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Bridging the Gap between Neuroscience and Education: What are Teachers' Perceptions of Applying "Neuropedagogy" to High School Classrooms?

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Bridging the Gap between Neuroscience and Education: What are Teachers' Perceptions of Applying "Neuropedagogy" to High School Classrooms?

A Thesis Submitted by
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Dedication

This is for you, Mom. You are my role model, my inspiration, and my greatest cheerleader. Your unwavering devotion and sacrifices have paved the way for all of my achievements, and I am forever grateful for every opportunity you have provided me.

This dedication is a small token of my appreciation. Your love, guidance, and belief in me have been the driving force behind my journey. I owe my success to you, and I will always strive to make you proud.

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Abstract

Teachers can use neurobiological explanations to evaluate students' behavior and performance and create more supportive learning settings in their school environment. According to Cozolino (2013), teachers are unaware that they can benefit from understanding how the brain processes data and learn how to use certain instruction and engagement techniques to address the crucial emotional, social, and cognitive developmental changes that go on in the classroom. There is a growing interest among educators regarding the potential benefits of incorporating neuroscience into teaching practices. However, there is a lack of comprehensive understanding of how to effectively integrate cognitive neuroscience into teacher education programs to maximize its impact on student learning and teacher development. This study focuses on understanding teachers' views on the integration of neuroscience principles in educational settings by utilizing a questionnaire and interviews to gather data from participating teachers. The findings reveal that the teachers hold a positive perception of the connection between neuroscience and education. The teachers also emphasize the value of studying the brain and gaining insights into cognitive functions such as attention, memory, and motivation. The teachers' perspectives highlight the importance of integrating neuroscience principles into educational practices to create more effective and personalized learning experiences. This research underscores the transformative potential of integrating neuroscience and education. The positive perceptions of teachers resonate with the need for informed and dynamic teaching methodologies that align with the intricacies of the human mind. By embracing neuroscience principles, educators can unlock new frontiers in education, empowering both teachers and students to reach unprecedented levels of knowledge and achievement.

Keywords: neuroscience, education, neuroeducation, pedagogy perceptions, teachers, integration, cognitive functions, instructional strategies, engagement

CHAPTER ONE: INTRODUCTION

Background and Significance

In Egypt, teacher education programs focus on a wide array of courses that encompass educational methodologies, curriculum development, classroom management, and subject-specific teaching techniques (El-Bilawi & Nasser, 2017). Globally, advancements in neuroscience have provided valuable insights into learning and cognition, which have the potential to greatly impact educational practices. (Silk et al., 2014). The integration of neuroscience into teacher education programs can offer educators a deeper understanding of how students learn and develop, leading to the implementation of more effective teaching methods (Howard-Jones, 2007).

The development, structure, and function of the human brain are the foundation of neuroscience. Understanding the learning process is a fundamental part of encouraging students to succeed, which is the ultimate goal of all educators. The brain changes as a result of learning. Understanding how the brain changes by implementing concepts from neuroscience research in the classroom can help teachers design lesson plans for more efficient instructional methods.

Teachers must comprehend how the environment, as well as the emotional, social, and cognitive aspects, influence the brain's capacity for learning, social interaction, and behavior (Closs et al., 2021). The active use of intentional techniques based on the findings of neuroscience and educational psychology is called educational neuroscience. The field of educational neuroscience connects the most recent findings about how the brain functions to classroom instruction. Each task, learning opportunity, and experience molds the human brain (Schrag, 2013). Fundamental to the teaching and learning process is an understanding of how the brain converts information into learning and an understanding of what it takes for students'

brains to be engaged, attentive, and alert (Owens & Tanner, 2017).

There has been significant debate both for and against the integration of neuroscience with other related disciplines into the field of education (Leisman, 2022). Some educational researchers have argued that combining the knowledge base of developmental cognitive neuroscience with education is overly ambitious (Bruer, 1997; Dougherty & Robey, 2018) while others have argued against this view (Horvath & Donoghue, 2016; Kelleher & Whitman, 2018).

Educational neuroscience is an emerging interdisciplinary research field that seeks to translate research findings on neural mechanisms of learning to educational practice and policy and to understand the effects of education on the brain (Thomas et al., 2018). According to Louis Cozolino (2013), adaptations of the brain's chemistry and architecture, or "neural plasticity," are what enable learning and memory. The ability of neurons to alter their structure and connect with one another in response to experience is known as neuroplasticity. In order to create enriched environments that encourage neuroplasticity and brain development, teachers must employ their interpersonal abilities, inventive teaching strategies, and personalities. A one-size-fits-all educational paradigm is doomed to fail the majority of students and teachers, according to Cozolino (2013), who further argues that the human brain was not designed for the demands of industrial education. Finally, educators must comprehend that the brain develops most effectively in supportive relationships, environments with less stress, and when stories are used creatively to teach social emotional learning to kids (Allen & Kelly, 2015). According to neuroscience, stable relationships have demonstrated emotional control that optimizes biological processes. This emotional circuit activation supports executive function, intelligence, and cognitive processes. (Cozolino, 2013)

Statement of the Problem

Teachers can use neurobiological explanations to evaluate students' behavior and performance and create more supportive learning settings in their school environment. According to Cozolino (2013), teachers are unaware that they can benefit from understanding how the brain processes data and learn how to use certain instruction and engagement techniques to address the crucial emotional, social, and cognitive developmental changes that go on in the classroom. There is a growing interest among educators regarding the potential benefits of incorporating neuroscience into teaching practices. However, there is a lack of comprehensive understanding of how to effectively integrate cognitive neuroscience into teacher education programs to maximize its impact on student learning and teacher development. The existing literature highlights the importance of providing educators with brain-related information, but there is a need to further explore the specific methods and strategies that can be used to achieve the integration of cognitive neuroscience into teacher education programs. Neuroscience must be contextualized, combined with what we know about social and emotional development, and made culturally relevant to facilitate techniques in the classroom (Cozolino, 2013).

Purpose of the Study

The purpose of this study is to emphasize the importance of integrating cognitive neuroscience into teacher education programs. By incorporating knowledge from the field of neuroscience, teachers can gain a deeper understanding of how the brain learns and the impact of environmental factors on student development. This will enable educators to create more effective instructional strategies and provide a supportive learning environment for their students.

In addition to the benefits outlined in the previous studies, integrating cognitive neuroscience into teacher education programs can also equip educators with the necessary tools to identify and address the unique needs of individual students. By understanding how the brain processes information and learns, teachers can tailor their instructional approaches to cater to different learning styles and abilities.

Furthermore, the inclusion of cognitive neuroscience in teacher education can also bridge the gap between theory and practice. By being familiar with the latest research and findings in neuroscience, teachers can apply this knowledge to their day-to-day classroom practices. This integration of theory and practice can lead to more effective teaching strategies and ultimately enhance student learning outcomes.

Research Questions

1. What are teachers' perceptions of neuroscience and education?

2. What neuro-pedagogical techniques are used by teachers in the classroom?

3. What are the challenges to linking neuroscience and education?

Scope of the Study

The scope of this study focuses on the integration of cognitive neuroscience into teacher education programs and its potential impact on teaching practices and student outcomes. Specifically, it aims to explore teachers' perceptions of neuroscience and education, the neuro-pedagogical techniques they can use in the classroom, the challenges in linking neuroscience and education, and the effects of educational practices based on neuroscience on students.

Chapter Summary

The link between neuroscience and educational sciences has gained significant attention in recent years, as teachers increasingly seek to understand how their students learn in order to better respond to their needs. Teachers have shown enthusiasm towards incorporating cognitive neuroscience into education and placing importance on understanding the brain for the development of educational programs. The translation of neuroscience knowledge is essential in serving the needs of educators, and communication between the two fields is emphasized. However, despite the positive perceptions, there is still a need for greater depth in bridging the two fields, with the realization that practical implementation has yet to come to fruition. The statement of the problem outlines the need to understand teachers' perceptions of neuroscience and education, the neuro-pedagogical techniques they can use in the classroom, and the challenges in linking neuroscience and education. The scope of the study is focused on the integration of cognitive neuroscience into teacher education programs and the potential impact on teaching practices and student outcomes, thus addressing the gap between theory and practice in this emerging field.

CHAPTER TWO: LITERATURE REVIEW

Methodology for the Literature Review

The research for the literature review was conducted utilizing the American University in Cairo's database (Library OneSearch). The search terms used for the literature review included "the human brain and learning," "neuroscience and education," "teacher perceptions of neuroscience," "integration of neuroscience in the classroom," and "neuro-pedagogical techniques." The articles and studies retrieved from the database were assessed for their relevance to the research topic.

After conducting a thorough search on the American University in Cairo's database, articles and studies were found to be used in the literature review. These sources were carefully assessed to determine their relevance to the research topic of neuroscience and education. The articles and studies selected for inclusion in the literature review provide valuable insights into the current practices, attitudes, and perceptions among teachers regarding the integration of neuroscience in the classroom.

