essential reason behind these is something very similar, as they all connect with the functional construction of various pieces of brain. According to Caine (1991) brain-based principles are particularly significant because they serve as a foundation for other psychologists to develop their own. Therefore, twelve principles by Caine and Caine (1991) are discussed above only from the perspective of their significance, as compared to the teaching in schools.

2.13 Teaching Approach

An innovative teaching approach overcome the gap between educational practices and neuroscience is brain-based teaching and learning (Edelenbosch, et al., 2015). Brain-based teaching usually focused on three basic aspects such as i) minimizing threats and increasing challenges, ii) improve and enhance learning iii) allowing students to receive and integrate information into meaningful way. Teachers must break down these aspects into different tasks or opportunities and ensure that these aspects must be provided in every teaching learning process. Learning requires five specific components such as i) emotions that help to recognize the process of knowing, ii) provision of threats free learning, iii) meaning from understanding, iv) increased

active processing and v) memory for realizing things, following skills, and creating experiences (Edelenbosch, 2015). The execution functions focus on the storage and activation of the addresses of these parts.

2.14 Executive Function of Brain

Executive performance of brain helps people to organize actions to complete tasks (Cooper-Kahn & Dietzel, 2024). Intelligence considered as the measurement of mental ability by using various instruments which aligned with brain abilities, resulting in a set score (Sattler, 2008). Executive functions brain are the guiding forces that perform various functions of the brain by using various strategies to achieve set goals (Cooper-Kahn & Dietzel, 2024).

Teachers must encourage students to engage multiple areas of their brains simultaneously to perform various functions in school and acquire new material and skills. The executive functions of the brain enable students to integrate all aspects of learning, rather than focusing on individual components alone. These functions include planning, focusing, remembering instructions, and managing multiple tasks, which are crucial for effective self-organization and overall cognitive development (Sattler, 2008).

Executive performance depends on three brain functions such as i) working memory, ii) self-control, and iii) mental resilience. Working memory is the ability to control, capture and manipulate pieces of information within a limited moment and period of time (i.e memorizing of phone numbers). Mental flexibility means being able to maintain and divert attention to different tasks as demanded. Self-control or moderation is the ability to resist a behavior and decide what to do next. Memory formation is important factor for learning and a major function of neuronal activity within the prefrontal cortex, which stores meaningful illustrations of the past. These data provide evidence for a link between stimulation and working memory (Lara & Wallis 2015).

2.14.1 Comorbidity

The brain orchestrates actions of every kind, and it is beneficial to consider that issues related to learning, behavior, language, mood, and neuromotor problems may share underlying similarities in the brain. When professionals identify symptoms

alongside a primary condition, and these symptoms do not fully resolve, it may indicate the presence of comorbid diagnoses (Hendriksen 2015). Comorbidity is frequently observed between intellectual problems and anxiety-based disorders (Hirabaru & Matsuo, 2018). Brain-based learning is shifting focus from addressing differences in specific brain designs to exploring commonalities in brain function, which can help educators teach more effectively, even in large groups.

2.15 Steps of Brain-Based Learning

There are five brain-based learning steps proposed Alsati (2004) and Marji (2010) which are as follows:

2.15.1 Preparation Stage

This is the first stage that involves summarizing the topic, allowing the learner to mentally grasp the topic, so they represent new information and processes. Focus on preparing the learner's brain to understand and connect related topics.

2.15.2 Acquisition of Directed and Indirect Learning

This is second step which highlights the importance of direct or indirect formation of neural relationships such as lectures, visual aids, stimulation and challenges.

2.15.3 Elaboration Stage:

In this stage, teachers engage learners in classroom activities using both implicit and explicit learning strategies, such as blended learning, brainstorming, and summarization. These methods help deepen understanding and facilitate exploration and interconnection among different topics.

2.15.4 Memory Formation Stage:

This stage tends to strengthen learning and the learner's brain will encode what has been learned. There are several aspects that can be helpful to get the meaningful information, such as good and healthy nutrition, suitable break and connections to prior knowledge.

2.15.5 Functional Integration Stage

This final stage of learning not only clarifies ideas and principles within the topic but also enhances and deepens understanding by encouraging learners to question and reflect on the significance of achieving the learning objectives.

2.16 Brain-Based Learning Strategies

The learning strategies proposed by Addasouqi (2013) are as under:

2.16.1 Formal and Perceptive Regulator

It is called the process that organize different concepts in a meaningful system that procedure interrelated networks. Organization of different concepts helps the learners to arrange and organize their learning, ideas and summaries, in order to discover the lost information in detail.

2.16.2 The Strategy of Brainstorming

The strategy of brainstorming is focused on the generation of different ideas related to the topic, which allow the learner to think fearlessly without any interference of the teacher. This is very useful strategy not only for small group but also could be applied for whole class.

2.16.3 Strategies of K-W-L

This contraction refers to identify needed learning and these techniques might be applied initially or toward the end of each and every growing experience and are predictable with the brain.

2.17 Teaching Techniques

Alamiri (2002) indicated that following three teaching techniques related to brain-based learning: -

2.17.1 Indulgement

Indulgement means the creation of an environment that promote learning and also encourage learner to involved in any teaching learning process.

2.17.2 Relaxation

Relaxation used to overcome fear, stress and hesitation of learners when they are engaged in encountering challenges.

2.17.3 Active Processing

Active processing simply refers to allowing the learner to integrating and processing the received information meaningfully way and supporting and justifying that with other information.

2.18 Types of Brain-Based Learning

According to Shabatat (2016), there are three types of brain-based learning which are given bellow:

2.18.1 Brain Harmonized Learning

In this type friendly, joyful and non-threatening teaching learning process is promoted and encouraged and all of such process based on learner's ability. Focus is also to increases relaxation and reduces or eliminates the learner's fear and anxiety of intense stress environment. Furthermore, to establish such learning process that encourages students to engage in learning experiences (Shabatat 2016).

2.18.2 Anti-Brain Learning

This type threatens both teachers and learners by using harmful language or punishment. It is used for testing with tension and ends with completion of examination. It simply focused on lectures rather than understanding and emphasized on delivery of large content only (Shabatat 2016).

2.18.3 Assessment

Decisions are made to achieve the goals of teaching and learning, as well as to identify appropriate strategies for overcoming challenges and improving the management of the educational process. In this approach, teachers utilize student records, self-assessment techniques, and cumulative documentation to guide and refine the teaching and learning experience (Shabatat 2016).

2.19 Application in Classroom

The design foundation of BBL theory proposed in 1991 can be applied to the class environment through two-way design. The first strategy; focus on cognition and involve learners in such knowledge-based activities that can be integrated with natural functions of the brain. The second strategy is to create a rich learning centered environment that helps the brain function normally without threat or stress. Purpose of these both strategies to help learners and enhance the innate abilities of their brain in teaching learning process (Khosravany & Amirian, 2023).

2.20 Teaching Learning Model Integrated BBL

The teachinh learning model integrated with brain-based learning was proposed by Dr. Bilal Duman in 2010.

2.20.1 Relaxed Alertness

The additional brain state of relaxation allows the learner to receive messages from a learning that is not threatening or negatively stressful and is more challenging for the learner. Under this teaching method, learners realize that they are socially, emotionally, academically, and physically safe. Teachers should create a friendly classroom environment without fear or threats. Teachers must recognize different interest levels and style, curiosity, initiative and intensity of motivation. Students do not have to worry about failure or receiving low grades. A difficult and challenging but stress-free classroom environment is created through the art and innovation of performing individual or group tasks on a notion "who can finish first" (Duman 2010).

Relaxed alertness can also facilitate students' exploration of new ideas, restore neural connections, and help them develop tolerance for ambiguity, uncertainty, and delayed gratification (Caine & Caine, 1991). It can also be practiced in a relaxed way within classroom by creating a challenging environment, playing with soft sounds, bright lights, smells or fresh air, and taking into account individual differences. Caine and Caine (1997) proposed the following pedagogical elements that RA should incorporate into their teaching.

I. Students' reactions to diverse stimuli in the classroom may depend on what the teacher is thinking and feeling: Therefore, the dignity of teachers must be maintained in classroom. Therefore, the authority of teacher lies with students because of his/her knowledge supremacy. Level and expertise are two positions. A teacher's expertise refers to his perception of things in a way of discovery or exploration. The teacher tells the students that all letters have been opened (Duman 2010).

II. Relaxed alertness is effective in two situations, namely childlike state or passive listening: The childlike (non-childlike) state of the learner means being ready for learning experiences, exposed to unexpected results, and generated in creative and interesting ways a positive sense of expectation. In any type of passive listening learners participated in learning activities in a relaxed and focused manner (Posick, 2016).

III. Students works in a relax environment:

Relaxed alertness allows different types of involvement, that helps to embed information meaningfully and naturally. All of this could be accomplished in three different ways. The first way is that such suggestions can be made intelligently based on the needs of the learners. Secondly, place real experiences as they can add knowledge in a relaxed way. Third, learners' social interactions may be balanced (Schoen, 2009).

IV. Two different types of relaxation can be proposed in the classroom:

Teachers may be trained in this area. During meditation, the mind relaxes, which has a positive impact on the body's functions. Learners can be trained through audio tapes. Positive relaxation exercises are auxiliary techniques to help learners become more focused. They can be accomplished through the development of events, processes, or scenes (Chantiluke 2015).

V. Traditional testing and grading create stress in learners: As a result, assessment methods must be replaced as students' brain structures are gradually disrupted by stress. All things being equal, instructive criticism ought to be presented that incorporates phrases like "I discovered myself thinking… when you did this or consider the possibility that" cooperation ought to be selected, and individual activities ought to assist everybody with succeeding (Sweller 2005).

VI. Key provisions of Relaxed alertness: Create a sense of responsibility, safety and encourage learners to engage in activities of active learning. The course allows students to be creative, excited and spontaneous (Sweller 2005).

2.20.2 Orchestrated Immersion

Orchestrated immersion is also an important strategy of brain-based learning. Through this strategy, learners are exposed to various teaching activities and can freely choose the most appropriate activities to effectively understand the meaning of learning activities. It links classroom and real-world information to the learner's brain; dynamic gestalt creates a useful learning environment that can make all learning enjoyable. (Caine and Caine, (1991). Learning with humor is also Contribute to Orchestrated immersion (Bada & Jita, 2022).

Both teacher and learners plan the lesson together in this strategy. To stimulate learners' creativity, Cane and Cane suggested that they should be provided with dynamic exercises. Dynamic Gestalt is a comprehensive model of understanding that integrates pieces of information into coherent meaning, through which students can increasingly explore facts. Some examples of this include establishing course themes; giving students unclear and genuine objectives of individual interest, providing multiple visions to tell and explore stories through metaphor; context for the whole body; and providing relationships in community (Carrillat & Melnyk, 2022).

2.20.3 Active Processing

It is a continuous process of active learning of conceptual knowledge even in the hours after school. Unconscious cognition is a basic human brain function and proceeds continuously. It’s an active process of data integration and internalization designed to increase connections, gain deeper insights, and understand additional features hidden within the experience. It does not arise at a fixed time during the course; it continually redraws or restores the meaning of experience through exploration (Cavazzi, 2014).

2.20.3.1 Five Elements of Active Processing

Caine and Caine (1997) discussed five elements of active processing which are given bellow:

i. Reflection

ii. Capitalizing (benefiting from) on an experience

iii. Creative Elaboration

iv. Combination Process

v. Contemplation

These five elements could be further discussed as:

i. Students may focus on such questions in order to capitalize on a learning experience.

What I do?

Why I do?

What I learn?

These questions can promote and enhance the intrinsic motivation among students.

ii. Reflection is considered as high order thinking or learning (Caine & Caine, 1991). It is a complex process and it can be occurred in three different ways.

First, receiving feedback from others

Second, without support of anyone

Third, it may be occurred through personal awareness and understanding of in-depth learning experience.

iii. Contemplation is considered as non-analytic way of thinking. It prevents learners from misunderstandings when understanding ideas.

iv. Focusing is a special contemplative technique through which the learner can think about an idea internally and draw conclusions from it.

v. The creative idea can be accomplished in three ways.

First, experience must be restructured from different perspectives.

Second, in order to perceive any message, the idea must be literally and symbolically reversed.

Third, personal analogies should be used to illustrate ideas such as compare and contrast in order to integrate information with previous.

The process of composition facilitates all processes of contemplation and reflection in different ways. Two approaches are important in this regard.

First, learners should be inspired in writing different summaries and daily diaries to express their true feelings and emotions.

Secondly, learners reasoning abilities should be upgraded and adequate time ought to be saved for the cultivating of critical reasoning (Caine & Caine, 1991).

2.21 Enhancing Brain-Based Practices through Teacher Collaboration

According to research on brain, feasible instructive works on, showing learning is more compelling and successful when it is a cooperative as opposed to a separated action and is in a setting that is relevant to students (Eun, 2019). As in proximal development of Vygotsky's zone, cognitive mediation and learning tasks are only sufficient to build new knowledge with the help of others to solve problems. In this mediation, one creates relational space in which shared and mutual recognition occurs not one person's recognition of another, but recognition of all with proper approval. All of this requires intelligence and the ability to articulate and communicate the way we process experience (Silalahi, 2019).

2.22 Brain-based Learning in Science Subjects

According to Fogarty (2002), the subjects covered in science courses encompass diverse academic fields such as physics, chemistry, biology, mathematics, and social studies, all intertwined with real-life experiences. Students encounter theories of physical sciences, different definitions of chemical compounds, and structures of cells, alongside concerns about phenomena like ecosystem dynamics, earthquakes, and volcanic events. Topics such as extraterrestrial life, planetary movements, solar and lunar eclipses also captivate students' interest over their educational journey. Understanding the ongoing advancements in science requires

students to grasp fundamental scientific terms and acquire related skills throughout their schooling.

Mangan (1998), remarked that in science education, the learning and teaching processes should prioritize exploration and inquiry. The brain naturally seeks meaning and establishes connections, making exploration and inquiry-based teaching methods compatible with brain-based learning principles. Brain-based learning helps educators facilitate these processes by empowering learners to take responsibility for their learning and encouraging them to connect previously learned concepts with new knowledge. To foster this conducive learning environment, educators can employ metaphors, thematic teaching approaches, integrated teaching methods, and open-ended questions. These strategies aim to enhance students' understanding and engagement in the learning process, promoting deeper connections between concepts and facilitating meaningful learning experiences (Mangan, 1998).

Teachers play a crucial role in creating a secure classroom environment that fosters rich learning experiences and challenges students to excel. According to Mangan (1998), this environment should include resources such as bulletin boards, aquariums, various models, computer technology, and simulations. Flexible lesson plans that cater to learners' emotional needs are also essential components.

Moreover, teachers should integrate science courses with related sub disciplines well as other disciplines. This interdisciplinary approach not only makes learning more meaningful and interesting for students but also accommodates diverse learning strategies. By linking different areas of study, educators can enhance the overall learning experience and promote deeper understanding among students.

Teachers can effectively integrate science courses with other disciplines by finding connections between topics. For example, when teaching about the refraction of light, educators can relate it to concepts in art, such as the study of colors, or in composition courses, such as writing reports. Understanding the brain's cognitive processes is crucial for effective science teaching and learning. According to Konecki and Schiller (2003), integrating social and emotional learning processes is essential in science education. Brain-based learning enhances learning outcomes by employing diverse teaching approaches and creating a supportive classroom environment where students are encouraged to take intellectual risks. This approach enriches the learning

experience by catering to different learning styles and fostering a sense of security and exploration among students.

According to Holloway (2000), the brain-based learning is the process of teaching science should incorporate thematic learning skills coupled with rich and natural yet complex language use. In addition, it ought to include a variety of evaluation methods and structured, long-term projects. There are three significant effects on students and the learning process when these brain-based learning components are implemented. The first step in critical thinking allows students to take part in the learning process which enhances their understanding of how learning occurs. Second, they recognize that learning is about their ability to express knowledge rather than solely focusing on exam grades. Finally, students realize that developing skill of critical thinking supports their overall academic success.

2.23 Critical Thinking

Critical thinking is considered as the process of systematically assessing statements, results, experiences and arguments to form a reasoned judgment or conclusion. It also assesses the precision, authenticity and validity of data. It is also called a judgment of the statement based on the information received. It evaluates the value and validity of existing knowledge and information. It involves precise, persistent, and objective analysis to justify any argument (Vieira & Tenreiro, 2016). Critical thinking skill is one of most important skill connecting to the higher order thinking skills needed for 21st century education. By integrating critical thinking skills into 21st century education systems, education systems will be able to support “long-term learning, problem solving, self-management and physical education” (Natthanan, 2009).

According to Norris (2020), critical thinking is best understood as the thinker’s ability to take charge of his or her thinking. There are two sides of “critical” i) the commonsense use: "negative or faultfinding. “ii) The critical thinking use: "involving or exercising skilled judgment or observation. Critical thinking has two distinct activities: i) analysis which refers to understanding an argument, ii) Criticism which refers to evaluating the truth of an argument.

2.23.1 Defining Critical Thinking

In modern education settings critical thinking is now a frequently used term. There are several definitions of critical thinking which are also discussed in this literature. According to Hildebrand (2022), John Dewey believed that critical thinking is reflective thinking which requires proper mental action to resolve uncertainty, hesitation, or psychological challenges. Paul (1990) defines critical thinking as thinking about thinking. Natthanan (2021), believes that critical thinking includes psychological skills such as forming hypotheses, looking at problems from multiple perspectives, asking questions, and providing solutions to problems.

2.23.2 Components of Critical Thinking

According to Alison (2017), critical thinking involves several key components or skills that help individuals engage in reflective and independent thinking. These components are foundational to various cognitive processes, such as problem-solving, decision-making, and evaluating information. They enable individuals to navigate complex situations with a structured and reasoned approach, ensuring that conclusions and decisions are based on thoughtful analysis rather than impulsive reactions or assumptions. The components of critical thinking are understanding, applying, analyzing, evaluating, and creating. It is a framework through which individuals can engage deeply with information and ideas.

2.24 Students' Academic Achievement

According to Pandey (2017), "academic" refers to schoolwork or academic work, with "academic work" denoting the outcomes resulting from learning accumulation, and "schoolwork" referring to learning tasks assigned by schools, typically progressing through stages. In educational contexts, "achievement" signifies reaching a particular level attainable after a series of learning experiences or training, whereas "performance" relates specifically to the outcomes of assessments in subjects or entire courses (Lamas, 2015).

However, there are varying perspectives among scholars regarding the definition of "academic achievement." Some scholars equate it simply with grades, leading to differences in defining the concept based on these varying interpretations (Brookhart, 2016).

Generally, academic achievement is defined broadly as the overall performance and abilities of any student throughout their education. On the other hand, Bloom (1956) stated that academic accomplishment involves acquiring information, developing values and perspectives, and mastering skills or appropriate behaviors. Astin (1985) further emphasized that the academic achievement of student not only encompasses psychological and intellectual understandings but also mental, emotional and social styles.

In dissimilarity, narrower different academic achievement definitions specifically focused on students' measurable performance in the examinations at different educational levels. Li and Wang (2022) equated it with academic performance, while Cai and Cao (2019) advocated for a broader view encompassing all different aspects of students' knowledge, competence, and literacy development. Empirical studies often adopt this narrower definition, particularly in assessing primary and secondary school students, where researchers like Li and Wang (2022) and Li and Chai (2018) commonly define academic achievement that based on the performance of student in school evaluation.

2.24.1 Factors Affecting on Students' Academic Achievement

According to Alfil Ozcan (2021), there are numerous factors influencing academic achievement, starting with:

I) Learner Characteristics

These include mental capabilities, motivation, interests, learning abilities, and capacity to comprehend information.

II) Family

Family plays vital and important role in providing social and psychological security and creating a conducive atmosphere for the learning process. Family factors, as highlighted by Liu (2018), this process also includes considering the influence of parents' involvement, different style of family interaction, different family cultural background, and the community environment, in which families reside. Liu (2018) underscores that parenting practices are closely intertwined with students' academic achievement. Additionally, the community environment significantly impacts students'

academic outcomes, with children in rural communities often exhibiting lower language application skills compared to their urban counterparts.

III) Teachers

The approach teachers take in interacting with learners and their methods of presenting topics significantly impact teaching outcomes.

IV) School

Schools play a crucial role in providing the physical environment necessary for education, including classrooms, laboratories, playgrounds, and ensuring safety. School-related factors such as teacher delivery style, teacher-student relationships, school support systems, and the level of information technology also influence educational outcomes.

Gong and Cheng (2024) discovered that the impact of information technology levels in schools on students' academic achievement is not strictly linear. Low to moderate levels of information technology can enhance academic performance, whereas high levels may have a detrimental effect on academic achievement of students.

V) Syllabus

The school syllabus should align with the learners' characteristics and accommodate their individual differences. It should also incorporate both vertical or horizontal assimilation of lessons and different topics.

VI) Teaching Methods

Through employing effective teaching methods, that prioritize the learner and afford them opportunities for self-directed learning.

2.25 Linkage between BBL and Critical Thinking, and Academic Achievement

The primary focus of Brain-based learning on how brain can process, integrate, stores, and recovers information. It draws from neuroscientific research to design teaching strategies that optimize learning. BBL emphasizes the importance of engaging the brain through activities that promote neuroplasticity (the ability of a brain to reorganize itself and by forming new ideas or neural connections), which is essential for enhancing cognitive skills like critical thinking (Duman 2007). According to

Hildebrand (2022) critical thinking involves higher order reasoning processes such as analyzing, evaluating, synthesizing, and making reasoned judgments. For students to develop these skills, their brain must be engaged in complex cognitive tasks that require reflection, reasoning, and decision-making. BBL supports critical thinking by integrating such teaching strategies and techniques with how brain can naturally learn and processes meaningful information

According to Hansen and Monk (2002) brain-based learning integration with the development of critical thinking skill creates a dynamic environment where students are allowed to actively involve with meaningful content in order to develop deeper and thoughtful understanding and apply knowledge effectively. This, in turn, leads to academic achievement. BBL enhances the ability brain to process and preserve information, which supports the cognitive demands of critical thinking. When students regularly engage in critical thinking, they develop the skills needed to succeed academically across all subjects. Therefore, BBL cannot supports the development of critical thinking only but also directly contributes to better academic performance (Jensen 2008).

2.26 Empirical Review

Brain-based teaching strategies focus on connecting new learning with previous or experiences to enhance retention. These methods aim to prevent the brain's automatic deletion of irrelevant information by making learning meaningful and engaging. The goal is for students to retain information by understanding concepts deeply rather than through simple repetition.

Altiti (2014), conducted a study on fifth-grade Jordanian students to evaluate the impact of brain-based instruction on their performance in science courses highlighted that brain-based learning significantly enhanced students' scientific achievement. Specifically, the experimental group, which utilized brain-based instructional methods, demonstrated notable performance improvements as compared to control group. However, the study pointed out no significant differences based on gender or interactions between gender or teaching methods.

The study conducted by Afacan and Akyurek (2013) observed the influence of brain-based research on achievement and effectiveness within a science curriculum.

Their findings indicated that brain-based learning was effective in achieving and sustaining positive outcomes in science education.

Farrajallah (2017) explored the impact of brain-based learning on the instruction of the subject of mathematics, focusing on enhancing primary school students' mathematical interaction skills and mental arithmetic abilities. The study found no differences among students in experimental and control groups.

Haddad and Al-Hashimi (2024), discuss brain-based learning as a core teaching strategy centered on optimizing how students' brains learn. They emphasize the importance of understanding brain anatomy and function to design effective learning experiences. The authors highlight the positive brain-based strategy impact on student achievement across different educational fields. They stress the ongoing need for research into brain structure and function to enhance educational practices continually.

Bonomo (2017) emphasizes that brain-based learning focuses on understanding the brain's developmental processes to improve teaching effectiveness. Recognizing the brain's complexity and its ongoing evolution underscores the need to continually refine educational approaches based on current understanding.

Erişti and Akdeniz (2016), highlight the importance of grasping fundamental aspects of the brain to comprehend theories related to brain-based learning. They stress that a solid understanding of brain anatomy and function is essential for fully understanding and applying brain-based learning principles.

Duman's (2006) research indicated that that involvement in brain-based activities improves end-of-unit exam performance compared to traditional teacher-centered methods with minimal student engagement. This highlights the significance of integrating brain-based learning principles in education to enhance academic outcomes effectively.

Alfilimbani (2014) studied training methods based on learning theory and their impact on developing specific brain characteristics, finding significant effects on academic issues and mastery motivation. On the other hand, Duman (2006) investigated brain-based research's influence on students with different learning patterns, demonstrating its effectiveness in improving academic performance.

Pociask and Settles (2007), study utilized contemporary brain research to enhance teacher learning through a multidisciplinary approach. This approach included practical activities and encouraged collaboration among students and teachers. Their findings demonstrated that coordinating different knowledge techniques into regular illustrations can support for students' confidence, upgrade memory maintenance, increase stimulus, and relieve professional associated issues.

In studies by Jackson (2003) and Pociask and Settles (2007), both explored the efficacy of brain-based teaching methods in enhancing student learning outcomes. Jackson's research focused on first- and second grade reading scores before and after implementing brain-compatible instruction based on the Iowa Test of Basic Skills. The findings revealed substantial improvements in reading scores following the adoption of brain-based strategies, indicating significant academic progress among students.

Similarly, Carey (2020) employed contemporary brain research to enhance teacher learning through a multidisciplinary approach that included practical activities and collaboration opportunities among students and teachers. Their study highlighted the benefits of integrating multiple intelligence strategies into daily lessons, such as improving students' self-esteem, memory retention, motivation, and reducing academic challenges.

Erland's (2000) research highlights that improving cognitive skills in low-scoring students can lead to substantial academic growth over time, though results may not be immediate. The study advocates for addressing cognitive skill deficits through diverse learning methods to effectively address various learning difficulties and enhance academic performance. However, Erland points out a challenge with current theories of intelligence that prioritize understanding strengths over correcting weaknesses, which could impact the effectiveness of educational interventions.

Donna (2014) quantitative study investigated brain-based teaching (BBL) skills in science education. The study highlighted a positive correlation among teachers' perceptions regarding BBL and their actual implementation in science teaching. It also highlighted that women and primary school teachers were more inclined than other groups to plan for integrating BBL into their science education practices.

Škrhová (2017) study focused on brain-based learning principles in English education. It examined how these principles address memory retention, brain lateralization, and the role of movement in learning. The study also explored connections with different learning styles and the theory of multiple intelligences. Practical applications of these theoretical concepts were demonstrated through activities conducted in a second-grade classroom setting.

Ahmed and Aftab (2022), conducted research to evaluate the impact of using the mind mapping approach on students' learning outcomes in science education. Their study aimed to determine effective teaching methods for enhancing student achievement in science. The findings demonstrated that employing the mind mapping approach significantly enhances students' learning experiences and improves their academic performance more effectively compared to traditional methods.

The study of Darcy (2010) focused on how our brain receive, processes, integrate and recalls the information, advocating for integrating these insights into pedagogical approaches. Despite prevalent adherence to traditional methods in schools, the research highlighted that brain-based learning promotes a holistic teaching approach. It underscores the importance of aligning educational practices with natural learning styles and leveraging cognitive processes to optimize learning outcomes.

Troy M. Kennett's 2020 study, "Brain-based Educational Pedagogy," explored how professional development grounded in brain research can assist educators in planning for students with autism spectrum disorder (ASD). The study identified five key themes influencing the implementation of brain-based learning: the impact of new knowledge on material applicability and skills among staff, prioritization of strategic and procedural training, effective group dynamics and task completion, improvement of standards through shared experiences, and the necessity for guidance in school management and teaching planning for educators.

Stacey (2001) examined the impact of brain-based strategies on classroom instruction effectiveness, revealing that students exposed to these methods outperformed in traditional instruction settings.

Hatice Bayindir's (2003) revealed that students held highly positive views regarding the effectiveness and relevance of these approaches.

The research of Fatima (2017) indicated that teachers generally hold unfavorable views about brain-based learning methods, whereas students exhibit high levels of motivation in their academic endeavors. Importantly, the study revealed a positive teachers' attitudes toward brain-based learning and students' achievement motivation.

Nita, et al., (2023) revealed that brain-based learning enhances teachers' creative thinking skills and improves the overall quality of learning as an alternative educational model. Key strategies include making learning relevant, fostering connections between concepts, employing trial-and-error approaches, providing constructive feedback, promoting revision, and engaging students emotionally with the material. Additionally, encouraging student choice and inquiry through questioning are advocated, supported by previous research (Ozden & Gultekin, 2008).

Brain-based strategies have been shown to significantly enhance student learning outcomes compared to traditional methods, as supported by research from Mekarina & Ningsih, (2017). These strategies encourage active student engagement with the material and with each other, leading to better retention of information and overall academic success.

Additionally, study by Akyürek and Afacan, (2013) explore that brain-based learning fosters a sense of ownership and responsibility among students for their learning. Survey data from these studies indicate that students perceive improvements in their understanding of learning strategies and demonstrate increased participation in group discussions when taught using brain-based approaches.

Integrating brain-based learning strategies enhances the learning experience for all students. When educators engage with young minds, they facilitate changes in how the brain processes information. As our understanding of how new knowledge is formed, organized and stored in our brain becomes clearer, fundamental transformations in teaching practices are inevitable (Gozuyesil & Dikici, 2014).

Educators play a crucial role in acknowledging fundamental changes in students, such as enhanced creativity, innovative thinking, and exploration of new ideas

facilitated by brain-based learning. When students engage in learning activities, they activate both the right left sides of brain, fostering holistic cognitive development (Badriyah, et al., 2020; Suparta, et al., 2018).

Brain-based learning incorporates activities that stimulate both hemispheres of the brain, such as mind puzzles, mapping, mathematical problem-solving, skill acquisition, writing, and reading. Research consistently demonstrates that students taught with brain-based methods achieve higher levels of retention and academic success compared to those taught with traditional methods. Study conducted by Awan and Fatima (2017), confirm that students exposed to brain-based instruction outperform their peers on achievement tests.

In brain-based learning, teachers prioritize creating enjoyable and engaging learning experiences centered around students, contrasting with traditional methods that often focus more on teacher-led instruction (Erol & Karaduman, 2018; Shabatat & Al-Tarawneh, 2016). Research indicated that that students excel in environments that are student-centered, where brain-based approaches encourage a growth mindset and lead to enhanced academic performance (Ekemen & Beyhan, 2020).

Brain-based learning has demonstrated positive effects in specialized areas such as English as a Foreign Language (EFL), online learning, spatial abilities, and various academic subjects like mathematics and science. Specifically for English Language Learners (ELL), brain-based activities serve as valuable tools to help them understand challenging material more effectively. Implementing brain-based instruction can make learning more meaningful for ELL students, addressing barriers to their educational success (Oghyanous, 2017; Salem, 2017).

In online learning, educators are innovatively engaging students through digital platforms, especially in technology-focused fields. Key priorities include actively involving students in course content, providing timely feedback, and cultivating a positive online learning environment that supports effective learning practices for all students (Hasliza & Wan Emilin, 2012).

Brain-based instruction has shown significant benefits in specialized areas such as spatial abilities, mathematics, and science. In spatial abilities, students exposed to

brain-based methods exhibited improvements in orientation, visualization, and overall spatial skills through activities like visualizing material and collaborative learning (Al-Tarawneh, et al., 2021).

Similarly, in mathematics and science, brain-based strategies have enhanced student retention and motivation by focusing on deep conceptual understanding. These approaches promote the development of reasoning, problem-solving skills and application of learned knowledge to real-life scenarios, fostering hypothetical thinking (Al-Balushi & Al-Balushi, 2018; Jazuli, 2019).

Brain-based learning encompasses various theories and perspectives aimed at optimizing educational practices. Griffee (2007) advocates for aligning curriculum and teaching methods with how the brain learns best to enhance effectiveness. According to Kelly (2011) introduces the framework, emphasizing intervals, grouping, novelty, interconnectedness, technology, time, and environment as key elements that positively impact student learning and facilitate growth. Bowen (2011) discusses brain-based learning in the context of educational transformation, highlighting its role in enhancing student learning outcomes through effective instructional practices.

Brain-based learning strategies, advocated by experts like Dr. Dave Kommer (2002) and curriculum specialists Schiller and Willis (2008), aim to optimize the learning experience by stimulating the brain in healthy ways and making learning engaging for students.

According to Stang (2022) highlights the importance of enjoyable learning experiences, while Schiller and Willis (2008), emphasize creating supportive environments that prioritize safety and well-being. Their strategies include using humor, music, pacing activities effectively, promoting responsibility for learning, proactive teaching approaches, and nurturing social-emotional intelligence. Overall, brain-based learning offers a diverse array of strategies to foster effective learning environments.

Prigge (2002) a professor of special education, provided actual strategies as “Advance Brain Based Teaching and Learning." These strategies encompass six methods for preparing students, four approaches for managing the learning

environment, four techniques for maintaining student attention and engagement, and six strategies for enhancing retention and memory.

The study of Davis (2004) critiqued the limited application of the science of brain in the ability of understanding of learning complexities in his research paper "The Credentials of Brain-Based Learning."

In contrast, Gulpinar (2005) explored how brain-based learning principles intersect with constructivist models in education. He highlighted that approaches such as problem centered learning, experimental learning and cooperative and mutual learning are well-aligned with brain-based strategies. Gulpinar emphasized the importance of acknowledging individual differences, contextuality, and complexity in creating enriched and challenging learning environments that promote meaningful content and effective information processing among learners.

Soonthornrojana (2007) investigated that the understanding accomplishments between brain based and conventional strategies, and to evaluate learner fulfillment with the BBL approach. The study pointed out that the BBL model essentially improved students learning.

In a separate study, Waters (2005) examined the effects of BBL techniques such as hydration, exercise, and music on academic achievement. The results indicated that implementing these strategies yielded positive outcomes.

Duman (2006) investigated "The Effect of Brain-Based Instruction on Improving Students' Academic Achievement in Social Studies." The research aimed to compare the instruction of social studies using brain-based methods versus conventional teacher-centered approaches. It also sought to assess the impact of BBL on the motivation and academic achievement among the students of sixth grade. The results pointed out that activities of brain-based learning elicited positive perceptions and insights, as revealed by qualitative outcomes of the study.