The literature review revealed that the link between neuroscience and education has been an area of growing interest in recent years. Teachers are increasingly recognizing the importance of understanding how the brain works and how it impacts learning. However, there is still a need for specific training and guidance in order to effectively implement neuroscience-based practices in the classroom.

Understanding How the Brain Works

The idea that learning involves change is not just a statement made by cognitive psychologists; it is supported by the physical properties of the brain (Inglis et al., 2014). The human brain is an intricately complex system, which changes as a result of learning. The following are some important concepts that are essential for comprehending the fundamental organization of the brain.

The brain is divided into four outer lobes, each containing an association cortex. The association cortex temporarily holds incoming information until it is either discarded, forgotten, or transferred to memory. The cortex is considered the initial responder to different types of stimuli.

- Frontal lobe—containing the primary motor cortex
- Parietal lobe—containing the primary sensory cortex
- Occipital lobe—containing the primary visual cortex
- Temporal lobe—containing the primary auditory cortex

The cerebellum, located at the brain's base, plays a key role in regulating and coordinating movement, posture, and balance. Moreover, it also serves as a crucial memory repository.

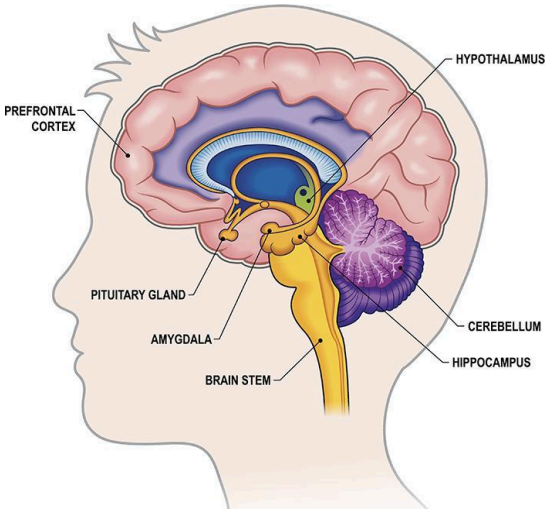
Located within the inner depths of the brain, there exists a section in the fifth lobe, the limbic system. Crucial components of this system are the hippocampus and amygdala, which both contribute significantly to information processing and memory development. The hippocampus is like an extensive library that effectively organizes and retains factual knowledge

obtained by the brain, including both mundane details and significant information. The amygdala, located close to the hippocampus, acts as a vital center for processing emotional information. It plays a crucial role in determining which incoming information is emotionally significant and should be stored in long-term memory. This highly sensitive area of the brain is involved in every aspect of information transmission. While the hippocampus retrieves factual details about someone, such as their identity, the amygdala influences our emotional response towards that person by recalling relevant emotional memories.

To comprehend the mechanisms of learning in the brain, it is necessary to explore how sensory information is received and directed to specific lobes and cortices. This intricate neurological and biological process can be summarized as follows: Our brains assimilate information through our five senses. Auditory input, along with a small portion of taste, touch, and vision stimuli, passes through the brain stem before reaching the thalamus. Situated at the core of the brain's central region and nestled within the hippocampus' branches, the thalamus assumes a most important role by serving as a relay hub for various sensory signals while also participating in pain perception and sleep regulation.

Figure 1

The Limbic System



Kopp, J. (n.d.). The Limbic System. Queensland Brain Institute - University of Queensland. Retrieved from https://qbi.uq.edu.au/files/28035/limbic-system-emotional-brain.jpg.

Learning is a fundamental process in which the brain seeks to assign meaning and organization to our experiences. This cognitive activity relies on the communication between neurons, as they form connections and transmit signals within the intricate pathways of the brain. (Gini et al., 2021). Neurons are specialized cells that transmit information through electrical signals and communicate with other cells. In the brain, learning takes place as a result of neural communication. (Sprenger, 1999).

Research on the developing adolescent brain suggests that there may be incomplete development of the prefrontal cortex, which is responsible for executive functions, impulse control, and consequential thinking (Inglis et al., 2014). Adolescents experience significant cognitive changes during their transition into adulthood. According to developmental psychologist Jeffrey Arnett (2000), this period known as emerging adulthood is not a mere delay in growing up but serves an important purpose as a critical stage for the development of complex thinking skills needed later in life. There are notable shifts in adolescents' self-perception and ability to introspectively analyze themselves (Arnett, 2000).

The extent to which emerging adults can achieve advanced cognitive development is significantly impacted by the education they receive during this crucial stage of their lives (Inglis et al., 2014). During this period, emerging adults often establish individual worldviews and gain an understanding that alternative perspectives are also valid. As the brain of an emerging adult undergoes a process of eliminating unused connections established earlier in life while forming new connections through a final phase of neural growth, it becomes better adapted for acquiring new knowledge and skills.

Inglis et al. (2014) believe that "there is a reason going back to school is harder the older you get." (p. 36) During adolescence, the brain undergoes a complex process of pruning and myelination. This involves deleting irrelevant information and strengthening neuron connections through the wrapping of myelin, which enhances the transmission of electrical impulses. As this process continues into adulthood, particularly in the twenties, stronger bridges are formed between emotional and motor centers with the prefrontal cortex (Inglis et al., 2014).

The growing interconnectedness of the emerging adult brain is its most defining characteristic. Educators in any educational setting have the unique chance to contribute to emerging adults' neural formation (Inglis et al., 2014). Emerging adults are actively forming connections, fostering empathy and understanding that impact their decision-making process, analyzing sensory information and new knowledge, as well as solidifying their identity and perspective about the world around them. Research suggests that full myelination of the brain may not be achieved until around age thirty or potentially even later (Wolfe, 2010). This implies that educators have a valuable opportunity to influence what adolescents will retain and remember as they navigate their lives and enter adulthood.

The Relationship Between Learning and the Brain

Bransford et al. (2000) argue that the disciplines of neuroscience and cognitive science are increasingly contributing to our understanding of human cognition and learning processes. While considering which findings from brain research apply to human learning and education, it is crucial to avoid adopting concepts that lack evidence of their value in classroom practice (Bransford et al., 2000).

The increasing popularity of neuroscience findings has led to the integration of brain research in various aspects of society, including education. The use of terms like "brain-based learning" and "brain-based teaching" reflects a growing interest in understanding how the brain functions and applying this knowledge to improve educational practices. As a result, there have been many positive changes in the field of education due to advancements made in neuroscience research (van Dijk & Lane, 2018).

However, there are also many misconceptions regarding neuroscience research which have had a significant impact on educational practice, such as the idea that teaching the left and right hemispheres of the brain separately can enhance learning effectiveness. Van Dijk and Lane (2018) said that the existence of "neuromyths," false beliefs about brain function, has pervaded various aspects of society including the media, advertisements, and the education system as a whole.

Misconceptions and “Neuromyths”

The Organization for Economic Cooperation and Development (OECD) defines a neuromyth as an inaccurate belief stemming from a misunderstanding, misinterpretation, or misrepresentation of scientifically established facts from brain research, used to advocate for the application of brain research in education and other areas (OECD, 2002). These myths are often used to advocate for the incorporation of brain research in education as well as other fields.

One such myth is that the development of different brain regions occurs at different times rather than in holistic "spurts" (Bransford et al., 2000). While it is still uncertain how this could specifically relate to education, it raises questions about whether educational objectives should

be aligned with specific stages of brain development. However, further research is needed to explore the potential implications for education.

Another commonly held misconception is the belief that humans only use 20 percent of their brains and should be able to tap into more of their potential. According to Bransford et al. (2000), this idea may have originated from early neuroscience research indicating the presence of "silent areas" in the cerebral cortex that are not directly activated by sensory or motor functions. However, it is now understood that these silent areas play a critical role in higher cognitive processes that are distinct from sensory or motor activities (Bransford et al., 2000).

Recent progress in neuroscience is providing support for long-held theories proposed by developmental psychology, particularly regarding the significance of early experiences in shaping development (Hunt, 1961). Through contributions from fields such as developmental psychology, cognitive psychology, and neuroscience, there is now a wealth of research studies that shed light on learning and development, which allows for a more comprehensive understanding of how intellectual growth takes place (Bransford et al., 2000).

How Does Learning Happen?

"How does learning happen and, more importantly, how does the teacher know when learning is occurring?" This question was posed by Inglis et al. (2014), who argues that there is, in fact, "a cognitive way to understand and approach the nature of learning." (p.11) Cognition refers to the process of acquiring knowledge. The field of cognitive psychology, which explores various processes such as attention, memory, problem-solving, and creativity, has emerged as a crucial perspective in education. It aids educators in understanding how learning takes place within the brain by shedding light on processes involved in acquiring and retaining information.