In their study, Ahmad, and Bajwa (2024), found that students of experimental group were taught through brain-based learning methods outperformed those in the control group. High achievers of experimental group demonstrated significantly better performance, while low achievers also showed notable improvements compared to

control group students. This research highlights the positive impact of the experimental intervention on both high and low achievers' academic outcomes.

Tompkins (2007) conducted research focusing on the creation of a theoretical brain-based model for designing online courses that could be applied in higher education. The goal was to develop a theoretical model for brain-based online course design in higher education, synthesizing indicators identified through analytical charting. The model presented with principles of brain-based learning theory. It incorporates elements aimed at enhancing online learning experiences based on the synthesis of relevant educational literature.

Troy Kennett (2020) investigated how brain-based professional development informs educators' strategies for teaching students with autism spectrum disorder (ASD). In his study he highlighted five themes: the influence of staff knowledge on material applicability, preference for strategy-based training, the need for real-time strategy application, the impact of prior experience on comfort levels, and the importance of guidance in instructional design. Recommendations included further action research across grade levels and disabilities to enhance educational outcomes through brain-based approaches.

Saunders and Vawdrey (2002), propose that brain-based learning involves mastering and organizing ideas in a way that facilitates transfer to different contexts. According to Goldberg and Stevens (2001), in a brain-compatible classroom, assessment serves both to measure achievement and to enhance motivation. Teachers aiming to foster a brain-based learning environment should consider allowing students to co-create assignments and rubrics, as suggested by Caine, et al., (2005). Assessment should be conducted to fit students' needs rather than imposing standardized requirements.

Erlauer (2003) recommends aligning assessment methods with students' preferred intelligences or learning styles, reflecting how they have acquired knowledge. Immediate and constructive feedback is crucial for boosting motivation and guiding students on how to improve their work.

The idea of brain usefulness revealed that the brain is constantly change the situation all through our lives to get to new memories and encounters. To get the most out of their education, students must use all of their abilities. Students' achievement can be improved by using brain-based method in the classroom, such as dancing, clapping, manipulative, and role play. (Jensen & McConchie, 2020; Slavkin, 2004).

Slavkin (2004), reveals that the brain operates through diverse strategies rather than in a linear, computer-like fashion as previously thought by some educators. According to Slavkin (2004) brain research, integrating with lessons is highly effective in enhancing student learning. Mastery of concepts is directly correlated with the time spent on task, emphasizing the importance of allowing sufficient time for students to achieve mastery before progressing. Additionally, scheduling regular breaks during instruction enables students to process information and engage in reflection. Summarizing brain-based pedagogy, Slavkin (2004) suggests that knowledge should be socially created, highlighting the significance of collaborative learning environments in education.

Erlauer (2003) proposes that collaborative learning facilitates the brain's exploration of new information, particularly in problem-solving contexts. This approach encourages students and teachers to work together, fostering an environment of relaxed alertness that enhances student comfort and focus on the classroom.

Thematic instruction, according to Slavkin (2004) and Wagmeister & Shifrin (2000), encourages students to connect meaningful activities with practical applications. By immersing learners in evocative experiences and complex situations relevant to their prior knowledge, thematic instruction deepens comprehension and promotes learning.

Students learn to psychologically organize new information in meaningful ways when thematic instruction involves patterning or chunking information, facilitating better internalization and recall, as highlighted by Wagmeister & Shifrin, (2000). Teachers can play a vital and crucial role in this process by recognizing the diversity among learners and emphasizing the connections between students' prior knowledge and new information to be learned.

Amjad (2023) emphasize that brain-based learning significantly enhances students' academic performance, suggesting that elementary level mathematics instruction should integrate activities based on brain-based learning to improve outcomes.

According to Adiansha, et al., (2021) brain-based learning model fosters creativity, provides platforms for student expression, and supports an active and conducive learning environment. The study underscores the benefits of brain-based learning in enhancing educational quality, particularly in Indonesia.

Maryati (2020) found that BBL enhances students' critical thinking and self-regulation abilities. They note that students find joy in developing their cognitive skills, including memory, through active participation in engaging learning processes. This approach ensures that learning remains stimulating and avoids boredom among students.

In Şahin and Kılıç's study (2023), the effectiveness of the BBL style cycle was investigated among sophomore students enrolled in the Faculty of Education at Duzce University during the 2020–2021 academic year. The study included 111 participants, consisting of 84 girls and 27 boys. The course implemented a brain-based learning style, and the findings indicated that students held a positive attitude toward this instructional model. Moreover, the study revealed significant improvements in students' attitudes toward cooperative learning, teachers' self-efficacy, and metacognitive thinking skills.

Meanwhile, Kohar (2022) concluded that the Brain-Based Learning Model effectively enhanced reading comprehension among seventh-grade students. The research indicated that brain-based learning: i) Is effective in enhancing reading comprehension, ii) Can improve pupils' inferential comprehension skills and iii) Demonstrates varying effects of text structure on comprehension, particularly in exposition texts. Similarly, Nur and Khalikin (2020) concluded that employing brain-based learning was beneficial for enhancing reading comprehension among first-year students.

Syahbandi (2018) conducted research to explore the significant impact of brain-based learning on the speaking skills of second-grade senior high school students in

Praia. Brain-based learning was employed as a form of cooperative learning to address students' speaking challenges. The study found that using such learning techniques in teaching speaking not only engaged students in learning the language but also improved their speaking abilities.

Farrell (2016) focused on enhancing learners' fluency through three core instructional strategies: relaxed alertness, orchestrated immersion, and active processing. By effectively applying Caine and Caine's twelve Principles, the study concluded that these strategies fostered oral communication fluency among participants. As a result, students overcame speaking anxieties, increased their self-confidence, built strong group dynamics, and utilized their individual strengths to support each other.

Shabatat and Al-Tarawneh (2016), pointed out that implementing brain-based learning has significantly enhanced the academic achievement of students. Additionally, students engaged more actively in class discussions, driven by a stimulating environment and the prospect of rewards.

Jampamoon (2014) remarked that activities aligned brain-based learning such as songs, games, and role-playing were employed to reduce stress and anxiety, thereby improving students' speaking skills. Kiedinger (2011) revealed that the use of brain-based learning techniques improves academic achievement of students.

CHAPTTER 3

RESEARCH METHODOLOGY

The research methodology outlines the approach for gathering or analyzing information, as well as the experimental aspects of the study. It explains how data collection instruments are developed and provides a brief overview of the data analysis conducted using various quantitative and qualitative methods.

3.1 Research Design

The study was experimental which employed a true experimental design with pretest posttest equivalent group design. According to Mackenzie and Knipe (2006), a true experimental design used to establish cause and effect relationships between two or variables by manipulating these variables and randomly assigning participants to different groups in a controlled environment. Study participants are randomly assigned to the experimental or control groups and random distribution ensures that every participant has equal chances of selection in this study. The researcher randomly assigned participants to groups, administered a pretest before the intervention, and then provided treatment to both groups (experimental and control) under controlled conditions and afterward, a post-test was conducted.

The study aimed to address external threats to ensure accurate results. Three variables were examined: teaching methods, critical thinking and academic achievement. Teaching methods, including the brain-based method and traditional method (Lecture and Discussion method) considered as an independent variable, while critical thinking and academic achievement were dependent variables. The researcher formed separate lesson plans for the brain-based and traditional methods covering all the selected topics from the 8th-grade general science textbook.

Following was the systematic description of the design: -

Figure 3.1

Systematic Description of the Design

R	O1	T1	O2
R	O3	T2	O4

Symbol “R” refers to randomly selected study participants, while O1 and O3 refers to Pretest, and T1 refers to the treatment of groups with brain-based method and T2 refers to the treatment of group with traditional method, whereas O2 and 4 refers to posttest respectively.

3.2 Population and Sample

All 6972 8th-grade General Science students from Kotli district were the population of the study. Random sampling technique was used, and it was most appropriate because the study needed a specific set of students who met certain conditions, such as the availability of sufficient number of students and ability to implement the experimental design with appropriate group size. Government Boys High School Panag Sharif was selected as no other school from the district have required number of students. There was total 64 students in 8^{th} class in that selected school. The researcher then used matching pairing to divide the 64 students into two equal subgroups based on their pretest scores, ensuring that both the groups (experimental and control) started with similar levels of critical thinking and academic achievement. Matching helps control for potential confounding variables (e.g., pre-existing differences in students' abilities), making the comparison between groups more valid. As a result, students were allocated to the experimental group that received the treatment with brain-based method and to the control group that received the treatment with traditional teaching method, while the researcher ensure a fair comparison between the two groups. Finally, four students who could not be matched were excluded, ensuring that both groups contained 30 students, thus maintaining balance and statistical rigor. This selection process makes it possible that the sample is both representative of the population in the context of the available schools and well-suited for testing the research hypothesis under controlled conditions.

Table 3.1

Sample of the Study

Gender	Experimental Group	Control Group	Total
Boys	30	30	60

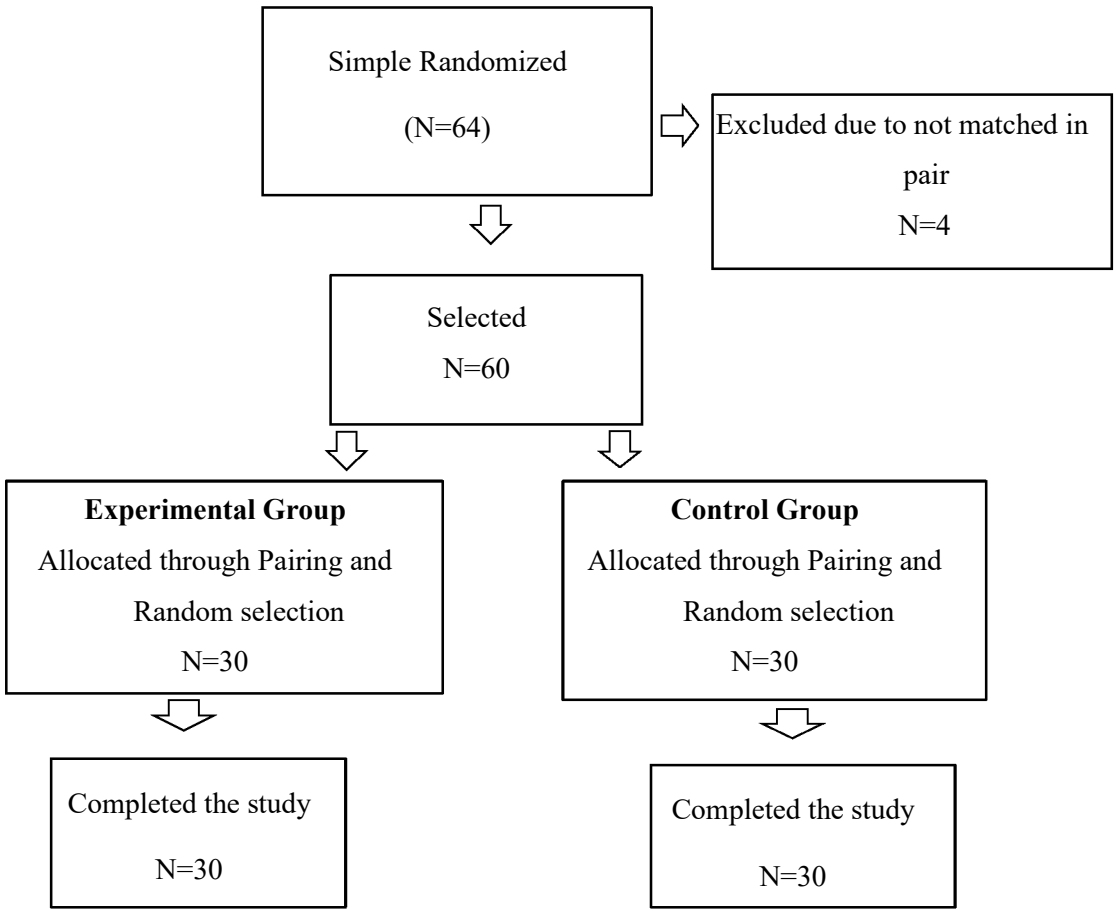

Figure 3.2 Sample and Sampling of the study

3.3 Instruments

Researcher made Subject Achievement Test and Critical thinking test were used as research instruments in this study. Restricted response test items were comprised in the Subject Achievement Test and open-ended response questions were included in Critical Thinking Test. The tests were administered as pretest and posttest on the experimental and control groups. Both tools of the study were developed by adopting the following steps:

3.3.1 Subject Achievement Test

Subject Achievement Test (Appendix 3) was formulated by the researcher, which was taken as both a pretest and post-test for both the experimental and control groups.

3.3.1.1 Construction of Subject Achievement Test (SAT) Items

The SAT was used for both pretest and posttest. This test comprised of conceptual items rather than text based items. This test was consisted of fifty multiple choice questions. 10 MCQs were taken from chapter 9, 12 from chapters 10, 13 from chapter 11 and from last chapter 12, 15 MCQs items were taken. The test was comprised 50 marks.

3.3.1.2 Preparation of Tables of Specification for Subject Achievement Test

The researcher created four tables of specifications (Appendix 4) for the four selected chapters. Each table was designed to represent the proportionate distribution of test items according to the main and sub-topics of each chapter.

3.3.1.3 Scoring Procedure of Subject Achievement Test Items

The researcher developed a rubric (Appendix 5) and use to the nature of the test items in the subject achievement test. This rubric included a stepwise scoring system for each item on the subject achievement test.

3.3.2 Critical Thinking Test

Critical Thinking Test developed by Alison King in 2017 at Brown University USA (Appendix 6) was adapted and used to measure critical thinking.

3.3.2.1 Construction of Critical Thinking Test Items

The researcher adapted critical thinking test which was used for pre and posttest. The test comprised of concept based questions rather than text based. While critical thinking and brain-based learning both involve cognitive processes and focus on different aspects of learning and cognition. So, critical thinking test can be useful tool to measure certain cognitive outcomes of brain-based learning. The components of critical thinking such as understanding, applying, analyzing, evaluating and creating was measured during this study. This test was consisted of open-ended response questions. Total 10 open-ended response questions (Appendix 6) were developed from all selected four chapters of General Science textbook.

3.3.2.2 Rubric for Critical Thinking Test

The researcher made rubric (Appendix 7) for critical thinking test.

3.3.2.3 Scoring Procedure of Critical Thinking Test

The researcher made rubric (Appendix 7) included a stepwise scoring system for each question on the Critical Thinking test.

3.3.3 Selection of Text

The following measures were taken when selecting text for the experimental study in the chosen school:

1. Consultation with current 8th-grade General Science teachers
2. Course syllabus proposed by district Elementary board Kotli.
3. School examination limitations.

As the experimentation process lasted for two months as per Taleemi calendar of AJK the last four units from General Science textbook must be covered during two-month time, hence, these units were selected to conduct this experimental study. Based on these considerations, the researcher chose four chapters from the 8th-grade General Science textbook, published by the Azad Jammu and Kashmir Textbook Board, Muzaffarabad, in 2023. The selected topics and subtopics from four selected chapters are given as follows:

Chapter 09 Reflection and Refraction of Light

1. Properties of Light

1.1 Speed of Light

1.2 Transmission of Light

1.3 Dispersion of Light

1.4 Absorption of Light and Colors of Objects

1.5 Refraction

1.6 Reflection of Light

1.7 Reflection and Refraction in Daily Life

2. Mirrors and Image Formation

3. Plane Mirrors

3.1 Image Formation from Plane Mirror

4. Convex Mirrors

5. Concave Mirrors

6. Optical Instrument

Chapter 10 Electricity and Magnetism

1. Current

1.1 Voltage

1.2 Resistance

2. Electric Power

3. Safety Devices for Circuits

4. Hazards of Electricity

5. Electricity Safety Precautions

6. Electromagnets

7. Factors that Affect the Strength of an Electromagnets

8. Properties of Electromagnets

9. Working of Electromagnets Devices

Chapter 11 Technology in Everyday Life

1. Bioplastic

2. Toothpaste

3. Soap and Detergents

4. Solar Cooker

5. Simple Wind Turbine

6. UPS (Uninterrupted Power Supply)

Chapter 12 Our Solar System

1. Celestial Bodies

1.1 Stars

1.2 Galaxies

1.3 Milky Way

1.4 Black Holes

2. The Life Cycle of Stars

3. The Life Cycle of Sun

4. Telescope to Study Space

1.5 Hubble Telescope

1.6 Galileo Probe

5. Advancement in Space Technology

5.1 Telescope

5.2 Spectroscopes

6. Spacecraft

6.1 Robotic Spacecraft

6.2 Manned Spacecraft

6.3 Space Shuttle

7. Benefits of Space Exploration

3.3.4 Development of Lesson Plans

The researcher developed 32 lesson plans covering all specified subtopics of the four selected chapters. Initially, 32 lesson plans were developed using the Brain-Based Method (Appendix 1), incorporating the five steps of brain-based learning. These plans were implemented in the experimental group. Following this, 32 lesson plans were developed using the traditional method and applied in the control group (Appendix 2). All teaching sessions for both groups were conducted according to their respective lesson plans at selected school.