Learning is viewed as a process that involves observing, organizing, and connecting new information with existing knowledge. In this approach, true learning occurs not solely due to external stimuli but because of internal cognitive efforts driven by learners' developmental needs to integrate information and create meaning from their experiences (Inglis et al., 2014). Learning is a process that evolves with cognitive growth, marked by distinct milestones at different stages. The objective, according to Inglis et al. (2014) is to acquire and accumulate knowledge progressively. Effective teaching involves recognizing the needs of learners at various ages and stages as well as providing appropriate information to promote cognitive development without overwhelming them.

It is essential for teachers to understand the significance of cognitive development and neuroscience when it comes to educating students. One of the most well-known theories on cognitive development is Jean Piaget's Cognitive Development Theory. This theory explores how children and young individuals develop their ability to think logically and scientifically over time. According to Jean Piaget (1952), children go through four stages of development: sensory-motor, intuitive/preoperational, concrete operational, and formal operational. In the sensory-motor stage, children rely on their senses to understand the world around them. During the intuitive/preoperational stage, they develop imagination and symbolic thinking abilities. The concrete operational stage is characterized by reasoning and logical problem-solving skills related to tangible objects. Finally, in the formal operational stage, children exhibit abstract thinking capacities such as deductive reasoning and hypothesis formation. This is also when metacognition emerges - the ability to think about one's thinking processes (Piaget, 1952).

Piaget's theory of cognitive development had a significant impact on educational practices by emphasizing the importance of aligning education with developmental stages. He

introduced the idea that children possess an innate framework that serves as a foundation for all learning, challenging the notion of a blank slate. As a result, his work inspired educational reforms aimed at recognizing and supporting individual student development (Inglis et al., 2014).

Jerome Bruner, a cognitive psychologist, offers alternative theories to Piaget's ideas. He emphasizes the active role of learners in constructing their own understanding and reshaping their cognitive processes (Inglis et al., 2014). According to Bruner, there are three stages of development: enactive (learning through actions), iconic (learning through visual representations), and symbolic (learning through language). In his work, particularly with children, Bruner highlights their natural curiosity and problem-solving abilities when presented with evidence. This approach is known as "discovery learning" and shifts the teacher's role from lecturer to guide.

Bruner proposes that learning extends beyond merely addressing a problem posed by a teacher. He recognizes learning as a cognitive process that occurs naturally but is heavily influenced by the complexity of the learner's environment and involvement with it. A barren learning environment is inadequate to kindle development. Purposeful instruction aims to foster a stimulating, immersive environment, enabling the inherently inquisitive learner to make self-directed discoveries and build newfound understanding.

According to Inglis et al. (2014), educators do not serve as gatekeepers of knowledge, deciding what learners can and cannot learn, but are rather "artists, creating a fertile environment and supporting the students' intellectual discoveries." (p.13) The philosophy of discovery learning continues to have a significant impact on education today. Numerous schools in the U.S. emphasize interdisciplinary study and often encourage group exploration of various topics.

Additionally, these explorations frequently take place outside of the traditional classroom setting but within local communities.

Lev Vygotsky's work, while predominantly centered on children, bears repercussions for adult learners as well. Sharing Bruner's belief in self-directed learning catalyzed by natural curiosity, exploration, and imagination, Vygotsky diverged slightly with his sociocultural approach to cognitive development. The outcome of his research led to the conclusion that the most effective learning takes place when a child engages with individuals in their surroundings and collaborates with their peers (Vygotsky & Cole, 1981).

Therefore, the individuals in the learning environment essentially form part of the curriculum. These individuals can be involved in the explicit curriculum (defined by clear objectives requiring learner interaction and collaboration) or in the implicit curriculum (comprising hidden facets like class structure and instructor attitudes). The inclusion and application of these individuals within the curriculum are contingent on the educational beliefs upheld by the institution or professor.

However, in numerous situations across all educational levels, individuals in the learning setting often form part of the null curriculum—elements purposely excluded from teaching. The importance of collaboration and optimizing the impact of classroom interactions for individual gains are seldom imparted to students. This often arises due to the instructor's lack of understanding or acceptance of this method, or because it challenges the prevailing competitive education system frequently used to measure student success (Inglis et al. 2014).

Vygotsky's idea of cognitive learning originates from social interactions. However, it primarily concentrates on developing independent problem-solving skills and personal behavior

changes based on learned environmental knowledge. He uses the "Zone of Proximal Development" concept to describe learning that occurs during social interaction (Vygotsky & Cole, 1981).

Although Vygotsky's research was primarily concentrated on children's cognitive development, his ideas provoke deeper contemplation on the framework and environment of learning in general. His theory, which suggests that learning is inherently social and that learners intellectually advance by incorporating the cognitive norms of their societal circles during pivotal developmental stages, encourages reflection on students' formal and informal interactions. Vygotsky underscores the significance of how, when, and even whether communication between learners is structured, asserting that such structuring impacts the learning process (Vygotsky & Cole, 1981).

Cognitive psychologists such as Bruner and Vygotsky have made significant contributions to the constructivist approach to education. This perspective emphasizes that learning is an active process where new information is combined with existing knowledge. Instead of simply delivering knowledge, it suggests that learning occurs through social interactions with peers. Therefore, schools should prioritize creating meaningful learning experiences for students rather than solely focusing on teaching them.

In recent years, there has been a growing emphasis on the shift from a focus on "teaching" to "learning" in higher education. Universities are moving away from their traditional role as providers of instruction and are instead prioritizing the creation of meaningful learning experiences (Barr & Tagg, 1995). Institutions of today are still trying to understand the nature of learning, taking cues from recent brain studies. This change from focusing on teaching to

focusing on learning is a big departure from the traditional education model, requiring major shifts in how the roles of both teachers and learners are viewed (Inglis et al., 2014).

Some educators struggle with the paradigm shift encompassing the notion of learning as an active process led by the student, with the teacher as a facilitator. Inglis et al. (2014) conclude that this change uproots traditional content delivery methods, such as endless lectures or unidirectional instruction, and prompts a reconsideration of the objectives of learning, with content mastery no longer being viewed as the primary measure of success.

Understanding cognitive development from a learning theories perspective is essential to the field of neuroscience education. Learning theories, such as Piaget's theory of cognitive development and Vygotsky's sociocultural theory, provide valuable insights into how the human brain processes information and constructs knowledge. These theories emphasize the importance of active learning, social interaction, and the role of experience in shaping brain development.

Neuroscience education draws on these theories to create effective teaching strategies that are in line with how the brain learns best. By understanding the cognitive processes involved in learning, educators can tailor their teaching methods to optimize knowledge retention and understanding.

Applications and Perceptions of Educational Neuroscience in the Classroom

Advances in neuroscience have shed light on the dynamic changes that occur within individual brains during the process of learning. However, there is a significant gap between the research findings and their practical implementation in educational settings, with most of the

knowledge flowing unidirectionally from researchers to teachers. The extent to which teachers incorporate ideas from neuroscience into their classroom practices is not well understood.

Chang et al. (2021) believe that while neuroscience explores the natural functions of the brain, it may not directly offer practical guidance for classroom teaching, or perhaps not in a manner that is easy to follow. This is because education requires specific pedagogical strategies aimed at enhancing learning outcomes, rather than solely relying on scientific descriptions of neurological processes. However, Thomas et al. (2018) argue that it is possible for neuroscience to indirectly impact education as it provides insights into teaching and learning that acknowledge the biological and physiological limitations imposed by our brain and body.

Different results have been documented from various initiatives that introduce neuroscience information to educators. According to Tham et al., (2019) teachers want neuroscience to be presented in a manner that is easy to understand and can be readily implemented. A brief introduction to neuroscience in education can prompt teachers to reflect on the teaching practices that they have developed (Howard-Jones et al., 2020). Neuroscience is increasingly being incorporated as essential background knowledge in formal teacher preparation programs (Deans for Impact, 2015). Professional development programs in neuroscience have a positive influence on pedagogy for in-service science teachers. Classroom observations show that these programs lead to increased use of inquiry-based teaching methods, as well as improvements in the cognitive environment of the classroom. This includes higher-order thinking skills, deep knowledge acquisition, meaningful conversations among students, and connections between learning and real-world problems (Roehrig et al., 2012). Professional development programs in neuroscience for in-service teachers have demonstrated positive effects on teacher self-efficacy and the implementation of student-centered practices (Brick et al., 2021).

Within focus and lesson study groups, educators can establish connections between principles from fundamental neuroscience and their own teaching methods (Dubinsky et al., 2013; Tan and Amiel, 2019). Following the completion of a graduate program centered on the neuroscience of learning and memory, non-science teachers described their modifications to a lesson plan incorporating concepts from neuroscience (Schwartz et al., 2019).

To prevent the suppression of learning caused by stress and trauma, teachers reported reducing disciplinary practices and increasing social and emotional support for students. Through a reflective lesson study process, grade school teachers were guided by neuroscience principles to transform their pedagogies towards student-centered approaches. This understanding enabled them to effectively justify their pedagogical decisions (Tan and Amiel, 2019; Tan et al., 2019).

These studies indicate that the integration of neuroscience concepts may have impacted teachers' decision-making in their teaching practices. However, most of the findings from these studies are based on observations, pre-planned actions, or self-reported data regarding pedagogy. Tan and Amiel (2019) and Tan et al. (2019) have examined the impact of lesson study research that incorporated observation, mentored feedback, and reflection on how teachers' instructional decisions were influenced by neuroscience ideas while teaching. To investigate how teachers apply neuroscience concepts in their teaching practices, it is necessary to observe their classroom implementations and examine their explanations of those applications.

To establish the direct correlation between neuroscience and education that Clement and Lovat (2012) believe exists, Chang et al. (2021) examined the actions of non-science teachers who had participated in a three-credit graduate course that focused on developing their basic knowledge of neuroscience from a constructivist perspective as well as how neuroscience might

impact their specific pedagogical choices. These teacher-initiated actions serve as evidence to support the connection between these two fields.

Clement and Lovat (2012) claim that the impact of neuroscience on education could only be determined by teachers themselves as the ultimate test of whether neuroscience is relevant to education should be if they can use what they learn about neuroscience to inform their pedagogical judgments in the classroom (Clement & Lovat, 2012). As part of the course evaluation, a set of ten Educational Neuroconcepts (ENCs) specifically designed for educators was utilized; these concepts covered various areas including memory, learning, and emotions:

1. Learning strengthens synapses. Remembering reactivates plasticity.
2. Different behaviors use different but overlapping circuits.
3. Experiences and genetics shape circuit development.
4. Rehearsal, application and self-evaluation lead to automaticity and mastery.
5. Salience and repetition strengthen synaptic and circuit development.
6. Emotions facilitate memory and decision-making.
7. Brain pathways, while similar across individuals, are shaped by unique experience.
8. Physiology influences learning, memory and decision making.
9. Nervous system complexity produces reasoning, communication, creativity, curiosity.
10. Safe learning environments provide opportunities for deeper learning.

(Chang et al., 2021, pp. 8-9)

These neuroconcepts encapsulate the findings of neuroscience research, providing an overview of the fundamental principles governing brain-induced behaviors. These ENCs are not mere standalone concepts to be understood by teachers about brain functions. Instead, they collectively portray the intricacy of human brain operations and the complex functioning of neuroscience. These concepts enable educators to recognize how learning takes place in students' brains, including the role played by memory, emotions, and context.

According to Chang et al. (2021), the ENCs provided teachers with a collective foundation of knowledge about the brain, empowering them to take control in their teaching. Teachers were able to make connections between the ENCs and their own instructional practices, shifting their attention from lesson delivery and classroom organization towards addressing students' individual needs, concerns, and achievements. Teachers also acknowledge the significance of students' experiences and strive to empower them as active participants in their own learning (Chang et al., 2021). This change became evident when teachers engaged in discussions and integrated neuroscience principles into their instructional approaches, rather than relying solely on prescribed classroom strategies from external sources.

Chang et al. (2021) suggest that all teachers involved recognize the importance of understanding the neurological aspects related to student behaviors, needs, emotions, and mental states. Similarly, elementary teachers who engaged in a lesson study program for two years were able to enhance their comprehension of how students construct knowledge and could justify their pedagogical choices using insights from neuroscience (Tan and Amiel, 2019; Tan et al., 2019). Accordingly, the teachers interviewed highlighted that the understanding of neuroscience concepts served as a valuable perspective for assessing student learning, development, and success. This knowledge facilitated the integration of effective teaching practices with an

understanding of students' needs (Chang et al., 2021). This study affirmed that a solid foundation in neuroscience provided teachers with a framework to enhance their pedagogical approaches and perceptions of their students.

Neuroeducation and Neuropedagogy

Neuroscience examines how the brain learns and remembers at a molecular and cellular level such as investigating the neural areas and pathways responsible for language comprehension (Elouafi et al., 2021). Given this knowledge, it is appropriate to contemplate how we can utilize our growing understanding of brain function and development to investigate educational inquiries (Goswami, 2006). By integrating findings from studies on brain function with behavioral data, we can gain insights into the underlying processes involved in learning which could potentially enhance teaching methods and improve overall student learning outcomes (Howard-Jones, 2014).

One of the current challenges in educational neuroscience is enhancing scientific dialogue and fostering a common language between educators and neuroscientists. This highlights the importance of professionals who can effectively communicate across disciplines (Rato et al., 2011). While there is a demand for evidence-based practices in education, there is limited agreement on the theoretical and methodological foundations of such research (Elouafi et al., 2021).This difficulty arises from the delicate balance between academic autonomy and establishing rigorous standards for research that can be applied to educational settings. According to Elouafi et al. (2021), it is important to establish principles that allow for thorough evaluation of relevant findings while respecting the integrity of each discipline involved.

When examining pedagogically relevant research from different academic disciplines, it becomes complex to integrate them (Elouafi et al., 2021). In the effort of bridging cognitive neuroscience and education, it is crucial to evaluate the variations and resemblances in methodology, approach, and conception of scientific research between what can be referred to as "traditional pedagogical research" and "traditional cognitive neuroscience research" (Ansari & Coch, 2006).

The integration of neuroscience into education has raised concerns among many researchers. The entry of brain science into the field of education is seen as intrusive, and there is still a lack of consensus on how to establish it as an academic discipline. Neuroeducation has not yet gained recognition as a distinct field, and its title and definition are still subject to debate. This makes it challenging to bridge the gap between cognitive neuroscience and traditional teaching methods. The main difficulty lies in translating findings from research laboratories into practical strategies for enhancing learning, especially when establishing connections between theory and practice proves to be complex (Elouafi et al., 2021).

However, recent advancements in brain imaging techniques now allow researchers to study the impact of specific teaching methods on student brains. A prime example is the investigation into reading strategies for individuals with dyslexia and dyscalculia, (Dehaene et al., 2014; Goswami, 2004) which clearly illustrates this clear connection between neuroscience and education. This has prompted the rise of a new field of research called "neuroeducation" (Jolles & Jolles, 2021). Neuroeducation is still a relatively new discipline. A movement known as "brain-based learning" only emerged in the early 1990s, aiming to connect findings from neuroscience with educational practices (Zadina, 2015). Nonetheless, neuroeducation offers valuable scientific insights that can benefit educators. Although researchers now have a good

understanding of the brain mechanisms involved in learning reading and mathematics, there still remains much unknown about how different teaching practices affect these cognitive processes at a neural level. Researchers realize that it is worth considering how this knowledge can be utilized to investigate educational issues (Goswami, 2009). Cruickshank (1981) put forth the idea of establishing a profile for neuroeducators, suggesting that knowledge about the brain could enhance teaching methods.

Neuroscience offers a biologically based approach that can provide explanations for the effectiveness of certain practices, propose new approaches, and identify typical or impaired neural functions. However, it is important to translate this knowledge into pedagogical interventions that can actually be evaluated through behavioral testing in educational settings (Howard-Jones, 2014).

Research in neuroeducation is relatively new but valuable to educators. While the brain mechanisms involved in learning certain skills are known, there is limited knowledge about how teaching practices affect the brain. The relationship between neuroscience and education can be more beneficial when ideas and approaches are exchanged in both directions (Elouafi et al., 2021).

Elouafi et al. (2021) conducted a study aimed at examining the potential of neuroscience research in influencing teaching methods to improve effectiveness and enhance students' cognitive and emotional capacities. The researchers utilized four neuro-pedagogical approaches as part of their experimental design. To gather data, they conducted guided observations using a grid system to document student behavior during both the pre-test session and the experimental session based on the instructional guidelines provided. Variables such as focus and participation

were assessed through direct classroom observations using a Likert scale in both pre-test and post-test. On the other hand, the number of memorized words, error feedback, and grades were measured by means of a written test at the conclusion of the experimental session as well as during two separate assessment periods: pre-test and post-test. Student satisfaction with the method used was gauged at the end of the experiment utilizing a Likert scale.

The field of neuroscience offers intriguing insights (Elouafi, 2021). Traditionally, learning has been examined primarily from a cognitive perspective and considered integral to "intelligence." However, it is important to explore its functional aspects rather than solely focusing on behavioral angles (Elouafi et al., 2021). Notably, experimental research has demonstrated significant improvements in various learning parameters; for instance, exam scores have increased from 57.01% to 440.54%. Nonetheless, these findings should not overshadow the broader understanding required for effective pedagogy nor should they necessitate that teachers become experts in the intricacies of the nervous system. Instead, neuroscience can assist educators by providing knowledge about how the brain processes information and shedding light on the cognitive and metacognitive processes involved in the learning journey.