3.3.5 Validation of Lesson Plans

The developed lesson plans were distributed to three experts to validate. As per their suggestions changes were made. After the finalization of lesson plans, it was used in the experiment.

3.3.6 Lesson Plans for Control and Experimental Group

The researcher developed lesson plans for control groups by using traditional teaching method and brain-based method was used to develop lesson plans for experimental group. Lesson plan model used in experimental group is given bellow:

3.3.7 Steps of Brain-Based Learning

There are five brain-based learning steps proposed Alsati (2004) and Marji (2010) which are as follows:

a) Preparation Stage:

This is the first stage that involves summarizing the topic, allowing the learner to mentally grasp the topic, so they are representing new information and processes. Focus on preparing the learner's brain to understand and connect related topics.

b) Acquisition of Learning:

This is second step which highlights the importance of direct or indirect formation of neural relationships such as lectures, visual aids, stimulation and challenges.

c) Elaboration Stage:

In this stage, teachers engage learners in classroom activities using both implicit and explicit learning strategies, such as blended learning, brainstorming, and summarization. These methods help deepen understanding and facilitate exploration and interconnection among different topics.

d) Memory Formation Stage:

This stage tends to strengthen learning and the learner's brain will encode what has been learned. There are several aspects that can provide assistance to get the information, such as good and healthy nutrition, suitable break and connections to prior knowledge.

e) Functional Integration Stage

This final stage of learning not only clarifies ideas and principles within the topic but also enhances and deepens understanding by encouraging learners to question and reflect on the significance of achieving the learning objectives.

3.4 Procedure

Following process was followed for the research instruments' reliability and validity.

3.4.1 Validity of Instruments

The researcher employed following procedures to refine or replace the developed test items:

1. The researcher confirmed that each test item was proportionately aligned with the particular table of specification of respective chapter.
2. Obtained feedback from different educational research experts.
3. Content and face validity
4. Conducted pilot testing

Initially, 60 test items were selected for Subject Achievement test based on the concepts from the four selected chapters of the 8th-grade General Science textbook. After reviewing these items, 10 were removed as per experts' feedback, alignment with the tables of specification, and suggestions from practicing General Science teachers (Appendix 10). Consequently, total 50 test items were selected. To measure critical thinking of students the researcher adapted Critical thinking test developed by Alison King in 2017 at Brown University USA. The test comprised of concept-based questions rather than text based. This test was consisted of open-ended questions. Total 10 open-ended questions were developed from all selected four chapters of General Science textbook.

The final selection process involved:

1. Aligning the items with their respective tables of specification
2. Consultation with the educational experts
3. Consultation with the working general science teachers

This process led to the development of the research tools for the study, including the Subject Achievement Test and the Critical Thinking test.

3.4.2 Reliability of Instruments

The researcher used KR-21 formula to assess the Student Achievement Test items' reliability because the nature of data was dichotomous, hence, KR-21 formula was used. Obtained value of KR-21 formula was .81 which reflected that the test was reliable. The test-retest reliability method was used to assess the reliability of Critical Thinking test. The researcher gave same Critical Thinking test to three educational experts at two different times and compare the responses from both time points using Pearson's correlation coefficient. The Pearson's correlation coefficient between the test scores at time 1 and time 2 was .85, indicated a strong positive correlation and good test-retest reliability and this also indicated that the research tool was reliable.

3.5 Data Collection

The study used experimental design to conduct this research, and the researcher formulate two groups and further divide these groups randomly into control and experimental groups. On 1st December 2023 subject achievement pre-test was given to all the students and results were collected.

After that on 4th December 2023 Critical Thinking test. was given to all the students and results were collected. After the treatment of eight weeks same tests with rearranged items were taken from control and experimental groups and results were collected. During this study experimental threats were controlled by using randomization and matching scheme.

3.5.1 Selection of Teacher

To instruct both groups (control and experimental) in their selected classrooms, an 8th-grade General Science teacher was chosen. The teacher taught to control group by using the traditional method and the experimental group through the Brain-Based Learning (BBL) method. The researcher gave proper training to that selected teacher and also remain present to assist that teacher throughout the experiment.

3.5.2 Experiments of the Study

Experiments of the study were conducted at government boys' secondary school in the village of Panag Sharif.

3.5.3 Schedule of the Experiment

The experiment was carried out by the researcher at Government Boys Secondary from village School Panag Sharif, which operates under the management of the Department of Elementary and Secondary Education of the Government of Azad Jammu and Kashmir. Government Boys Secondary School Panag Sharif was selected for completing the experiment. The distance of the school was less than one kilometer, which was easy for research to conduct the experiment conveniently. The research took place from 11th December 2023 to 12th February 2024 after second term exams.

The researcher selected last four units from general science textbook and these units were the syllabus for third term exam. So, the study was conducted in this period and it was impossible to delay the experiment as board exams started soon after third term exams. Additionally, the school administration and teachers were focused on completing the syllabus before these exams. School administration assigned 3rd period started from 9:00 am to 9:40 am and 5th period started from 10:20 am to 11:00 am without changing the schedule and timetable of the school but they adjusted separate classrooms for the control and experimental groups. The researcher received written permission (Appendix 11) from the school headmaster before conducting the experiment. Details of the experiment is given bellow: -

3.5.4 Duration of the Experiment

The experiment was conducted from 11th December 2023 to 12th February 2024, following the second term exams of the 2023-24 academic session. At the selected school, 40 minutes each day was allocated for teaching the control group, and another 40 minutes was set aside for the experimental group. The whole experiment continued for 8 weeks, with sessions held six days a week.

3.5.5 Teaching to Experimental Group

The concern general science teacher taught the experimental group of the selected school through brain-based teaching method and the researcher also there to assist that teacher.

Following strategies were adopted during teaching:

1. The researcher gave provided training to the teacher about brain-based method.
2. The researcher provide assistance to the teacher throughout the experiment.
3. The experiment of the study was conducted on after second term exams to resolve course completion issue.
4. Last four units were selected from general science textbook as these units were included in final term exams syllabus.
5. The researcher and school head make sure to manage proper workload of general science teacher.
6. Strategies related to brain-based learning such as i) formal or perceptive regulator, ii) brain -storming and iii) Know Wanted Learning KWL were adopted during teaching experimental group.
7. Brain-based teaching techniques such as i) Indulgement, ii) Relaxation and iii) Active processing were also adopted during teaching experimental group.
8. Students were encouraged to ask questions.
9. Students were assigned group tasks in a challenging manner.
10. Students were active participants during teaching learning process.
11. Teacher maximized students learning in a safe but challenging manner.
12. Teacher linked students learning with their previous learning or information.
13. Factors such as age, sex, academic qualifications, and teaching experience in general science were considered when selecting the teacher.
14. All teaching sessions for the experimental group followed the 32 lesson plans developed by the researcher, which covered the topics from the selected four units using the brain-based method and its five steps.
15. The teacher adhered strictly to the lesson plans during all teaching sessions for the experimental group.

3.5.6 Teaching to Control Group

In the selected school, the traditional method (Lecture method and Discussion method) for teaching 8th-grade General Science involved the lecture method, which was used as the traditional method throughout the study. This group was taught through lecture method, following the 32 lesson plans. The general science teacher at the school instructed the control group in the four selected chapters. The school headmaster ensured that the lesson plans were strictly implemented for the control group. During the teaching of the control group, the following strategies, based on the 32 lesson plans, were adopted:

1. Emphasis on rote memorization and learning
2. Delivery of content through whiteboard writing
3. Content delivery through lectures only
4. Mandatory notetaking
5. Limited teacher student interaction
6. Minimal student interaction
7. Poor students' interaction with each other
8. Assigning homework only
9. Classroom tests taken from the textbook only
10. Individual work of students is encouraged
11. Use of threats, blame, taunting, sarcastic remarks, and punishment.
12. Students cognitively active but passive learner in real
13. Explanation of concepts based only on textbook content
14. Authoritative classroom management
15. Explanation of General Science concepts directly from the textbook
16. Whiteboard writing and requiring students to note in their notebooks
17. Teacher read the topic from textbook or write on whiteboard and asking students to copy.

18. Ignoring students' readiness, motivation, and individual differences.
19. Strict discipline is followed
20. Students are punished for their poor attention, mistakes, talking or laughing, questioning, or needing breaks during the session.
21. All teaching sessions for the control group were conducted according to the 32 lesson plans developed with the traditional teaching method.

3.5.7 Availability of Academic Opportunities

The selected students in both groups had equivalent access to the following opportunities:

1. Same teaching hours in a day
2. Same content in same day
3. Same chapters covered
4. Same number of lesson plans used
5. Same duration of period each day.
6. Time allocated for each period each day.
7. Timing for conducting of pre-tests and post-tests

3.5.8 Physical Facilities Provided by the Concerning School

1. At the request of the researcher, the headmaster of the selected school provided the following physical facilities:
2. Two spacious and well-ventilated classrooms.
3. Appropriate furniture, including whiteboards, erasers, a dais, and a cupboard.
4. Adequate seating arrangements for students.
5. Access to a printer.

3.6 Execution of Experiment

Following steps were taken to process the experiment.

3.6.1 Ethical Consideration

The researcher conducted the study after getting permission from Headmaster of concerned school, Government Boys High School Panag Sharif. Data were collected from the participants after taking permission from the head of the institution where the study was conducted. Ethical issues such as informed consent, confidentiality, anonymity and conflict of interest were considered by the researcher. The researcher insured the secrecy and confidentiality of the school. Obtained information was kept secretly and obtained data were only used for research purpose.

3.6.2 Administration of Pre-test

Before starting the intervention, Subject Achievement Test was administered as pretest on December 01, 2023, to all the selected students. These scores established baseline measurements of each student's ability before the experiment began. Students were divided into two equal groups based on their pretest results. After that on December 04, 2023, Critical thinking test was taken from both selected groups students.

3.6.3 Teaching Learning Sessions

Teaching learning sessions were conducted from December 11th to February12th 2024. During this period, the intervention involved implementing 32 validated lesson plans for each group over the course of eight weeks.

3.7 Control of Variables of the Study

The study was conducted in a one government school only. To minimize the impact of various extraneous variables, the researcher implemented specific measures. The following six variables, relevant to the internal validity of the experiment, are detailed below along with the measures taken to control them.

3.7.1 History and Maturation

No such incident occurred throughout this study that influenced the results. Therefore, historical factors did not influence the internal validity of the study. Additionally, maturation occurred uniformly among students in both groups.

3.7.2 Testing

The concept of Brain-Based Learning (BBL) was unfamiliar to both students and teachers. Textbook-based pre- or post-tests made students aware of the material, potentially threatening the validity of the experiment. However, the research tool formed by the researcher was new to the students. The uniqueness of these different items, along with the two-month interval between the pretest and posttest and the fact that students were unaware of the post-test administration, helped reduce the risk of testing threats.

3.7.3 Instrumentation

The researcher employed the same tool for both the pretest and post-test, calculating achievement scores based on the difference between these tests. The research tool was validated before its administration. By using the same test for both the pretest and post-test and incorporating this approach into the study's design, the researcher effectively controlled for instrumentation variables.

3.7.4 Statistical Regressions

The researcher used two approaches to control this variable:

1. Sampling Method: Students were sampled based on a normal distribution of pretest scores, using matching and randomization. Students who could not be matched in pairs were not taken as the sample of the study.
2. Correlation of Pretest Scores: The pretest scores of each student were expected to find significantly correlated.

3.7.5 Differential Selection of Subjects and Maturation Interaction

This variable was controlled by not using the entire class as the study sample. Instead, the researcher employed matching pairing to select students for the study sample.

3.7.6 Mortality

This variable was managed by restricting the experiment to a duration of 8 weeks. Additionally, obtaining consent from the teacher and ensuring students' willingness helped maintain full attendance throughout the study, with no students falling ill or being absent.

3.8 Variables for External Validity of the Experiment

The following variables pertain to the external validity of experiment. Details of these variables and the quality measures taken to control these are provided below.

3.8.1 Pretest Treatment Interaction

The researcher managed this variable by giving a pretest that was unfamiliar to all students. The items for the Subject Achievement Test were taken from the textbook. The same test, with the order of items unchanged, was then readministered as a post-test after a two-month interval.

3.8.2 Multiple-Treatment Interference

This variable was controlled since the students were included as the sample of this study and the researcher made it possible that theses selected students were not included any other study during this experiment. Furthermore, the researcher uses same treatment for both groups in selected school.

3.8.3 Selection-Treatment Interaction

Students were randomly selected using a matching pairing procedure to reduce the effect of this important variable within the selected school. Additionally, intact classes were not assigned to the control or experimental groups. Instead, equivalent groups were formed, and students were randomly assigned through matching pairing.

3.8.4 Specificity of Variables

The study intended to assess the effect of brain-based learning compared to traditional teaching methods in General Science subject. Students were taught using 32 specific lesson plans, and a 50-item test, developed by the researcher, was administered to them. The experiment was conducted from December to February during the 2023-24 academic session, with students divided into two groups i.e experimental and control.

The specific conditions did not significantly impact the study's results because a validated sampling procedure was used. The post-test was taken immediately after the 8-week treatment period. All parameters, including pre- and post-tests, rubrics, study duration, period length, and achievement scores, were clearly defined, resulting

in no significant interaction between historical factors and treatment effects or between the timing of measurement and treatment effects.

3.8.5 Experimenter Effects

The concept of Brain-Based Learning (BBL) was new from our perspective, and the working teacher was also unfamiliar with this innovative approach. The researcher had been involved with BBL for the past three years, gaining training through literature reviews and YouTube clips. Consequently, the researcher decided to provide thorough training on the BBL teaching method to the General Science teacher before involving him in teaching both control and experimental groups.

To minimize the experimenter effect, the researcher ensured that both groups were taught by same teacher, on the same day, using identical content and lesson plans. An objective scoring rubric for pre- and post-tests helped reduce scoring bias. The study-maintained equivalence in different factors, including the lesson plans, period duration, timing and location of treatments, all topics covered, students' sex and socio-economic status, and the composition of homogenous ability groups. The timing of pre- and post-testing for both groups was also kept consistent throughout the research, ensuring that all these variables were controlled by the researcher.

3.8.6 Reactive Arrangements

Students in the control group continued their studies using the traditional teaching method and were unaware of any comparative aspect of the study. Similarly, students in the experimental group were also kept uninformed about comparisons with other students throughout the experiment. By ensuring that students were unaware of any comparative elements and implementing an 8-week study duration, the researcher effectively controlled potential biases.

The principal of the respective school ensured strict adherence to the specified lesson plans for both groups, helping to manage any potential overambitious behaviors and allowing students to respond according to the lesson plans. There was no placebo effect in this study, as all control group students received the traditional teaching method, while the experimental group was taught using the BBL method without any biases. The 8-week study period also helped mitigate any novelty effects of the treatments.

3.9 Variables of the Study

The following were the variables of the study:

3.9.1 Independent Variable

Teaching methods (Brain-based and Traditional method) were the independent variables of the study.

3.9.2 Dependent Variable

Critical Thinking and Academic Achievement were the dependent variable of the study.

3.9.3 Extraneous Variables

An extraneous variable can affect the results of an experiment but is not the primary focus of the study. In this research, extraneous variables included temperature, mood, and intelligence of participants, as well as individual differences such as age and gender. These variables were controlled through techniques such as randomization, matching, and pairing during the experiment.

3.9.4 Intervener Variables

An intervening variable is a theoretical construct used to explain the causal relationships between other variables, though it cannot be directly observed in an experiment. In this study, intervening variables included the content, teaching methodology, classroom environment, teaching environment, teaching techniques, and management of instructional materials. The researcher controlled these intervening variables to identify and measure their effects and adjusted the treatment by modifying the content, tactics, management of instructional materials, and the teaching environment.

3.10 Conduction of posttest

The posttest was administrated immediately after the final session of the intervention on February 13, 2024, marking the end of the eight-week study period. The pretest was taken as the posttest to all the students in the study sample. The post-test scores for each student were recorded and used to calculate the changes in their subject achievement and critical thinking scores by deducting the pretest scores from the post-test scores.

3.11 Data Analysis

The data for the study included the following scores:

1. Pretest Score: Before the experiment, all selected students were administered a Subject Achievement Test and a Critical thinking test, each worth 50 marks. The scores obtained from these tests before the intervention were referred to as the Pretest Scores.

2. Post-test Score: The same Subject Achievement Test and Critical thinking test, each worth 50 marks, were re-administered immediately after the eight-week intervention to both control and experimental groups. The scores obtained from these tests at the end of the 8 weeks experiment were referred to as the Post-test Scores.

3. Critical thinking test: Critical thinking test was used to measure critical thinking.

4. Data Analyses: To assess the effect of the experiment on critical thinking and academic achievement of students' pre and posttests scores were compared. Data were analyzed using the SPSS version 23. The researcher used paired sample t test and ANOVA for testing research hypotheses. Paired sample t test was used by the researcher to compare the score of pretest and posttest. While ANOVA was used to check BB method effects on critical thinking and academic achievement of students. Based on this analysis, the researcher concluded and made recommendations.

CHAPTER 4

ANALYSES OF DATA

This chapter presented the data analyses for the experimental and control groups from the selected secondary school. Statistical analyses were performed using SPSS version 23. The null hypotheses were tested based on the results of these analyses, with all tests conducted at a significance level (SL) of 0.05. The researcher utilized paired sample t-test and ANOVA to test the research hypotheses.

The results of these statistical tests are presented below:

4.1 Comparison of Experimental and Control Group before Intervention

Data received from pretest of experimental and control group before intervention. The data were analyzed to test the knowledge of the sample in 8th grade students in general science subject before the intervention.

4.1.1 Comparison of Experimental and Control Group Regarding Critical Thinking

Table 4.1

Pretest Score of Critical Thinking

	Group	N	Mean	SD	t	df	p value
Pretest score	Experimental	30	4.43	3.617	.391	58	.697
	Control	30	4.07	3.638			

Table 4.1 shows the pretest results for students in both groups (experimental and control) before intervention. The calculated mean scores of experimental group was 4.43, compared to 4.07 for control group. On the other hand, standard deviation was, 3.617 and 3.638 respectively. The slightly higher standard deviation in the control group indicates a greater spread in their scores compared to the experimental group. The significance level of the difference between the two groups was .697 i.e. 0.0071

(Bonferroni adjusted alpha) which is greater than the alpha value (.05), and the t-value was 0.391, which is statistically insignificant. Therefore, the analysis indicated no significant difference between both groups regarding the critical thinking skill before the intervention.

4.1.2 Critical Thinking of Experimental and Control Group

Table 4.2

Critical Thinking of Control Group

	Group	N	M	SD	Sig.
Pair 1	Pretest	30	4.07	3.638	.000
	Posttest	30	9.23	5.177	

Table 4.2 shows that the critical thinking scores were measured for the comparison of pretest and post-test results. The mean scores for the pretest and post-test were 4.07 and 9.23 which showed the mean score difference of 5.16. While standard deviation was 3.638 and 5.177 respectively, indicating that post-test scores were more dispersed than pretest scores. The improvement in mean scores suggests that students' critical thinking skills improved after the intervention.

Since the significance level of .000. While Bonferroni adjusted alpha value was .0071 which is less than the alpha value (.05), it confirmed a significant improvement among students critical thinking skills in the control group after the intervention.

4.1.3 Critical Thinking of Experimental Group

Table 4.3

Critical Thinking of Experimental Group

	Group	N	M	SD	Sig.
Pair 1	Pretest	30	4.43	3.617	.000
	Posttest	30	18.53	5.406	

Table 4.3 shows that the critical thinking scores were evaluated based on the difference between pretest and posttest results. The calculated mean value of pretest was 4.43 and posttest value was 18.53. The standard deviation of pretest was 3.617, whereas the post-test standard deviation was 18.53, indicating greater dispersion in post-test scores compared to pretest scores.

The mean score difference between the pretest and post-test was 14.1. Since the significance level of .000. While Bonferroni adjusted alpha value was .0071 which is less than the alpha value (.05), it confirmed a statistically significant improvement among students regarding their critical thinking skills in the experimental group following the intervention.

4.1.4 Comparison of Critical Thinking in Experimental and Control Group

Table 4.4

Mean Difference of Experimental and Control Group

Control Group	N	M	SD
Pretest score	30	4.07	3.638
Post-test score	30	4.43	3.617

In above table number 4.4, revealed that the pretest mean value of control group was 4.07 and experimental group was 4.43. This showing minor difference of 0.36. Additionally, the control group standard deviation value was 3.638 and 3.617 for experimental group. This indicates that the scores in the control group were slightly more dispersed than those in the experimental group. Overall, mean values suggested that the performance of experimental group was slightly higher compared to the control group.

Table 4.5

Comparison of Pretest Mean Score between Control and Experimental Group Critical Thinking

	Group	N	M	SD
Pretest score	Experimental	30	4.43	3.617
	Control	30	4.07	3.638

Table 4.5 shows that the pretest mean value for experimental group was 4.43 and 4.07 for control group, reflecting the average difference of 0.36. Additionally, the standard deviation value weas 3.617 for experimental group and 3.638 for control group that indicated that the scores of control group were slightly dispersed than those in the experimental group. Overall, the mean values suggested that the performance of the experimental group was marginally high than that of the control group before the intervention.

Table 4.6

Comparison of Post-test Mean Score between Control and Experimental Group Critical Thinking

	Group	N	M	SD
Post-test score	Experimental	30	22.43	6.826
	Control	30	9.23	5.177

The above table no. 4.6 shows experimental group post-test mean value was 22.43 and 9.23 for control group, indicating a difference of 13.2 points. In addition, the standard deviations for experimental group were 6.826 and 5.177 for control group, suggesting that the scores in the experimental group were more widely spread as compared to control group participants. The calculated mean score highlighted that the performance of experimental group students was significantly high as compared to the control group.

Table 4.7

Comparison of Mean Score between Control and Experimental Group Critical Thinking

	Group	N	M	SD
Post-test score	Experimental	30	22.43	6.826
	Control	30	9.23	5.177

The above table 4.7 revealed that the post-test mean value for the experimental group students was 22.43 and 9.23 for the control group, reflecting an average difference of 13.2 points. Furthermore, the experimental group standard deviations were 6.826 and 5.177 for the control group. These results indicated that the scores in the control group were more dispersed compared to those in the experimental group. These results highlighted that the experimental group performance was superior to the control group.

4.1.5 Comparison of Critical Thinking in Experimental and Control Group

Table 4.8

Comparison of Critical Thinking in Experimental Group

Group	N	M	SD	t	df	p value
Pretest	30	4.23	3.617	-18319	29	.000
Posttest	30	22.43	6.826			

Table 4.8 shows that the critical thinking was assessed through comparing the pretest and post-test scores of students. The mean value for the pretest was 4.23, while 22.43 was the post-test mean value. The pretest standard deviation was 3.617, compared to 6.826 for the post-test, indicating greater variability in the post-test scores. This variation suggests an improvement among students' regarding their critical thinking skill following the treatment.

The t value was -18.319, with .000 i.e. 0.0071 (Bonferroni adjusted alpha) significance level, indicated a significant difference among the critical thinking results of pretest and post-test for experimental group students.

Table 4.9

Comparison of Critical Thinking in Control Group

Groups	N	M	SD	t	df	p value
Pretest	30	4.07	3.638	-7942	29	.000
Post test	30	9.23	5.177			

Table 4.9 shows that the critical thinking scores were assessed through comparing the results of pretest and post-test, with mean value of 4.07 and 9.23, respectively. The pretest, standard deviation was 3.638, while it was 5.177 for pretest. These results indicating greater variability in posttest scores. The mean scores suggest an improvement in students' critical thinking following the intervention. The t value was -7.942, and the significance level was .000, i.e. 0.0071 (Bonferroni adjusted alpha) indicated a significant difference among the pretest and post-test scores of control group.

4.2 Comparison of Experimental and Control Group Before Intervention Regarding Academic Achievement

4.2.1 Pretest Score of Academic Achievement

Table 4.10

Pretest Score of experimental and control group in Academic Achievement

	Group	N	M	SD	t	df	p value
Pretest score	Experimental	30	15.37	6.446	.020	58	.984
	Control	30	15.33	6.424			

Table 4.10 shows that the average pretest scores of experimental group was slightly higher in the, with a mean value of 15.37 as compared to 15.33 of control group. The experimental group standard deviation was 6.446 for the and 6.424 for the control group. This calculation indicated that the scores of control group was slightly less dispersed. The level of significance difference was .984, which was greater than the alpha value of 0.05, i.e. 0.0071 (Bonferroni adjusted alpha) and the t-value was .020, which is statistically insignificant. Therefore, the results indicated no significant difference in the mean pretest scores between the experimental and control groups, suggested that their academic achievement levels were equivalent before the intervention.

4.2.2 Academic Achievement of Experimental Group

Table 4.11

Experimental group pretest post-test mean score

	Group	N	M	SD	Sig.
Pair 1	Pretest	30	15.37	6.446	.000
	Post test	30	34.67	5.122	

Table 4.11 revealed that academic achievement of students in experimental group was measured through comparing their pretest and post-test results. The analysis revealed that the mean value of pretest was 15.37. On the other hand, posttest mean value was 34.67 respectively. The data also highlighted that pretest standard deviation was 6.446, while posttest was 5.122 respectively. These results indicated that as compared to posttest, pretest scores were more dispersed. The calculation demonstrated an improvement among student performance after the treatment.

The difference between mean value was 19.3 and level of significance was 0.00. While Bonferroni adjusted alpha value was .0071 which was less than the alpha value (.05). These results highlighted that there was a significant academic achievement difference among students of experimental group before and after the treatment.

4.2.3 Academic Achievement of Control Group

Table 4.12

Control group pretest post-test mean score.

	Group	N	M	SD	Sig.
Pair 1	Pretest	30	15.33	6.424	.000
	Post test	30	20.00	5.977	

Table 4.12 revealed that there were 30 students in control group. Academic achievement of students was assessed through the comparing of pretest and post-test scores. The pretest mean score was 15.33, while the post-test mean score was 20.00. The standard deviation of pretest was 6.424, and 5.977 for posttest respectively. These results indicated that the as compared to the post-test scores, pretest scores were more dispersed. This highlighted an improvement among student performance after the treatment.

The data also revealed that there was a difference in the mean score of pretest to the post-test was 4.67 with 0.00 significance level. While Bonferroni adjusted alpha value was .0071 which is less than the alpha value (.05), which is less from alpha value of .05. These results indicated that there was a significant difference among students' academic achievement in control group before and after the treatment.

4.2.4 Comparison of Academic Achievement in Experimental and Control Group

Table 4.13

Comparison of Pretest Post-test Mean Score of Control Group Academic Achievement

Control Group Scores	N	M	SD
Pretest	30	15.33	6.424
Post-test	30	20.00	5.977

The above table 4.13 revealed that the pretest mean scores of control group was 15.33 and 20.00 for the experimental group. These results indicated an average difference of 4.67. Furthermore, the control group pretest standard deviation was 6.424 and 5.977 for the posttest. These results indicated that the pretest values were more spread-out as compared to the score of posttests. The difference between mean values highlighted that student's performance in the posttest was slightly better as compared to the pretest.

Table 4.14

Comparison of Pretest Mean Score between Experimental and Control Group Academic Achievement

	Groups	N	M	SD
Pretest score	Experimental	30	15.37	6.446
	Control	30	15.33	6.424

Table 4.14 showed that 15.37 was mean scores for the pretest in experimental group and 15.33 for the control group. These results indicated a minor difference of .05. Moreover, 6.446 was the experimental group standard deviations and on the other hand 6.424 was for the control group. These results indicated that the experimental group score was slightly more dispersed as compared to control group. This calculated value of mean suggested that the performance of experimental group students had slightly better as compare to the control group before the intervention.

Table 4.15

Comparison of Post-test Mean Score between Experimental and Control Group Academic Achievement

	Groups	N	M	SD
Post-test score	Experimental	30	34.67	5.122
	Control	30	20.00	5.977

The above table no. 4.15 demonstrated that post-test mean score of experimental group was 34.67 and 20.00 for control group respectively. These results indicated an average difference of 14.67 between both groups. Moreover, the experimental group standard deviation was 5.122 and 5.977 for control group. These results indicated that the data in experimental group was more dispersed as compared to control group. The difference in calculated mean score confirmed that the performance of the experimental group students was much better from control group students.

4.3 Significant Effect of Brain-Based Method and Traditional Method on Students' Critical Thinking (Hypotheses H_o1 and H_o2)

To analyze the hypotheses following analytical steps have been taken:

H_o1: There is no significant effect of brain-based method on students' critical thinking.

Table 4.16

Significant effect of brain-based method on students' critical thinking

	Group	N	M	SD	t	df	p value Sig.
Mean score	Pretest	30	4.43	3.617	-18.319	29	.000
	Posttest	30	22.43	6.826			

Table 4.16 displays that the mean scores were 4.43 for the pretest and 22.43 for the post-test, showing a substantial increase of 18.00 in the mean score post-intervention. This improvement indicates a significant enhancement in students' performance following the treatment. The standard deviations were 3.617 and 6.826 suggesting that the post-test scores were more dispersed compared to the pretest scores. The t-test value was -18.319 with the significance level (p-value) of .000. While Bonferroni adjusted alpha value was .0071 which is less than the alpha value (.05), demonstrated a statistically difference in critical thinking before and after the treatment.

Consequently, the null hypothesis (H_o1) there is no significant difference in the mean score of the brain-based method on students' critical thinking was rejected. The alternative hypothesis (H1), which posits that there is a significant difference, was accepted, supporting the effectiveness of the brain-based method in enhancing students' critical thinking skills.

H_o2: There is no significant effect of traditional method on students' critical thinking.

Table 4.17

Significant effect of traditional method on students' critical thinking

	Group	N	M	SD	t	df	p value Sig.
Mean score	Pretest	30	4.07	3.638	-7.942	29	.000
	Posttest	30	9.23	5.177			

Table 4.17 presents data from the mean value for the pretest and posttest were 4.07 and 9.23, respectively. These results indicated a modest improvement among students' performance after the treatment. The standard deviations were 3.638 for the pretest and 5.177 for the post-test, reflecting a greater dispersion in posttest scores. The t-value of -7.942 and the significance level (p-value) of .000. While Bonferroni adjusted alpha value was .0071 which is less than the alpha value (.05) confirmed a statistically significant difference in critical thinking before and after the treatment.

So, the null hypothesis (H_o2) there is no significant difference in the mean score of the traditional method on students' critical thinking was rejected. Therefore, the H2, alternative hypothesis suggesting that there is a significant difference was accepted.

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4.4 Significant Difference in the Mean Score of Brain Based Method and Traditional Method on Critical Thinking of Students (Hypothesis H_o3)

H_o3: There is no significant difference between the mean score of students critical thinking taught through brain-based method and traditional method.

Table 4.18

Significant difference between brain-based method and traditional method on students' critical thinking

	Group	N	M	SD	t	df	p value Sig.
Mean score	Control	30	4.25	3.601	-11.363	58	.000
	Experimental	30	18.23	8.965			

Table 4.18 showed the mean value of the control group was 4.25, whereas the mean value of experimental group was 18.23 respectively. This result indicates that there was an extensive difference of 13.98. The data revealed that students of experimental group achieved a significantly better scores as compared to control group. Which simply demonstrated a notable enhancement among students in experimental group. Furthermore, the value of standard deviation for control group was 3.601, compared to 8.965 for the experimental group. This data indicated that the experimental group scores were more dispersed.

The t-test value was -11.363 with the level of significance (p-value) .000 i.e. 0.0071 (Bonferroni adjusted alpha) which was less then alpha value. This signifies a significant difference in critical thinking among students who taught using the brain-based method and those who taught using the traditional method. Consequently, the null hypothesis (Ho3) stating that there is no significant difference between the mean scores of brain-based and traditional methods on students' critical thinking was rejected.

Thus, the alternative hypothesis (H3), which proposes a significant difference between the mean scores of brain-based and traditional methods on students' critical thinking, was accepted.

4.5 Significant Effect of Brain Based Method and Traditional Method on Students' Academic Achievement (Hypotheses H_o4 and H_o5)

H_o4: There is no significant effect of brain-based method on students' academic achievement.

Table 4.19

Significant effect of brain-based method on students' academic achievement

	Group	N	M	SD	t	df	p value Sig.
Mean score	Pretest	30	15.37	6.446	-14.717	29	.000
	Posttest	30	34.67	5.122			

Table 4.19 presents the results for the experimental group, with an equal number of students tested before and after the intervention. The mean score for pretest was 15.37 and 34.67 for the post-test respectively. This data indicated a substantial improvement of 19.30 points. This significant increase reflects the usefulness of the treatment. Additionally, the pretest standard deviation was 6.446 as compared to 5.122 for the posttest. This suggested that the pretest score was more dispersed than the post-test score.

Furthermore, the t-test value was -14.717, and the p value was .000. While Bonferroni adjusted alpha value was .0071 which is less than the alpha value (.05). This indicated a significant difference among students' academic achievement who taught through brain-based method as compared to their pretest scores.

Hence, the null hypothesis (Ho4), which posits no significant difference in academic achievement due to the brain-based method, was rejected. Consequently, the

alternative hypothesis (H4), which asserts a significant difference in academic achievement due to the brain-based method, was accepted.

H_o5: There is no significant effect of traditional method on students' academic achievement.

Table 4.20

Significant effect of traditional method on students' academic achievement

	Group	N	M	SD	t	df	p value Sig.
Mean score	Pretest	30	18.33	6.424	-6.877	29	.000
	Posttest	30	20.00	5.977			

Table 4.20 showed the pretest mean score result was 18.33, and the post-test mean score was 20.00 respectively. These results indicated a modest improvement following the treatment. Additionally, the standard deviations for the pretest and post-test results were 6.424 and 5.977, respectively. This suggests a slight reduction in dispersion of scores from pretest to posttest.

Furthermore, the t-test value was -6.877, whereas p-value was .000. While Bonferroni adjusted alpha value was .0071 which is less than the alpha value (.05), suggested a significant difference in academic achievement due to the traditional teaching method.