Neuroscience has traditionally focused on studying the structure and function of the nervous system from a physiological standpoint, similar to neurobiology. Initially, educational neuroscience mainly involved neurological research related to learning and memory. This is why the concept of educational neuroscience has expanded to encompass a broader range of disciplines, using the scientific method to investigate learning. In this context, it includes the study of pedagogy among other educational phenomena.

Neuropedagogy, as described by Chojak (2018), is a field within the realm of the social sciences that encompasses disciplines focused on the development and evolution of educational processes across an individual's lifespan. This implies that the interdisciplinary area of study involving teaching methods and neurobiology could be termed as "neuropedagogy" and may evolve into an acknowledged subfield of pedagogy in the future (Chojak, 2018). According to Chojak (2018), the objectives of neuropedagogy should involve gathering data on the neurobiological aspects of educational settings, analyzing the interconnectedness and explanations of this environment, and sharing acquired knowledge to bring about change in this reality (Chojak, 2018).

The scope of educational research is currently extensive and diverse. Brain neuroimaging methods could also enhance the reliability and objectivity of educational research. Thus far, teachers have limited standardized tools to assess children's development or teaching effectiveness. Pedagogical experiments and innovations in schools or kindergartens are often implemented without prior research to demonstrate their efficacy, a gap that neuropedagogy may fill in the future (Chojak, 2018).

CHAPTER THREE: METHODOLOGY

Introduction

The purpose of this study was to explore teachers' perceptions of the relationship between neuroscience and education and to investigate the use of neuro-pedagogical techniques in the classroom. By examining these factors, a deeper understanding of the challenges in linking neuroscience and education can be gained as well as an understanding of how educational practices informed by neuroscience can impact students' learning.

Understanding the intersection between neuroscience and education is crucial in enhancing teaching practices and promoting effective student learning. It provides educators with valuable insights into the biological underpinnings of students' behaviors and cognitive processes. By studying the brain and its functions, teachers can gain a deeper understanding of how students acquire and process information, as well as the factors that influence their motivation, attention, and memory.

By incorporating neuroscience concepts into pedagogical approaches, teachers can gain insights into how students construct knowledge and tailor their instructional strategies accordingly. The following research questions guided this study:

a) What are teachers' perceptions of neuroscience and education?

b) What neuro-pedagogical techniques are used by teachers in the classroom?

c) What are the challenges to linking neuroscience and education?

Research Design

To address the research questions outlined above, a mixed-method approach was used in this study. The first stage of the study involved a questionnaire that was designed to gain insights into educators' perspectives on the integration of neuroscience and education. In the second stage, a series of semi-structured interviews was conducted with teachers as part of the research process, which allowed for flexibility in the conversation while still ensuring that key questions and topics were covered.

Both the questionnaire and the interview questions were structured using the three research questions that guide this study. The collected and analyzed data from the questionnaires and interviews served as the foundation for the study's conceptual framework. It provided a comprehensive understanding of teachers' perceptions, practices, and challenges in incorporating neuroscience into their pedagogical approaches. Sieber (1973) suggests that quantitative and qualitative data can complement each other during both the data collection and analysis stages. By using quantitative data, researchers can avoid bias towards specific groups of individuals. On the other hand, qualitative data provides meaning, clarification, and validation of quantitative findings. This integration of different types of data strengthens the generalizability of research outcomes (Sieber, 1973). Using a mixed method approach offers the benefit of obtaining a more comprehensive overview and deeper insight into the subject, potentially improving the credibility of results through triangulation (Johnson, Onwuegbuzie, & Turner, 2007). This study emphasizes the importance of teachers gaining familiarity with neuro-pedagogical methods and tools.

Site and Participant Selection

The research process began with a questionnaire (see Appendix A) administered to high-school teachers from two International schools in the city of Port Said. This grade level was selected as it was an ideal setting for this study due to the unique perspectives and experiences that educators at this level can provide. High school teachers have a deep understanding of the academic and social challenges that students face as they transition into young adulthood. Their insights and feedback are crucial in understanding the dynamics of the school environment and the impact it has on students.

Access to these schools was ensured by contacting the school administrations directly, explaining the purpose and significance of the research, and assuring them that the Institutional Review Board approval as well as CAPMAS approval were obtained before proceeding with data collection. Additionally, efforts were made to establish rapport and build trust with potential participants through effective communication and collaboration.

The researcher was informed by the director of one of the schools that some teachers had participated in a brain-based learning workshop. The list of attendees was obtained from the school's secretary, after which these teachers were contacted directly to ensure that some of the questionnaire respondents were familiar with the subject of neuroscience and education. Teachers from the other school were not as familiar with the subject, as shown through their responses.

Table 1

School A Participants Biodata

School A High School Teachers					
	Gender	**Education Level**	**Years of Experience**	**Interviewed**	**Code**
1	Female	Bachelor's Degree	6-10 years	*	TAF1
2	Female	Bachelor's Degree	6-10 years		TAF2
3	Female	Bachelor's Degree	6-10 years		TAF3
4	Female	Bachelor's Degree	6-10 years		TAF4
5	Female	Bachelor's Degree	6-10 years		TAF5
6	Female	Bachelor's Degree	6-10 years	*	TAF6
7	Female	Bachelor's Degree	6-10 years		TAF7
8	Female	Bachelor's Degree	6-10 years		TAF8
9	Female	Bachelor's Degree	6-10 years		TAF9
10	Female	Bachelor's Degree	6-10 years		TAF10
11	Female	Bachelor's Degree	10+ years		TAF11
12	Female	Bachelor's Degree	10+ years	*	TAF12
13	Female	Bachelor's Degree	10+ years		TAF13
14	Female	Bachelor's Degree	10+ years	*	TAF14
15	Female	Bachelor's Degree	4-5 years		TAF15
16	Female	Bachelor's Degree	1-3 years		TAF16
17	Female	Bachelor's Degree	1-3 years		TAF17
18	Female	Bachelor's Degree	1-3 years		TAF18
19	Female	Bachelor's Degree	1-3 years		TAF19
20	Female	Bachelor's Degree	1-3 years		TAF20
21	Male	Bachelor's Degree	4-5 years	*	TAM21
22	Male	Bachelor's Degree	10+ years		TAM22
23	Male	Master's Degree	10+ years	*	TAM23
24	Male	Master's Degree	10+ years		TAM24
25	Male	Master's Degree	10+ years		TAM25

26	Male	Master's Degree	10+ years		TAM26
27	Male	Master's Degree	10+ years		TAM27
28	Male	Master's Degree	6-10 years		TAM28

Table 2

School B Participants Biodata

School B High School Teachers					
	Gender	**Education Level**	**Years of Experience**	**Interviewed**	**Code**
1	Female	Bachelor's Degree	1-3 years		TBF1
2	Female	Bachelor's Degree	1-3 years		TBF2
3	Female	Bachelor's Degree	1-3 years		TBF3
4	Female	Bachelor's Degree	1-3 years		TBF4
5	Female	Master's Degree	6-10 years	*	TBF5
6	Male	Master's Degree	6-10 years		TBM6
7	Male	Bachelor's Degree	4-5 years	*	TBM7
8	Male	Bachelor's Degree	1-3 years		TBM8
9	Male	Bachelor's Degree	4-5 years		TBM9
10	Male	Bachelor's Degree	4-5 years		TBM10
11	Male	Bachelor's Degree	6-10 years		TBM11
12	Male	Master's Degree	6-10 years		TBM12

For the questionnaire, there were 40 participants in total, 28 from School A and 12 from School B. The questionnaire was a means of purposive sampling, which was used to discover which participants have an interest in incorporating neuroscience into their teaching practices. After the completion of the questionnaire, a subset of the participants were chosen for the follow-up interviews. (see Appendix B) This selection was based on the responses provided in

the questionnaire, with a focus on teachers who have demonstrated a strong interest and/or proficiency in implementing neuro-pedagogical methods. This helped ensure that the data collected was from teachers who are interested or actively engaged in the integration of neuroscience and education. Eight in-depth interviews were conducted for this stage, with six teachers from School A and two teachers from School B.

Data Collection

The instruments used in this research study were carefully selected to gather both quantitative and qualitative data that provided a comprehensive understanding of the teachers' perceptions, practices, and challenges in incorporating neuroscience into their pedagogical approaches. The integration of these instruments aimed to ensure the reliability and validity of the study's findings.

Questionnaire

The research process commenced with the administration of a questionnaire to high-school teachers from two International schools in the city of Port Said. The questionnaire aimed to identify teachers who have an interest in incorporating neuroscience into their teaching practices. It consisted of both open-ended and closed questions. Both hard-copies and online distribution through the schools' Facebook groups were utilized to gather responses, enhancing the reach and inclusivity of the quantitative data collection. The data collected from the questionnaire provided a broad understanding of the teachers' beliefs about the benefits of studying neuroscience for teaching and learning. Based on the responses provided in the questionnaire, teachers who demonstrated an interest in implementing neuro-pedagogical methods were contacted semi-structured interviews.