Thus, the null hypothesis (H_o5), which posited no significant difference in academic achievement with the traditional method, was rejected. Consequently, the alternative hypothesis (H5), which asserts a significant difference in academic achievement due to the traditional method, was accepted.

4.6 Significant Difference in the Mean Score of Brain-Based Method and Traditional Method on Academic Achievement of Students' (Hypothesis H_o6)

H_o6: There is no significant difference in the mean score of students' academic achievement who taught through brain-based method and traditional method.

Table 4.21

Significant difference among students' academic achievement taught through brain-based method and traditional method

	Group	N	M	SD	t	df	p value Sig.
Mean score	Control	30	15.35	6.380	-9.975	58	.000
	Experimental	30	27.33	9.227			

The above table 4.21 presented the mean score results. The data revealed that control group mean value was 15.35, and 27.33 for experimental group respectively. This result indicated that there was a considerable mean value difference of 11.98 points between both the groups (experimental and control). This calculation also revealed that the experimental group students achieved significantly better results. The mean value reflected a notable improvement among students in the experimental group. Moreover, the standard deviation of control group was 6.380 and 9.227 for the experimental group respectively. These results suggested that the scores of experimental group were more dispersed as compared to control group.

The t-test value was -9.975, with the level of significance (p-value) .000, i.e. .0071 (Bonferroni adjusted alpha). This calculation revealed that this value was a below from alpha threshold. The data showed a significant difference among students' academic achievement taught through brain-based method and compared to those taught through traditional method.

Hence, the null hypothesis (H_o6) was rejected. Consequently, the alternative hypothesis (H6), which posits a significant difference between the mean scores of students' academic achievement taught through brain-based and traditional methods was accepted.

4.7 There is no significant difference between the mean score of students' critical thinking and academic achievement taught through brain-based method. (Hypothesis H_o7)

H_o7: There is no significant difference between the mean score of students' critical thinking and academic achievement taught through brain-based method.

Table 4.22

Results of ANOVA for Significant difference between brain-based method on students' critical thinking and academic achievement

		Sum of Squares	df	Mean Square	F	Sig.
Critical Thinking	Between Groups	2613.600	1	2613.600	71.211	.000
	Within Groups	2128.733	58	36.702		
	Total	4742.333	59			
Academic Achievements	Between Groups	3226.667	1	3226.667	104.163	.000
	Within Groups	1796.667	58	30.977		
	Total	5023.333	59			

Table 4.22 assessed the significant difference among the mean scores of students' critical thinking and academic achievement when taught using the brain-based method. The obtained F-ratio for critical thinking was F = 71.211, which significantly exceeded the critical F-value from the table. This result indicates that

students taught using the brain-based method exhibited notably better critical thinking skills as compared to the individuals taught through traditional methods, with F = 71.211, P = .000 (P < .005) i.e. .0071 (Bonferroni adjusted alpha) and SL = .05.

Similarly, the F-ratio for academic achievement was F = 104.163, which also surpassed the table value of F. This finding demonstrated that students who taught through brain-based method attained significantly effective academic outcomes than those taught using traditional methods, with F = 104.163, P = .000 (P < .005) and SL = .05.

Therefore, the null hypothesis (H_o**7**) there is no significant difference between the mean scores of the brain-based method on students' critical thinking and academic achievement was rejected. This rejection means that the data provided sufficient evidence to conclude that there is a significant difference among the performance of students taught through brain-based method versus**.** Consequently, the alternative hypothesis (H1) that there is a significant difference in the mean scores of students' critical thinking and academic achievement when taught using the brain-based method was accepted that means brain-based method is more effective in enhancing both critical thinking and academic performance. This result demonstrate that the brain-based teaching method significantly improves both critical thinking skills and academic achievement of students.

CHAPTER 5

SUMMARY, FINDINGS, DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The purpose of this research study was to evaluate the effect of instruction based on brain-based strategies to teach general science for enhancing students' critical thinking and academic achievement. It was an experimental study by nature and used true experimental design. The target population for this experimental study was sixty students of Government Boys Secondary School Panag Sharif Kotli AJ&K. The study was conducted by using two groups; experimental and control and in each group thirty students were randomly selected. Four units (9,10, 11 and 12) were selected from general science textbook of 8th class published by AJK Text-book Board, 2023, Muzaffarabad, for this experiment. The researcher developed 32 lesson plans from these selected units to treat the control and experimental groups. To develop lesson plans expert opinion were taken and changes and improvement were made as per experts suggestion and guidlines. The resercher made Subject Achievement Test and critical thinking test as research instruments through table of specifications. These test were applied before and after intervention as pretest and post-test respectively. Furthermore, the researcher conducted pilot testing for the reliability of the research istruments through split-half method to check the research istruments reliability. After this teacher made subject achievement pretest was given to all the students and results were collected. Then students in control group was taught through traditional method and students in experimental group was taught through brain-based method for eight weeks. After the last session of intervention same pretest was administrated as posttest. The pre and post test scores difference of each student was considered as the academic achievement of that student. Students' critical thinking was checked through Critical thinking test. Collected data were analyzed by using Statistical Package for the Social Sciences (SPSS) version 23. The paired sample t-test and ANOVA tests used by the researcher for testing the research hypotheses. Based on the analyses of the collected data the findings of the study were obtained

5.2 Findings of the Study

Following findings were made from the analyses of the data.

1. The students of both groups; (experimental and control) were tested before the instruction. The experimental groups pretest mean scores was 0.36 which was greater on average as compared to control group scores. The mean score of students of experimental group were 4.43 and control group were 4.07 (Table 4.1). Moreover, standard deviation in experimental and control group is 3.617 and 3.638. The control group data having slightly higher standard deviation shows that the control group data is less spread out or dispersed than the experimental group. The significance level of the difference remains .697 which is more from p value (0.05) and the calculated t value which is .391 is statically insignificant. This indicated that there is no significant difference in the mean score of both experimental and control group groups before intervention. Hence, on the basis of students' pretest scores, it is concluded that both groups remained equal in critical thinking test.

2. Both groups' students were tested before the intervention to check academic achievement of students. The pre-tests scores of experimental group students were 0.05 greater than the control group scores. The mean score of experimental group students were 15.37 and control group were 15.33. Moreover, experimental and control group groups standard deviation is 6.446 and 6.424 respectively. The experimental group data having slightly higher standard deviation shows that the control group data is minor less spread out or dispersed than the experimental group. The significance level of the difference remains .984 which is more than p value (0.05) and t-value is .020 which is statically insignificant. Consequently, the value in significant level indicated that there is no significant mean score difference in both groups before intervention. So, based on pretest result it was concluded that academic achievement test scores of students remained equal in both groups.

5.2.1 Findings of Objective 1: The Effect of Brain Based Method on Students Critical Thinking

The table 4.16 findings indicated the difference in students' critical thinking before and after the treatment. The calculated mean score of pre and post tests were 4.43 and 22.43 respectively. The difference in mean score (18.00) indicated improvement among students after treatment. In addition, the correlation in the pre and post test scores of 30 students in experimental group was .622 which was a positive correlation and indicate enhancement of critical thinking of the sample after the treatment. Furthermore, the t-value is -18.319 and the level of significance (p value) was 0.00, which was less than p-value. This calculation indicated that there was a significance difference in pretest and post-test results confirmed that critical thinking of experimental group students, taught through brain-based method was improved after the intervention.

5.2.2 Findings of Objective 2: The Effect of Traditional Method on Students Critical Thinking

The findings of table no. 4.17 indicated the difference in critical thinking among students before and after the treatment. In addition, the mean score of pretest and post-test were 4.07 and 9.23 respectively which indicated a slight improvement among students after the intervention. Furthermore, the t-value is -7.942 and the p-value (level of significance) was 0.00 which was less than alpha value, indicated that there was a slight significance difference in critical thinking of students who taught through traditional method in control group.

5.2.3 Findings of Objective 3: The Effect of Brain Based method and Traditional method on Students Critical Thinking

Table no. 4.18 indicated the mean score of control and experimental groups were 4.25 and 18.23 separately. This value indicated the difference of 13.98 in the mean score of experimental group that was notably higher from control group. The mean results indicated improvement in students in experimental group. Additionally, the t-test value was -11.363 and the p-value was 0.00 which was less than alpha value, indicated a significance difference in experimental group students' critical thinking who taught through brain-based method as compared to control group students. In addition, it was found that brain-based method gave significantly better results and improve

critical thinking of general science students at elementary level as compared to traditional method.

5.2.4 Findings of Objective 4: The Effect of Brain Based Method on Students' Academic Achievement

The findings of the table 4.19 indicated students' academic achievement difference before and after the intervention. The pre and post, tests mean score were 15.37 and 34.67 respectively which indicated a difference of 19.03 in mean value of posttest that was significantly higher than pretest mean score. These mean results indicated improvement in students' academic achievement after the treatment. In addition, the correlation value between the pretest and post-test scores of 30 students in experimental group was .245 which indicated a positive correlation in the enhancement of academic achievement of the selected sample after the treatment. Likewise, the t-test value was -14.717 with the p-value of 0.00 which was less than alpha value of 0.05. This calculation indicated a significance difference students' regarding their academic achievement who taught through brain-based method in experimental group before and after the intervention. The significant difference in pretest and post-test score confirmed that students' academic achievement was significantly improved who taught through brain-based method.

5.2.5 Findings of Objective 5: The Effect of Traditional Method on Students' Academic Achievement

The findings of table no. 4.20 indicated the academic achievement difference of students' before and after the intervention. The calculated mean score of pre and post tests were 18.33 and 20.00 respectively which indicated a slight improvement in students' performance after the treatment. Moreover, the t-test value was -6.877 with the p-value of 0.00 which was fewer than alpha value of 0.05. So, these results indicated a significance difference among students regarding their academic achievement, who taught through traditional method in control group before and after the treatment.

5.2.6 Findings of Objective 6: The Effect of Brain Based method and Traditional method on Students' Academic Achievement

In table no. 4.21 it was highlighted that the calculated mean value of control and experimental groups were 15.35 and 27.33 respectively. This calculation revealed a

difference of 11.98 in mean score of the experimental group which was significantly higher as compared to control group. These mean results revealed that there was an improvement among students in the experimental group. Likewise, the t-test value was -9.975 with the p-value of 0.00, which was less than alpha value of 0.05. These results indicated that there was a significance difference among students of experimental group who taught through brain-based method regarding their academic achievement as compared to control group. So, as per this calculation, it was found that academic achievement of students in general science subject was significantly improved as compared to traditional method at elementary level.

5.2.7 Findings of Objective 7: The Effect of Brain Based method on Students' Critical Thinking and Academic Achievement

In table no. 4.22 the ANOVA (analysis of variance) measured the significant difference among the mean score of brain-based method on students critical thinking and academic achievement. It was also found that the critical thinking and academic achievement of students significantly improved through brain-based method. Hence the null hypothesis H_o7 there is no significant difference between the mean score of brain-based method on students' critical thinking and academic achievement was rejected in favor of the brain-based method for the selected students. So, the alternative hypothesis H1 was accepted.

5.3 Discussion

The experimental research study was conducted to check the effect of brain-based learning on critical thinking and academic achievement of students. The researcher selected general science subject taught at elementary level in Azad Jammu and Kashmir. The study was based on seven objectives to check the effect of brain-based method and traditional method on students' critical thinking and academic achievement in general science subject at elementary level. For this purpose, general science subject of 8^{th} class was selected for intervention. Through pretest of students, it was confirmed that students' critical thinking and academic achievement in both control and experimental group were the same before the intervention and found no significant difference before the treatment. Through pretest scores it was found that there was no difference in students' critical thinking and academic achievement in both control and

experimental group, as performance of the students remained same in both groups. After the treatment, a significant difference acquired in the scores of students' critical thinking and academic achievement in general science. The finding of this study was similar to the previous studies conducted Nurbaeti and Sugiharti (2019), Lestari (2014) and Sudibyo, et al. (2024) that students taught through brain-based method obtain better grade than students taught through traditional method.

According to Lin (2018) in this modern era every teaching learning process requires that each student must be capable to acquire skills such as communication, problem solving and collaboration, innovation and creativity and most importantly critical thinking skill in order to improve their performance. Brain-based learning improves students' critical thinking skills (Rapi, et al. 2022); Anugrah (2022). Samad (2024) found in his study that the teaching learning process can affect students learning outcomes. Therefore, the Haryulinda, et al. (2020) found in their study that brain-based learning improves students' critical thinking skill. As Laksana, et al. (2019) concluded that BBL improved students' critical thinking as it facilitated teaching learning process with none threatening, relaxed and fun learning where students encouraged to learn stress free which improve their critical thinking skill. The research study conducted by Fitriani (2019) revealed that brain-based learning effect on students critical thinking and suggested that critical thinking of students can be improved through BBL. As. In their study Nisa and Rhosaliana (2020) concluded that the application of BBL increased critical thinking skills of students in mathematical subject. Another study conducted by Mubarika, et al. (2020) pointed out that critical thinking of students increased who taught through BB method as compared to traditional method. The research study of Djohar, et al. (2022) highlighted the improvement of students' critical thinking skill of who were taught through brain-based method in experimental group as compared to traditional method. The result of present study supports the above discussed findings of previous studies that brain-based learning improves students' critical thinking. Rafli, et al. (2020) concluded that students' critical thinking ability who were taught through BB method. It was also concluded that experimental group students significantly perform better but there was also an improvement of control group students. The finding of current study also produced same results as students' performance is significantly improved through BB method after the intervention.

The study conducted by Wulandari, (2014) find out that brain-based learning improves students' critical thinking as well as learning outcomes. Kong (2017) stated that in brain-based learning, students worked in small learning groups, which improve their communication, collaboration, creative and critical thinking skill. The research study of Novenda, et al (2020) revealed that critical thinking of students improved in biology subject using BB method. The findings of the research conducted that applying brain-based learning in the classroom can improve student results and can increase critical thinking capability of students. The findings of current study also revealed that experimental group taught through brain-based method perform better as than control group who taught through traditional method. This study also concluded that critical thinking of experimental group students significantly increased as compared to control group students as they learned basic concepts through traditional method. It was concluded that there was a significant difference in critical thinking of students in control and experimental group. After reviewing related studies and discussion, it was concluded that experimental group students' critical thinking in general science is significantly improve by using brain-based method as compared to traditional method.

The current study indicated a significance difference in students' academic achievement who taught through brain-based method and confirmed that students' academic achievement was improved through brain-based method. Brain-based learning not only enhance brain working but also improve academic scores of students (Klinek, 2009; Mc-Guckin and Ladhani, 2010). These studies also pointed out that working capacities of brain improved through BBL. This study also supported the results of previous studies which pointed out that achievement of students increased when they taught through BB method (Shabatat and Al-Tarawneh, 2016). The findings of this research study highlighted that brain-based learning is more effective than traditional method in teaching general science subject in order to improve students' academic achievement. This finding is similar the results of Duman, (2010) study as he also found that brain-based Learning is more effective to improve achievement of student rather than traditional method. Uzezi and Jonah (2017) pointed out that brain-based learning is more effective for student success. The finding of this study revealed that instead of traditional method, brain-based learning is more effective for science subjects in improving academic achievement of students. This finding is similar with

the findings of the studies conducted by Wortock (2002) and Ceylan & Saka (2022). As Yağbasan & Altun (2023) found out that brain-based learning improved achievement of student in social science subject. Findings of this research study supports the findings of previous studies (Duman, 2010; Gozuyesil and Dikici, 2014) that also pointed out that BBL is more supportive in improving academic achievement students. The brain-based method shows better results than traditional method. The findings this study was similar to the findings of the studies conducted by Davis (2024), Akyurek and Afacan (2013) who applied BB method different subjects such as science and technology in their classes.

Critical thinking skills of students improve through the application of brain-based instruction (Duman, 2010; Andari, et al 2019). Furthermore, Juniatri, Subagia & Rapi (2022) found that brain-based learning improves critical and creative thinking of students. This means application of BB method improve critical thinking skills among students which is very important in improving their learning outcomes because, their critical thinking skill of students enable them to evaluate and analyze the information which they get from teaching learning process (Anazifa, 2016; Mutakinati and Anwari, 2018). This study also revealed that brain-based learning enhances academic achievement of students than traditional methods. This finding is similar with the findings of other studies (Gozuyesil & Dikici 2014; Yıldırım, et al 2022; Binyameen & Khan 2022). Wortock (2002) revealed that BB approach was very influential and effective for enhancing the achievements of students. The results of current research concluded that application of BBL shows better results than traditional method. The results of present research also support the above discussed findings of previous research studies that brain-based learning improve critical thinking and academic achievement of students.

5.4 Conclusions

Based on findings of this study following conclusions have been drawn:

Brain-based method is considered as more effective than traditional method at elementary level to teach general science because it enhances students learning as learner is considered active participant throughout teaching learning process.

Brain based method is also more effective than traditional method because this method ensures maximize engagement of human brain in a challenging but stress-free environment. Brain based method is much effective than traditional method in better understanding of general science concepts in a challenging manner. Experimental group students' critical thinking is significantly high than the control group in general science subject at elementary level. This was due to experimental group students participate and interact with suitable and meaningful content and group discussion. In brain-based class students were also encouraged to ask questions for their better understanding of general science concepts.

Brain based method is also found more effective as compared to traditional method to teach general science at elementary level because teacher encouraged students individual, or group work and they were also engaged in group discussion for better understanding of general science concepts. An important aspect was noted that students' performance had remained equal before the intervention but after the treatment, students who taught through BB method perform significantly better than those who taught through traditional method. In in experimental group, implementation of Brain-based method has effective as compared to control group in improving critical thinking of general science students at elementary level in Azad Jammu and Kashmir. Brain based method was also more effective than traditional method as it only promotes rote memorization among students while BB method promotes conceptual and meaningful understanding of different general science concepts through active participation of learner in teaching learning process.

Brain-based method improve the academic achievement of students in general science subject in experimental group as this method promote understanding and processing of information into meaningful way by using maximum capabilities and capacities of brain. Unlike the traditional method which only promotes rote memorization and make students passive learners. The academic performance of students taught through brain-based method was significantly better than students who taught through traditional method. The difference in academic performance of students occurred, because in brain-based class students were encouraged ask question, involve themselves in class discussion, works in pairs and small groups,

assigning of individual tasks considering individuality of every brain, real-life problems exploration, engagement in learning activities, new learning based on previous knowledge to better understand general science concepts given in general science textbook.

A significant mean difference among students' critical thinking and academic achievement in experimental group was noted after intervention as compared to control group students who perform low than experimental group students. Through the analysis of variance, it was also concluded that experimental group students' critical thinking and academic achievement was significantly better than control group students in general science subject at elementary level in Azad Jammu and Kashmir. It was also concluded that general science students at elementary level in Azad Jammu and Kashmir performed better in improving their critical thinking and academic achievement through brain-based method.

5.5 Recommendations

This study proves that students' critical thinking and academic achievement can be improved by using brain-based method. It is also proved that brain-based method positively effective in improving critical thinking and academic achievement of students in general science subject at elementary level. In the light of this study recommendations are suggested in such way that: firstly, for teachers secondly for students thirdly for the curriculum developer and in last for future researchers.

5.5.1 Recommendations for Teachers

The teaching learning process considered best which conducted with proper cooperation and not in a passive way. Teachers need training to understand the critical thinking skill and capable to teach their students according to this skill. This study shows that the critical thinking and academic achievement of students were better who taught through brain-based method as compare those who did not use this method. So, in the light of conclusion, it is recommended that;

1. Elementary teachers need training in teaching critical thinking skill and apply this skill in the classroom.

2. Teachers may engage students in practical work like regular lab work, group work, group discussion, peer learning, project-based learning, visual aids, presentations and provision of intime feedback to enhance their academic achievement and improve their critical thinking skill for better learning of General Science concepts.
3. Teachers may encourage students to work in groups to develop different necessary skills such as social responsibility, listening to others, empathy and independence etc. So, working cooperatively allows students to improve their critical thinking as well as academic achievement.
4. Teachers may also incorporate facts of students' health such as nutrition, stress management, relaxation and exercise into learning process.
5. It is also recommended for teachers to create leaner-centered class environment in which students are encouraged to ask questions, involve in divergent thinking process, actively participate in class discussion, remain physically and cognitively active in the class and solve their academic problems through divergent and critical thinking.
6. Brain-based method is a student-centered method which is equally useful to enhance critical thinking as well as academic achievement of students. So, it is recommended to apply this method by general science teachers in their class at elementary level to improve critical thinking and academic achievement of students.

5.5.2 Recommendations for Students

Students may think critically in general science subject to solve their academic problems in order to improve their critical thinking and academic achievement which means students must be active participant in teaching learning process. Therefore, it is recommended that;

1. Students are always encouraged by the teacher to express their ideas, emotions, thoughts, responses, and different point of views freely and respectfully without any hesitation.
2. Students who face different learning disabilities such as difficulty with reading, difficulty in understanding General Science concepts, auditory processing disorder and visual processing disorder, are always encouraged to take part in class

discussion and activities to overcome their learning disabilities and improve their performance.

3. Deep understanding cannot occur through passive learning. So, it is recommended that students may actively participate in classroom through raising questions, involving classroom discussion, link new knowledge with prior knowledge, applying new knowledge to new situation and collaboration and discussion for meaningful understanding of concepts.
4. Students may use metacognition strategy that promote self-reflection ability among them regarding their understanding, identify gaps in knowledge and learn about the educational implications of brain-based method for their in-depth learning and subject matter knowledge for their better understanding of concepts.

5.5.3 Recommendations for Curriculum Developers

The primary purpose of any education system is to produce sensible and educated citizens in society. Poor education system may produce an uncivilized society that should be a serious problem for that society. Curriculum designer and textbook writer may cope such type of issues. So, the conclusions of this study recommended policy makers, curriculum designers and textbook writers:

1. Brain-based research emphasizes the importance of active involvement in learning. Curriculum developers should design activities, such as problem-solving, discussions, and project-based learning, that encourage students to actively engage with content. This helps activate multiple areas of the brain and deepens understanding.
2. Develop a learning environment that promotes positive emotions and a sense of safety. Emotional experiences are closely linked to learning and memory. It is recommended for Curriculum developer to revise curricula that foster an emotionally supportive environment, where students feel safe, valued, and motivated. Encourage teachers to build relationships with students and make learning relevant to their lives
3. Curriculum developer and policy makers guide textbook writers to design and develop such materials in textbooks which incorporate different ways of enhancing critical thinking among students.

4. Integrate practices that promote brain health into the curriculum, including sleep, exercise, and nutrition. Brain function is optimized when students engage in brain-healthy behaviors. Policymakers can work with schools to ensure students have time for physical activity, access to nutritious food, and strategies for managing stress. These practices help improve focus, memory, and overall cognitive function
5. There is a dire need for modification of the textbook of "General Science" and policy makers may make such policies to use brain-based method as a replacement of traditional one. So, it is suggested that general science curriculum may be reviewed properly and also revised according to the findings of this study. The curriculum developers prepare such textbooks that promotes and enhance critical thinking among students by using brain-based method.
6. To avoid the repetition and replication of knowledge in annual examinations at elementary level, Elementary Board may take responsibility to train exam question paper setters to assess the critical thinking of students' in-depth understanding.

5.5.4 Recommendations for Future Researchers

This study was conducted to check the effect of brain-based learning on critical thinking and academic achievement of general science students at elementary level. Recommendations for future researchers are as under;

1. To verify the findings of this study, a similar study having different population may be conducted.
2. This study was done on general science at elementary level. So, this method may be investigated on other science or arts subjects at the same or different level.
3. This current study was experimental by nature. So, it is suggested that there might be conducted a descriptive study in this area.
4. As per this study BB method is effective for general science, so further study may be conducted to check the effect of BB method on other subjects at secondary or higher level.
5. The effectiveness of the brain-based learning on students' attitudes toward different science subjects may be checked.

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APPENDICES

Appendix 1

Brain Based Lesson Plan

Lesson Plan

Name Teacher	
Class	8th
Subject	General Science
Topic:	Properties of Light
Time	40 minutes
School	

Objectives

General objectives

After teaching the subject students will be able to

i. Define science.
ii. Explain the concept of science.
iii. Use their scientific knowledge in daily life.
iv. Apply knowledge to solve problems.

Specific Objectives

After learning the lesson students will be able to

i. Identify basic properties of light.
ii. Explain basic properties of light with proper examples.

(**Strategy of K-W-L:** The teacher uses this strategy to identify required students learning and this may be applied before the start of teaching or at the end of every growing experience and to predict students learning difficulties.)

Teaching Material

The material teacher will use during the learning process is as following

White board.

Marker

Duster

Charts

Textbook

Teaching Method

Teacher will use Brain Based method to teach the class and use different A.V aids during the lecture.

Topic	Statement	Board Writing
Preparation Stage (3 minutes)	Dear students! Today we are going to discuss about and interesting topic and I hope you will enjoy it learning so listen to me4 carefully In this topic we will learn about **Properties of Light** (**The Strategy of Brainstorming:** The teacher will use this strategy and focused on the generation of different ideas related to the topic, which allow the learner to think fearlessly without any interference of the teacher. This is very useful strategy not only for small group but also could be applied for whole class.) Actually, light is a form of energy and in this topic, we learn about speed, transmission and dispersion of light. (**Indulgement:** It means the creation of an environment that promote learning and also encourage learner to involved in any teaching learning process.)	

Acquisition of Direct or Indirect Learning **(5 minutes)**	Teacher will ask the following question from the students. i. Do you know what is meant by properties? ii. What is light? iii. What is energy? (**Relaxation:** This technique is used to overcome fear, stress and hesitation of learners when they are engaged in encountering challenges.) After receiving the answers from students, teacher will write the topic on white board and start enplaning the topic	
Elaboration Stage **(20 minutes)**	**(Formal and Perceptive Regulator:** It is the process of organizing concepts in a meaningful way that procedure interrelated networks. Organization of different concepts helps the learners to arrange and organize their learning, ideas and summaries, in order to discover the lost information in detail.) **Properties of Light** Light is a form of energy. It shows some specific behaviours', such as transmission, speed, and dispersion. Here we will discuss these below. **Speed of light** Light can travel from vacuum. The speed of light is 3*108 ms. It is a universal constant denoted by **C**. it is interesting to know that the sunlight reaches the earth in eight minutes. Light provides an important link between matter and energy.	

	Transmission of Light The transmission of light depends on the transparence of objects. For example, 1. Transparent objects such as air, water, glass and some plastics allow a large quantity of light to pass through them. Almost all the light passes through transparent objects. 2. Translucent objects such as butter paper, oil, thin sheets of plastics, ground glass etc. allow some light to pass through them. This is the reason we cannot see clearly through them. 3. Opaque objects do not allow light to pass through them. They completely block light. Light either gets blocked or bounce back when striking opaque objects. Materials such as wood, stone, and mirrors are opaque objects. **Dispersion of Light.** A prism is an optical object with transparent, flat and polished surfaces that refract light. At least two of the flat surfaces have and angle smaller than 90 between them. Prisms are responsible for an interesting phenomenon called the dispersion of light Visible light is made up of seven colors, violet, indigo, blue, green, yellow**,** orange and red. When a ray of light strikes a refracting surface of the prism, it is split into rays of its constituent colors.	
Memory Formation **(5 minutes)**	**(Active Processing:** This technique simply refers to allowing the learner to integrating and processing the received information meaningfully way and supporting and justifying that with other information)	

Functional Integration Stage. **(5 minutes)** **Home Assignment** **2 min.**	For the memory formation purpose teacher will ask the following question. i. How much time light takes to reaches on earth? ii. What are translucent objects? iii. What are the Opaque objects? Now we are moving towards competition. In this segment, everyone tries to ask me to question the one who asks more questions will win the competitions. Possible questions students can ask from teacher. 1. How light works? 2. On which pattern transmission of light depends? Dear students! Draw a chart about transmission of light on your notebooks.	

Traditional Lesson Plan

Introduction:

Name Teacher	
Class	8th
Subject	General Science
Topic:	Space Crafts
Time	40 minutes
School	

Objectives

General Objectives

After teaching the subject, students will be able to

1. Define Science.
2. Use their skills to solve their daily problems.
3. Apply their knowledge in daily life.

Specific Objectives

After learning the topic, students will be able to

1. Define Space Crafts.
2. Discuss types of Space Crafts.
3. Write importance of Space Crafts.

Teaching Material

Following material will be used for teaching the topic.

- Textbook.
- White board.
- Marker.

- Duster.
- Charts.

Teaching Method

Teacher will use lecture method and discussion method to teach the class and use different A.V Aids during the lecture.

Topic	Statement	WBR
P.K Testing **6 minutes**	To check the previous knowledge of students, teacher will ask the following questions. 1. In previous lecture, we discuss about telescope. What is telescope?	Instrument for the observation of remote objects.
	2. Do you know we can know about weather before time, how that is possible?	With the help of technology.
	3. Do you know about that technology?	Satellites.
Announcement of topic (2 minutes)	After receiving the answers teacher will announce he topic in front of class and write the topic on white board.	**Space Crafts**
Presentation (20 minutes)	**Space Crafts** A space craft is craft or machine designed for space flights. Space crafts are used for a variety of purpose, including communication, earth observations, meteorology, navigation, planetary exploration and space tourism. Space crafts are also known as spaceships. **Types of space Crafts.** **i. Space probes.**	

	A space probes is a space craft that travels through space to collect scientific information. Probes that do not have astronauts. Probes send data back to the earth for scientific study. Many space probes have been sent in space, which are sending information about heavenly objects and artificial satellites. **ii. Space Station.** A space station is a spacecraft capable of supporting a crew. It is designed to remain in space for a long time. A space station is distinguished from other spacecraft use for human space flights. International space station is the largest space station in the space. It looks like a star in the space. **iii. Space shuttle.** Space shuttle is the type of spacecraft, which is used to carry men in the space. NASA launched the first space shuttle in 1918. Now NASA has launched many space shuttles now. Teacher will give the short summary of lecture to the class and then ask questions from the class about today`s lecture.	
Evaluation. (8 minutes)	To evaluate the learning of the students, teacher will ask the following questions 1. What are Space Crafts? 2. Why is Space Crafts used? 5 What are the types of Space Crafts?	
Homework **4 Min**	Dear students! Learn by heart space shuttle, also draw a diagram.	

Subject Achievement Test

Subject: General Science

Student Name: _____ **Class: _____**

Time: 1 Hour **Total Marks= 50**

Multiple Choice Questions (MCQs)

Note: Each question is followed by four options. Encircle the correct answer.

(1x50=50)

1. Bending a light due to change of medium is called:
   a. Refraction
   b. Reflection
   c. Convection
   d. Conduction
2. The angle between the incident ray and normal is called:
   a. Angle Reflection
   b. Angle Refraction
   c. Angle of Incident
   d. None of these
3. Which color has a smaller index of refraction and bends the least
   a) Red
   b) Yellow
   c) Violet
   d) Purple
4. A rainbow is caused by:
   a) Dispersion.
   b) Reflection
   c) Refraction
   d) Total internal reflection

5. The principal of reflecting prism is:
   a) Dispersion
   b) Reflection
   c) Refraction
   d) Total internal reflection
6. Which of the following statement is correct about laws of reflection?
   a. The angle of incidence equals to the angle of reflection.
   b. The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant.
   c. The angle of incident ray reflected ray, and the normal all lie in opposite plane.
   d. Both b and a
7. Which of the following color is apparently not a part of the spectrum of light?
   a. Orange
   b. Blue
   c. Grey
   d. Green
8. The image that only appears to be formed at a position behind the mirror is:
   a) Real
   b) Virtual
   c) Both a and b
   d) None of these
9. Which mirrors are used for security purposes?
   a) Plane mirror
   b) Convex mirror
   c) Mixed mirror
   d) Concave mirror
10. A highly enlarged image of object is formed at infinity, when the object is:
   a) Principal focus
   b) Center of structure

c) Pole of concave mirror

d) None of these

11. Electric current in metal is due to the flow of:

a) Protons

b) Electrons

c) Neutrons

d) Both Protons and Electrons

12. A rate of flow of one coulomb of change per second is called:

a) Volt

b) Watt

c) Ampere

d) Newton

13. Resistance causes an energy drop in the form of:

a) Heat

b) Light

c) Sound

d) Chemical energy

14. In which of the following circuits all the components are connected end to end?

a) Parallel circuit

b) Series circuit

c) Short circuit

d) None of these

15. The Sl unit for electric power is:

a) Newton

b) Ampere

c) Watt

d) Volt

16. In electric circuit, electric current is carried to the load by a wire called:

a) Live wire

b) Neutral wire

c) Earth wire

d) None of these

17. The unit of electricity consumption is
    a) Meter per second
    b) Watt per hour
    c) Kilowatt hour
    d) None of these
18. By reducing number of loops from electromagnets, the magnetic field will be:
    a) Weak
    b) Strong
    c) Not effected
    d) None of these
19. Which core can produce the strongest magnetism?
    a) Soft core
    b) Rubber core
    c) Hard core
    d) None of these
20. In speaker, a cane made of paper or plastic is called:
    a) Diaphragm
    b) Magnet
    c) Dust cap
    d) None of these
21. In speaker, coil that moves the diaphragm back forth is called:
    a) Basket
    b) Voice coil
    c) Spider
    d) None of these
22. Main source of heating energy is:
    a) Sun
    b) Coal
    c) Gas
    d) Oil
23. Which material expand more on heating.
    a) Solids.

b) Liquids.

c) Gas.

d) All of them

24. Usually objects expend on:

a) Heat

b) Cold

c) Gas

d) All of them

25. Which of the following factor make bioplastic significant?

a) They are cheap

b) They are environment friendly

c) They are none-biodegradable

d) They are none-flammable

26. What is the only active ingredient in toothpaste?

a) Sodium fluoride

b) Sorbitol

c) Both a and b

d) Water

27. The pH of toothpaste is:

a) Acidic

b) Highly acidic

c) Alkaline

d) Neutral

28. The break down and decomposition of food in our mouth release:

a) CO2

b) Base

c) Acid

d) Salt

29. How sunlight concentrated in the solar panel cooker?

a) Through convex mirror

b) Through concave mirror

c) Through plane mirror surface

d) Through convex lens

30. Which of the following can be used to make bioplastic?
    a) Steel
    b) Tin
    c) Glass
    d) Vegetable fat
31. A windmill converts mechanical into:
    a) Kinetic energy
    b) Potential energy
    c) Chemical energy
    d) Electrical energy
32. The production of energy through windmill is:
    a) Kinetic energy
    b) Potential energy
    c) Chemical energy
    d) Electrical energy
33. The power source in UPS is:
    a) A generator
    b) Electricity
    c) Battery
    d) A diode
34. Electric fire alarm works on the principle of
    a) Contraction.
    b) Expansion.
    c) Heat transfer.
    d) None of these.
35. UPS stands for:
    a) Unwanted power supply
    b) Uneven power supply
    c) Uninterrupted power supply
    d) Undersized power supply
36. The word galaxy is derived from
    a) Greek
    b) Latin

c) German

d) Chinese

37. Which of the following does not belong to the family of solar system?

a) Planet

b) Galaxy

c) Meteors

d) Comet

38. Which star is nearest to Earth?

a) Pole star

b) Orion

c) Cassiopeia

d) Sun

39. Our galaxy is known as:

a) Earth galaxy

b) Sun galaxy

c) Milky galaxy

d) Constellation

40. After complete utilization of hydrogen, the red giant becomes:

a) Black hole

b) Nebula

c) Comet

d) Asteroid

41. Stars, dust and gas particles along with certain gravity are called:

a) Space

b) Milky way

c) Galaxy

d) Universe

42. Telescope was invented in

a) England.

b) Russia.

c) America.

d) Netherland.