Semi-Structured Interviews

Following the quantitative stage, semi-structured interviews were conducted with a subset of the participants who demonstrated a strong interest and/or proficiency in implementing neuro-pedagogical methods. Consisting of open-ended questions (see Appendix B), the interviews provided an in-depth exploration of the teachers' experiences, thoughts, and perspectives, contributing to the collection of qualitative data. The interviews allowed for a more nuanced exploration of the need for neuro-pedagogical techniques to be used by teachers in the classroom. Through these interviews, teachers had the opportunity to share their experiences and perspectives on how they can incorporate neuroscience knowledge into their teaching practices. These interviews allowed for a deeper insight into the subject and complemented the questionnaire findings, thereby strengthening the generalizability and credibility of the research outcomes.

By utilizing a mixed method approach with the carefully chosen instruments, this study aimed to offer a more comprehensive overview and deeper insight into the integration of neuroscience in education. The following sections will delve into the analysis and results derived from the data collected through these instruments.

Pilot Test

After obtaining consent from the Institutional Review Board and CAPMAS to conduct this research, four teachers were asked to complete the questionnaire as a pilot test to identify any potential issues or ambiguities in the questions. These teachers were selected from one of the schools involved in the study that had previously participated in a workshop on brain-based learning. Subsequently, all four teachers indicated no issues with the questionnaire and found it easy to understand. The pilot test aimed to ensure clarity in wording of the questions.

Reliability and Validity

To ensure the reliability of the data collected, several steps were taken throughout the research process. Firstly, the questionnaire underwent a pilot test with four teachers from one of the participating schools. Their feedback indicated that the questions were clear and easily understood, thus establishing the reliability of the questionnaire. Furthermore, the use of a mixed-method approach enhanced the credibility of the research outcomes through triangulation (Carter et al., 2014).The integration of both quantitative and qualitative data provided a comprehensive understanding of the teachers' perceptions, practices, and challenges in incorporating neuroscience into their pedagogical approaches. This approach also allowed for the validation of findings and ensured that no biases towards specific groups of individuals were present.

Regarding the validity of the research, efforts were made to establish rapport and build trust with the participating teachers. Clear communication and collaboration with the school administrations as well as the teachers aimed to ensure the validity of the data collected. The use of semi-structured interviews provided an opportunity for in-depth exploration of the teachers'

experiences and perspectives, further contributing to the validity of the study. In addition, obtaining approval from both the IRB and CAPMAS strengthened the ethical and methodological validity of the research. These measures reassured the participants and the institutions about the credibility and ethical conduct of the study. Overall, the pilot testing, data collection protocols, and ethical considerations taken throughout the research process aimed to ensure the reliability and validity of the study's findings.

Ethical Considerations

Ethical considerations are of utmost importance in this research study. Informed consent was obtained from all participants, ensuring that they are aware of the purpose of the study, their rights as participants and that their participation is voluntary. Confidentiality was maintained by assigning code numbers to each participant instead of using their names, with all data kept securely to protect their identities. Furthermore, the research adheres to ethical guidelines regarding the proper handling and storage of data. Any personal information collected was anonymized and only used for the purpose of this study. Finally, approval was obtained by both the Institutional Review Board (IRB) and the Central Agency for Public Mobilization and Statistics (CAPMAS).

CHAPTER FOUR: FINDINGS AND ANALYSIS

The purpose of this research was to evaluate the perceptions and experiences of educators regarding the integration of neuroscience concepts into teaching practices. The questionnaire findings provided valuable insights into the attitudes and knowledge of educators in this regard. The questionnaire revealed a diverse sample in terms of gender, level of education, and years of experience. This diversity provides a comprehensive perspective on the integration of neuroscience in education, considering the varying backgrounds and experiences of the participants.

Participants were asked about their sources of knowledge regarding neuroscience and education. The responses indicated that some had obtained their knowledge through formal education or professional training, while others cited workshops, and research articles as their sources of information. This diverse range of sources suggests a multifaceted understanding of the relationship between neuroscience and education among educators.

The questionnaire findings serve as a foundation for understanding the current landscape of neuroscience integration in education. The following paragraphs will present and analyze the findings obtained from both the questionnaire and the interviews, providing valuable insights into perceptions and experiences regarding the integration of neuroscience into teacher education programs.

Questionnaire Findings

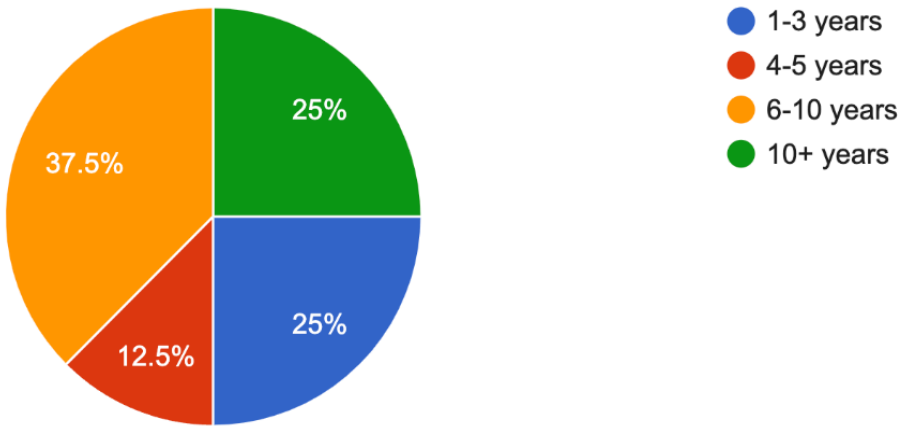
Understanding the Context

The questionnaire consisted of ten questions that aim to gather insightful information about the participants' knowledge and perception of the connection between neuroscience and education. Among the 40 respondents, 62.5% of participants were female and 37.5% were male. This gender distribution was an important consideration when assessing the readiness and interest in integrating neuroscience into teaching practices, as it may reflect different perspectives and experiences related to the implementation of neuro-pedagogical methods.

The responses to the questionnaire reflect a diverse educational background among the participants. 75% of the respondents held graduate-level (bachelor's degree) qualifications and 25% had postgraduate-level (master's degree) qualifications. None of the respondents held Ph.D. qualifications.

Figure 2

Participation According to Years of Experience



In terms of years of experience, 25% of the respondents had 1-3 years of experience. This indicates that they may still be in the early stages of their professional or educational journey, and their responses may reflect their relatively recent exposure to the topics being discussed. 12.5% of the respondents had 4-5 years of experience, suggesting that a few individuals have gained a moderate level of experience in the field of education, which may have influenced their responses and understanding of the topic. 37.5% of the respondents had 6-10 years of experience. This is the largest category, indicating that a significant portion of the participants have a substantial amount of experience in the field being surveyed, allowing them to acquire a deeper understanding and expertise. Their responses may reflect a more nuanced perspective based on their extensive involvement in the field. 25% of the respondents had 10+ years of experience. This category represents a sizable proportion of the participants, indicating a significant number of individuals who possess extensive experience in the field. These respondents likely have a wealth of knowledge and expertise.

The distribution of experience levels among the respondents provides a diverse range of perspectives. This diversity in experience levels can contribute to a richer and more comprehensive understanding of the topic being surveyed.

Exploring Experiences, Definitions, and Implementation

Fifteen respondents out of the 40 have actively engaged in programs or courses that mentioned the link between learning and the brain. This included attending workshops that discussed neuroplasticity, brain-based teaching strategies, and the intersection of psychology and education with an emphasis on the fight-or-flight response. A limited number of the participants (5) mentioned attending workshops where brain-related learning was briefly mentioned, but they

did not have in-depth exposure to the topic. These individuals may not have a strong familiarity with the neuroscience of learning. TAM4 and TAM5 mentioned taking seminars and courses in college that explored how the brain learns. Although the details were not provided, it suggests a formal academic exposure to the topic, which could have provided a comprehensive understanding of the subject matter. Twenty of the respondents indicated that they have not participated in any programs or courses specifically related to learning and the brain.

Overall, the findings suggest a range of experiences and knowledge levels regarding learning and the brain. Those who have actively engaged in programs or courses on the topic are likely to possess a deeper understanding of the subject matter, while others may have limited exposure or awareness. It also underscores the need to address the awareness gap among teachers who have not yet participated in such initiatives.

The participants were asked to define education and several common themes can be highlighted. All respondents mentioned that education involves acquiring knowledge, skills, and values. This emphasizes the importance of gaining information and abilities that contribute to personal growth and development. Seven participants also emphasized that education is a process rather than a one-time event. It involves various methods, experiences, and structured activities that facilitate learning and growth. Education is seen as a means to foster personal and intellectual development. It encompasses not only the acquisition of knowledge and skills but also the cultivation of attitudes, beliefs, and habits that contribute to overall growth. While some respondents specifically mentioned schooling and college as places of education, others acknowledged that education can occur through various methods, including formal institutions, training, and self-directed learning.