43. Which one is the modern version of spectroscope being
    a) Spectro form.
    b) Spectro sign
    c) Digital Spectroscope.
    d) Spectrograph.
44. The reflector of largest radio telescope is meters wide.
    a) 290.
    b) 305
    c) 320.
    d) 335.
45. Spectroscope was invented in.
    a) 1804.
    b) 1809.
    c) 1814.
    d) 1819.
46. The Hubble telescope is:
    a) Refracting telescope
    b) Small telescope
    c) Light telescope
    d) Reflecting telescope
47. The instrument which splits light in different colors is called:
    a) Electrograph
    b) Spectrograph
    c) Lactometer
    d) Cardiograph
48. The voyager 1 space craft is sent to collect data about:
    a) Mars
    b) Venus
    c) Saturn
    d) Moon
49. Which system is used in spacecraft for power generations?
    a) CDH
    b) GNS

c) RTG

d) ADC

50. Milky Way is the galaxy in which our _____ lies?

a) Solar system

b) Sun system

c) Both a and b

d) None of these

Appendix 4

Table of Specifications

Unit 1: Reflection and Refraction of Light

Ability/ Topic	**Number of Recitation (hours)**	**Cognitive Knowledge**	**Cognitive Comprehension**	**Cognitive Application**	**Total Test Items**
Properties of Light	3	4	2	0	6
Mirrors and Images Formation	1	0	1	1	2
Plane Mirrors	1	0	0	1	1
Spherical Mirrors	1	1	0	0	1
Optical Instruments	2	0	0	0	0
Total	8	5	3	2	10

Unit 2: Electricity and Magnetism

Ability/ Topic	Number of Recitation (hours)	Cognitive Knowledge	Cognitive Comprehension	Cognitive Application	Total Test Items
Current	2	2	1	0	3
Electric Power	2	2	0	1	3
Safety Devices for Circuits	1	1	0	1	2
Electromagnets	3	2	2	0	4
Total	8	7	3	2	12

Unit 3: Technology in Everyday Life

Ability/ Topic	Number of Recitation (hours)	Cognitive Knowledge	Cognitive Comprehension	Cognitive Application	Total Test Items
Bioplastic	30 minutes	1	1	0	2
Toothpaste	1	2	1	0	3
Soap and Detergent	30 minutes	0	0	0	0
Solar Cooker	2	0	1	2	3
Wind Turbine	2	1	1	0	2
UPS	2	2	1	0	3
Total	8	6	5	2	13

Unit 4: Our Solar System

Ability/ Topic	Number of Recitation (hours)	Cognitive Knowledge	Cognitive Comprehension	Cognitive Application	Total Test Items
Celestial Bodies	2	3	1	0	4
Life Cycle of Stars	2	1	0	1	2
Telescope to Study Space	1	2	1	0	3
Advancements in Space Technology	2	3	1	1	5
Benefits of Technology	30 minutes	0	0	0	0
Space Exploration	30 minutes	1	0	0	1
Total	8	10	3	2	15

Table of Specification for Critical Thinking Test

Ability/ Topic	Cognitive Knowledge	Cognitive Comprehension	Cognitive Application	Total Test Items
Questions	3	4	3	10
Total	3	4	3	10

Appendix 5

Rubric for Subject Achievement Test

S. No.	Score Range	Grade	Description
8	45-50	A+	• Demonstrates exceptional understanding of general science concepts. • Accurately answers almost all questions.
7	40-44	A	• Demonstrates strong understanding of general science concepts. • Accurately answers most questions with minor errors.
6	35-39	B+	• Demonstrates good understanding of general science concepts. • Accurately answers a majority of questions with some errors.
5	30-34	B	• Demonstrates adequate understanding of general science concepts. • Accurately answers many questions but with significant errors.
4	25-29	C+	• Demonstrates basic understanding of general science concepts. • Accurately answers some questions with limited understanding.
3	20-24	C	• Demonstrates limited understanding of general science concepts. • Accurately answers a few questions with significant gaps in knowledge.
2	15-19	D	• Demonstrates minimal understanding of general science concepts. • Accurately answers very few questions.
1	0-14	F	• Demonstrates insufficient understanding of general science concepts. • Unable to accurately answer most questions.

Questions Provoking Critical Thinking

Varying question stems can sustain engagement and promote critical thinking. The timing, sequence and clarity of questions you ask students can be as important as the type of question you ask. The table below is organized to help formulate questions provoking gradually higher levels of thinking.

Thinking Skills	Purpose	Sample Action Prompts	Example Questions[1]
Lower Levels			
Remembering	memorize & recall facts	recognize, list, describe, identify, retrieve, name	What do we already know about...? What are the principles of ... ? How does ... tie in with what we learned before?
Understanding	interpret meaning	describe, generalize explain, estimate, predict	Summarize ... or Explain ... What will happen if ... ? What does ... mean?
Higher Levels			
Applying	apply knowledge to new situations	implement, carry out, use, apply, show, solve, hypothesize	What would happen if...? What is a new example of...? How could ... be used to...? What is the counterargument for...?
Analyzing	break down or examine information	compare, organize, deconstruct	Why is ... important? What is the difference between... and...? What are the implications of...? Explain why / Explain how? What is ... analogous to?

			How are ... and ... similar?
Evaluating	judge or decide according to a set of criteria	check, critique, judge, conclude, explain	How does ... affect...?
			Why is ... happening?
			What is the best ... and why?
			Do you agree or disagree with the statement...? What evidence is there to support your answer?
			What are the strengths and weakness of?
			What is the nature of...?
Creating	combine elements into a new pattern	design, construct, plan, produce	What is the solution to the problem of...?
			What do you think causes...? Why?
			What is another way to look at...?

[1] From Alison King, "Inquiring Minds Really Do Want to Know: Using Questioning to Teach Critical Thinking," Teaching of Psychology 22 (1995): 14.

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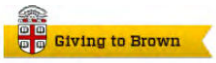

Critical Thinking Test

How Clearly Can You Think?

Here is an opportunity to use your brain!

Try every question carefully.

The outcomes from this will not affect your school marks in any way.

Your Name: _____ Class: _____ Total Marks= 50

Give answers to all questions. (10x5=50)

Q.1 Explain the dispersion of light.

Q.2 How does an image form by a plane mirror?

Q.3 What do you know about telescope?

Q.4 Differentiate between voltage and current.

Q.5 Describe the working of a speaker with the help of a well-labeled diagram

Q.6 Write the purposes of toothpaste in everyday life.

Q.7 Enlist the benefits of bioplastics.

Q.8 Explain the life cycle of stars.

Q.9 Why telescope discovery is helpful for exploration of space?

Q.10 How are space crafts' helpful for humans?

Appendix 7

5 Point Rubric for Critical Thinking

Marks	Percentage %	Value	Level	Description
05	100	5	Outstanding	• Well written • Well organized • Clear and concise statements • Excellent effort • Presentation with detail • Demonstrates a thorough understanding of the topic
04	80	4	Good	• Writes fairly clear • Good presentation • Well organization of content • Sufficient effort and detail
03	60	3	Fair	• Minimal effort • Fair presentation • Few supporting details
02	40	2	Poor	• Somewhat unclear • Shows little effort • confusing and choppy • Incomplete sentences • No organization of thoughts
01	20	1	Very Poor	• Lacking effort • Very poor • Very unclear • Does not address topic • Limited attempt

Subject Achievement Test

Pre-Test Results

S.No.	Experimental Group	Obtained Marks	S.No.	Control Group	Obtained Marks
1	Sajid	38	1	Bilal	38
2	Murad	29	2	Falk	29
3	Imdad	26	3	Ghulam Sarwar	26
4	Zeshan Ali	21	4	Iftikhar	21
5	Danish	20	5	Muhammad Ali	19
6	Rahat	18	6	Haseeb Shah	18
7	Syed Ali	17	7	Fiazan	17
8	Yaseen	17	8	Afzal	17
9	Sharjeel	17	9	Ameer Hamza	17
10	Asif	17	10	Umar Farooq	17
11	Shah Awais	16	11	Khaliq	16
12	Naseeb	15	12	Ayaz	15
13	Arsalan	15	13	Burhan Ali	15
14	Abdulllah	14	14	Jamaal	14
15	Ashyan	14	15	Qamar	14
16	Ali Haider	13	16	Naveed	13
17	Ameen	13	17	Shahmees	13
18	Zaki ul Hassan	13	18	Waqas	13
19	Ashar	13	19	Haseeb Ahmed	13
20	Armaan	13	20	Furqan	13
21	Muzammal	12	21	Masroor	12
22	Ajmal	12	22	Moseeb	12
23	Saim	12	23	Afaq	12
24	Umar	11	24	Shakeel	11
25	Haseeb	11	25	Athar	11
26	M. Zeshan	10	26	Amin	10
27	Wajahat	09	27	Kamal	09
28	Nauman	09	28	Shafqat	09
29	Fahad	08	29	Hassan Ali	08
30	Jawad	08	30	Zulqarnain	08

Critical thinking test

Pre-Test Results

S.No.	Experimental Group	Obtained Marks	S.No.	Control Group	Obtained Marks
1	Sajid	06	1	Bilal	06
2	Murad	09	2	Falak	10
3	Imdad	14	3	Ghulam Sarwar	05
4	Zeshan Ali	04	4	Iftikhar	0
5	Danish	05	5	Muhammad Ali	02
6	Rahat	04	6	Haseeb	07
7	Syed Ali	03	7	Fiazan	10
8	Yaseen	13	8	Afzal	07
9	Sharjeel	01	9	Ameer Hamza	07
10	Asif	0	10	Farooq	0
11	Shah Awais	0	11	Khaliq	0
12	Naseeb	07	12	Ayaz	0
13	Arsalan	0	13	Burhan Ali	13
14	Abdulllah	06	14	Jamal	01
15	Ashyan	10	15	Qamar	04
16	Ali Haider	04	16	Naveed	03
17	Ameen	02	17	Shahmees	04
18	Zaki ul Hassan	02	18	Waqas	04
19	Ashar	0	19	Haseeb Ahmed	11
20	Armaan	02	20	Furqan	01
21	Muzammal	03	21	Masroor	04
22	Ajmal	03	22	Moseeb	0
23	Saim	06	23	Afaq	04
24	Umar	07	24	Shakeel	01
25	Haseeb Shah	03	25	Athar	06
26	M. Zeshan	05	26	Amin	01
27	Wajahat	06	27	Kamal	02
28	Nauman	0	28	Shafqat	03
29	Fahad	03	29	Hassan Ali	06
30	Jawad	05	30	Zulqarnain	0

Subject Achievement Test

Post-Test Results

S.No.	Experimental Group	Obtained Marks	S.No.	Control Group	Obtained Marks
1	Sajid	39	1	Bilal	39
2	Murad	21	2	Falak	37
3	Imdad	33	3	Ghulam Sarwar	36
4	Zeshan Ali	30	4	Iftikhar	24
5	Danish	26	5	Muhammad Ali	29
6	Rahat	40	6	Haseeb Shah	23
7	Syed Ali	16	7	Fiazan	20
8	Yaseen	26	8	Afzal	24
9	Sharjeel	21	9	Ameer Hamza	14
10	Asif	41	10	Umar Farooq	19
11	Shah Awais	21	11	Khaliq	21
12	Naseeb	28	12	Ayaz	18
13	Arsalan	37	13	Burhan Ali	19
14	Abdulllah	27	14	Jamaal	14
15	Ashyan	24	15	Qamar	28
16	Ali Haider	31	16	Naveed	15
17	Ameen	40	17	Shahmees	16
18	Zaki ul Hassan	36	18	Waqas	31
19	Ashar	29	19	Haseeb Ahmed	34
20	Armaan	24	20	Furqan	38
21	Muzammal	32	21	Masroor	16
22	Ajmal	27	22	Moseeb	31
23	Saim	12	23	Afaq	32
24	Umar	19	24	Shakeel	12
25	Haseeb	20	25	Athar	28
26	M. Zeshan	38	26	Amin	10
27	Wajahat	41	27	Kamal	13
28	Nauman	19	28	Shafqat	13
29	Fahad	40	29	Hassan Ali	15
30	Jawad	31	30	Zulqarnain	25

Critical Thinking Test

Post-Test Results

S.No.	Experimental Group	Obtained Marks	S.No.	Control Group	Obtained Marks
1	Sajid	16	1	Bilal	15
2	Murad	18	2	Falk	21
3	Imdad	29	3	Ghulam Sarwar	05
4	Zeshan Ali	26	4	Iftikhar	02
5	Danish	25	5	Muhammad Ali	22
6	Rahat	14	6	Haseeb	03
7	Syed Ali	18	7	Fiazan	16
8	Yaseen	18	8	Afzal	07
9	Sharjeel	15	9	Ameer Hamza	10
10	Asif	09	10	Farooq	06
11	Shah Awais	14	11	Khaliq	02
12	Naseeb	19	12	Ayaz	04
13	Arsalan	14	13	Burhan Ali	18
14	Abdulllah	19	14	Jamal	10
15	Ashyan	25	15	Qamar	14
16	Ali Haider	22	16	Naveed	03
17	Ameen	24	17	Shahmees	11
18	Zaki ul Hassan	21	18	Waqas	04
19	Ashar	09	19	Haseeb Ahmed	27
20	Armaan	24	20	Furqan	09
21	Muzammal	17	21	Masroor	06
22	Ajmal	19	22	Moseeb	19
23	Saim	25	23	Afaq	15
24	Umar	14	24	Shakeel	10
25	Haseeb Shah	13	25	Athar	08
26	M. Zeshan	10	26	Amin	10
27	Wajahat	21	27	Kamal	02
28	Nauman	23	28	Shafqat	03
29	Fahad	23	29	Hassan Ali	14
30	Jawad	12	30	Zulqarnain	10

الجامعة الإسالمية العالمية إسلام آباد

International Islamic University Islamabad

Faculty of Education

Department of Teacher Education

CERTIFICATE OF VALIDATION

Research Title: Effect of Brain Based Learning on Critical Thinking and Academic Achievement of General Science Students at Elementary Level

By Nauman Saeed,

PhD Education

This is to certify that attached research instrument developed by Nauman Saeed student of PhD Education scholar underwent validation by me. It is considered that instrument(s) developed by the researcher is according to the objectives of research and it also assure the adequate Face & Content validity. The instrument(s) had passed through the examination and were proven substantially useful for her thesis.

CERTIFIED BY:

Name: ----------

Designation: ----------

Institution: ----------

Department: ----------

Signature: ----------

Date: ----------

Permission Letter

PERMISSION FOR THE CONDUCTION OF EXPERIMENT FROM HEAD OF THE INSTITUTION

Respected Senior Headmaster,
Government Boys High School Panag Sharif
Sir!

It is stated that the researcher is a PhD (Education) scholar at International Islamic University Islamabad. For the research entitled Effect of Brain Based Learning on Critical Thinking and Academic Achievement of General Science Students at Elementary Level, Class VIII of Government Boys High School Panag Sharif has been selected as a sample. The critical thinking and academic achievement of the students in the General Science subject of Class VIII will be checked by using brain-based learning. All of the work will be for academic research only and will not have any negative impact on the school timetable and routines.

Therefore, it is requested to give permission to conduct the research on the selected students (Experimental Group) in General Science subject of class VIII from 11th December 2023 to 12th February 2024 (eight weeks) so that the researcher can complete his research.

The data and results obtained from tbe experiment will be used for research purposes only.

Stay blessed.

Regards:
Nauman Saeed
PhD Education Scholar
International Islamic University Islamabad

Allowed
30/11/2023
Headmaster
Govt. Boys HIS Panag
Kotli Azad Kashmir