Some of the teachers view education as a fundamental pathway to personal development and growth, offering opportunities for individuals to elevate themselves socially, economically, and culturally. TAF6 mentioned that it prepares individuals for the workforce, fostering economic self-sufficiency. She also said that education is a means of personal empowerment, providing people with the autonomy to make informed decisions and to participate fully in their community.

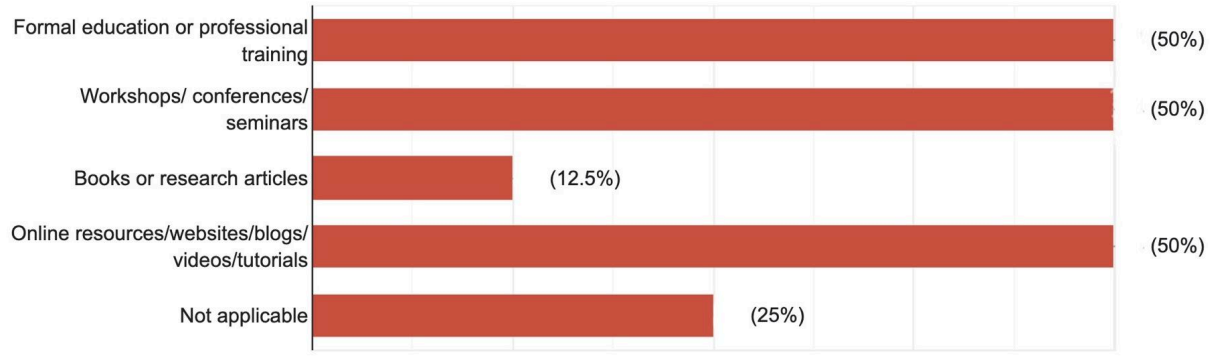
Furthermore, the concept of lifelong learning is deeply ingrained in some of the teachers' perceptions. TAM23 and TAM25 highlighted that education is not confined to the early years but is a continuous pursuit throughout one's life. In addition to formal education settings, learning is recognized to occur in a variety of environments - from family discussions and community activities to ongoing professional development. This reflects the recognition of education's diverse delivery mechanisms and its integration into everyday life. Five participants also mentioned that education should be adaptable and inclusive, catering to the needs of diverse learners. In this respect, as said by TAF6, "education is not static but a dynamic process that equips individuals with the necessary tools to navigate and shape an ever-changing world."

When asked to define neuroscience, the participants' definitions shared several common elements. All respondents mentioned that neuroscience involves the scientific study of the nervous system, some mentioned the brain, spinal cord, and neurons. This highlights the central focus of neuroscience on understanding the structure and function of these components. Many participants emphasized that neuroscience is a multidisciplinary field that integrates various disciplines, such as biology and psychology. This indicates an awareness of the diverse approaches and perspectives involved in studying the nervous system and its relationship to behavior, cognition, and other aspects of human functioning. Several respondents highlighted the

connection between neuroscience and the brain. They mentioned that neuroscience explores how the brain works, affects behavior and cognition, and influences various aspects of human experience. The definitions provided by the participants convey a shared understanding of neuroscience as a scientific field that investigates the nervous system, particularly the brain, and its relationship to behavior, cognition, and other aspects of human functioning. The responses reflect an awareness of the multidisciplinary nature of neuroscience and its focus on understanding the structure, function, and development of the nervous system to gain insights into how it influences various aspects of human experience.

Figure 3

Participants' Sources of Knowledge about Neuroscience and Education



The above findings indicate that the participants' knowledge about neuroscience and education has been obtained through a combination of formal education or professional training, attending workshops/conferences/seminars, utilizing online resources, and, to a lesser extent, engaging with books or research articles. These varied sources of knowledge reflect the diverse learning pathways and resources available to individuals interested in understanding the intersection of neuroscience and education.

Multiple participants mentioned that online resources, such as websites and blogs focused on neuroscience in education, were useful in learning about the connection between the brain and education. These resources likely provided practical strategies and insights into applying neuroscience principles in educational settings. Some respondents mentioned that they found research articles helpful in their learning process. Research articles can provide in-depth information, empirical evidence, and scholarly perspectives. Several participants mentioned attending workshops or seminars related to psychology and education. These sessions likely provided valuable information and interactive learning experiences, allowing participants to deepen their understanding of the brain-education connection. Three respondents mentioned finding hands-on activities that apply neuroscience concepts helpful. TAM23 highlighted the usefulness of a specific YouTube channel that explained neuroscience in a fun and easy-to-understand manner. Video resources like YouTube channels can offer visual explanations and engaging content for learning about complex topics like neuroscience. These resources likely contributed to participants' understanding of the connection between the brain and education, providing them with practical strategies, empirical insights, and engaging learning experiences.

Assessing the Link Between the Brain and Education

The next section of the questionnaire asked about teaching practices that participants have encountered, connecting the brain to education, along with their perceptions of their potential usefulness.. The responses highlight a range of teaching practices that connect the brain to education. Retrieval practice, brain-based learning strategies, creating a safe and supportive classroom environment, incorporating movement and physical activity, mind mapping, and hands-on activities are mentioned as potential approaches. These practices align with

neuroscience principles and are perceived as useful for enhancing student engagement, retention, understanding, and overall well-being in the learning process.

In response to whether the teachers' institutions have implemented any teaching or learning techniques based on neuroscience, some teachers said that their schools have implemented brain breaks and physical activity breaks. These techniques are perceived as useful in improving focus, reducing stress, enhancing engagement, and promoting overall well-being. However, it is worth noting that there are also several participants who reported a lack of specific implementation or awareness of neuroscience-based techniques.

Identifying and Overcoming Challenges

According to the respondents, one common challenge in linking neuroscience and education is finding practical strategies that can be easily implemented in the classroom. It can be challenging to translate complex neuroscience findings into actionable and applicable strategies for teachers to use effectively. Another challenge is ensuring that teachers have access to accurate neuroscience information and training. Providing educators with reliable resources and professional development opportunities is crucial for understanding and applying neuroscience findings in educational practices. Some teachers said they think educators may exhibit resistance or skepticism towards incorporating neuroscience into education. Convincing educators of the benefits and relevance of neuroscience-based approaches can be a challenge, especially if they are not fully convinced or open to change. Educators may struggle with knowing how to apply neuroscience findings in the classroom and would benefit from clear guidance and examples of practical application. The changing nature of neuroscience research also poses a challenge for educators. Staying updated with the latest findings and understanding how to effectively apply them in the classroom can be difficult, especially considering the time

constraints educators face. It can be difficult to bridge the gap in communication and understanding between neuroscientists and educators in a way that convinces educators to adopt new methods, specifically those who have been teaching in the same way for many years. These challenges need to be addressed to effectively integrate neuroscience findings into educational practices.

Semi-Structured Interview Results

The interviews (see Appendix B) provided deeper insights into educators' perceptions and experiences with the integration of neuroscience concepts into teaching practices. Several themes emerged from these interviews, shedding light on challenges, potential benefits, and ethical considerations associated with this integration.

According to the teachers interviewed, they have positive perceptions about linking neuroscience to education. TAF12 mentioned, "Understanding how the brain works and applying that knowledge to our teaching practices can really make a difference in student learning outcomes." TAM21 expressed, "Neuroscience provides valuable insights into cognitive processes and how students learn best, which can guide us in designing effective instructional strategies." Teachers emphasized the significance of catering to individual differences and diverse learning needs. TAM23 stated, "Neuroscience helps us recognize that each student has unique strengths and challenges, and we can tailor our instruction to meet their specific needs." TAF1 said, "Engaging multiple senses in the learning process, such as incorporating visuals and hands-on activities, allows us to address different learning styles and enhance student understanding."

The teachers acknowledged the challenges in implementing neuroscience-informed strategies. TAM21 mentioned, "Translating neuroscience findings into practical applications can

be complex, and it requires ongoing training and staying up-to-date with current research." TAM23 highlighted the need for collaboration, stating, "Working with other educators and participating in professional development opportunities can help us overcome these challenges and effectively apply neuroscience principles in the classroom."

Ethical considerations were also raised by the teachers. TBF5 emphasized, "We must prioritize student well-being and ensure we respect their privacy when applying neuroscience findings." TAM21 stressed the importance of evidence-based practices, stating, "Ethical guidelines and informed consent are crucial to ensure that we are using neuroscience-informed strategies that have been validated and supported by research."

The teachers discussed the influence of neuroscience on instructional design and curriculum development. TAF6 mentioned, "Neuroscience insights can guide us in creating interactive activities and real-world examples that engage students and promote deeper learning." TBM7 added, "Assessments based on neuroscience principles can provide valuable feedback to students and enhance their skills."

Regarding professional development, teachers recognized its role in bridging the gap between neuroscience and education. TAF14 stated, "Keeping up with the latest research and attending professional development workshops allows us to integrate neuroscience effectively into our teaching practice." TAF14 also highlighted collaboration, saying, "Collaborating with experts in neuroscience can provide us with guidance and support in applying research findings to our classrooms."

The teachers also acknowledged misconceptions and challenges when integrating neuroscience and education. TBM7 stated, "There can be misconceptions about oversimplifying

the complex brain processes." TBM7 further mentioned the need for resources, stating, "Access to neuroscience resources and tools is limited, and that can make it hard to integrate neuroscience findings into our teaching practice."

Recurring Themes

Several themes emerge from an in-depth analysis of the interviews. The first is the recognition of potential. The teachers acknowledged the potential benefits of integrating neuroscience and education. They believe that insights from neuroscience can inform instructional strategies, enhance teaching practices, and improve learning outcomes. Another theme is relevance of concepts and principles: The teachers highlight specific concepts and principles from neuroscience that they find relevant and beneficial in educational settings. These include neuroplasticity, multisensory engagement, retrieval practice, and the brain's reward system.

The teachers emphasize the significance of the connection between neuroscience and education, another theme. They believe that applying neuroscience findings can lead to more effective teaching practices, cater to individual differences, and optimize student engagement and motivation. The teachers recognize that knowledge of neuroscience can influence instructional design and curriculum development. It can lead to the inclusion of interactive activities, real-world examples, project-based learning, and the use of formative assessments to promote effective learning.

The teachers acknowledge challenges in implementing neuroscience-informed strategies, including the need for additional training and resources. They also highlight ethical considerations, such as prioritizing student well-being, respecting privacy, and avoiding

stigmatization. The teachers emphasize the importance of ongoing professional development and collaboration to effectively apply neuroscience findings in the classroom. They value opportunities to stay updated on research, learn from experts, and collaborate with other educators. The teachers acknowledge common misconceptions when incorporating neuroscience findings, such as oversimplification and misinterpretation. They also recognize the limitations and complexities of neuroscience research, highlighting the need for critical evaluation and considering other factors influencing learning.

The last theme is personal reflection. The teachers provide personal reflections on the potential benefits and limitations of integrating neuroscience and education. They emphasize the need for partnerships, communication between researchers and educators, and platforms for knowledge exchange.

In conclusion, the interview findings indicate that teachers perceive the integration of neuroscience and education as beneficial. They recognize the potential impact on instructional strategies, student engagement, and personalized learning approaches. However, they also acknowledge the need for ongoing professional development, collaboration, and addressing misconceptions to effectively apply neuroscience findings in the classroom.

CHAPTER FIVE: DISCUSSION AND CONCLUSION

A most noteworthy finding was the varying degree of implementation of neuroscience-informed teaching techniques in educational settings. While some educators reported encountering such practices, most indicated a lack of exposure. This discrepancy sheds light on the unequal dissemination and adoption of neuroscience findings in schools.

The questionnaire and the interviews mainly shed light on the dynamic nature of neuroscience research and the challenge of staying updated with the latest findings. Participants highlighted the difficulty that teachers face in keeping pace with new developments in neuroscience and understanding how to effectively integrate them into their teaching practices. Bridging the gap in communication and understanding between neuroscientists and educators was identified as a key challenge that needs to be addressed to facilitate the adoption of new methods.

Research Question 1: What are teachers' perceptions of neuroscience and education?

The teachers who participated in the questionnaire and the interview all had a positive perception of the connection between neuroscience and education. Some demonstrated prior knowledge and exposure to the field of neuroscience and its potential applications in education. The teachers believe that neuroscience can significantly contribute to our understanding of teaching and learning. They recognize the value of studying the brain and gaining insights into cognitive processes such as attention, memory, and motivation. The teachers perceive the connection between neuroscience and education as highly significant and believe it has the potential to improve educational outcomes by informing instructional strategies, addressing individual differences, and enhancing student engagement and motivation.

The emphasis on lifelong learning and the recognition of diverse learning environments resonate with the idea of incorporating neuroscience-based strategies into educational practices beyond traditional classroom settings. This aligns with the concept of neuroplasticity, which highlights the brain's ability to adapt and reorganize in response to experiences, emphasizing the importance of creating enriched learning environments that stimulate neural connections. Individuals' identities, thoughts, and actions are directly related to the structure and function of the nervous system. The interaction between our genetic makeup and environment shapes our individuality. (Silbereis et al., 2016) According to Hohl (2020), neuroplasticity, also known as neural plasticity, refers to the brain's capacity for change. This involves the creation and removal of connections between neurons and is influenced by our continual interaction with both internal and external stimuli. It plays a crucial role in memory formation processes, making it fundamental to the biological foundation of learning.

During the early years of life, the nervous system exhibits a high degree of adaptability. This indicates that sufficient stimuli can result in easier reorganization of neural circuitry and developmental learning. (Silbereis et al., 2016) Conversely, a deficiency in such stimuli may significantly impede this capacity, potentially leading to obstacles in learning or inadequate development for children with limited or absent environmental stimulation, including social interactions.

The recognition of neuroscience as a multidisciplinary field aligns with the idea of integrating insights from neuroscience, psychology, and other relevant disciplines into education. (Bransford et al., 2000) This interdisciplinary approach can provide educators with a holistic understanding of how cognitive processes, emotions, and learning experiences are intertwined with neural mechanisms, influencing pedagogical strategies and learning outcomes.

Incorporating neuroscience principles in education has the potential to revolutionize teaching strategies and improve student outcomes (Thomas et al., 2018). By understanding how the brain processes information and emotions, educators can tailor their teaching methods to maximize learning and retention. Furthermore, this interdisciplinary approach can lead to the development of more personalized and effective educational interventions, catering to the diverse needs of students. Moving forward, it is imperative to continue exploring the implications of integrating neuroscience into education and to conduct further research to maximize its benefits (Inglis et al., 2014). This will ultimately contribute to the advancement of educational practices and the overall improvement of the educational experience for students.

The diverse sources of knowledge mentioned by the participants, ranging from online resources to interactive workshops, highlight the multitude of avenues through which educators can access neuroscience principles and apply them in educational settings. Furthermore, the reference to practical hands-on activities and engaging video resources underscores the importance of providing educators with actionable strategies and engaging content to effectively integrate neuroscience findings into their teaching practices.

The participants' perspectives on education and neuroscience not only underline the potential benefits of integrating neuroscience principles into education but also emphasize the varied resources and practical applications available to educators in this endeavor. As educators continue to explore the intersection of neuroscience and education, leveraging the multidisciplinary nature of both fields and embracing continual learning and adaptation can pave the way for enriching educational experiences and empowering diverse learners.

Research Question 2: What neuro-pedagogical techniques are used by teachers in the classroom?

The data collected reveals that while not all teachers have implemented neuro-pedagogical techniques in their classrooms, some mentioned strategies such as retrieval practice, which involves incorporating regular quizzes or review activities to actively recall information and strengthen long-term memory. Practicing the material not only helps with retaining it, but also supports the learning and memory of new information encountered later (Kliegl & Bäuml, 2021). The teachers also mentioned utilizing multisensory approaches, combining visual aids, hands-on activities, and auditory elements to cater to diverse learning styles. These techniques align with the principles derived from neuroscience, such as neuroplasticity and the importance of engaging multiple senses in the learning process.

Given the potential benefits of integrating neuroscience principles into education, it is essential to consider the implications of these findings. By incorporating strategies rooted in neuropedagogy, educators can create inclusive learning environments that cater to the diverse needs of students. Additionally, cultivating an understanding of how the brain learns can inform the development of tailored interventions for students with learning differences or special educational needs.

Moving forward, further research in this area could explore the long-term impact of neuro-pedagogical approaches on student academic performance and overall well-being. Additionally, professional development opportunities for educators focused on neuroscience principles can support the successful implementation of these strategies in diverse educational settings. (Brick et al., 2021).

The integration of neuroscience principles in education holds significant promise for enhancing teaching practices and fostering positive learning outcomes for students across varying disciplines and age groups. (Clement and Lovat, 2012) As educators continue to embrace new insights from the field of neuroscience, the potential to optimize learning experiences and academic success for all students becomes increasingly achievable.

Research Question 3: What are the challenges to linking neuroscience and education?

The findings from this research highlight several common challenges in linking neuroscience and education. One significant challenge identified by the respondents is the translation of complex neuroscience findings into practical and applicable strategies for the classroom. Educators often struggle with understanding how to effectively implement neuroscience-based approaches in their teaching practices (Chang et al., 2021, Elouafi et al., 2021). Clear guidance and examples of practical application are necessary to bridge this gap and facilitate the integration of neuroscience findings into educational practices.

Another challenge is the accessibility of accurate neuroscience information and training for educators. Providing reliable resources and professional development opportunities is crucial for equipping teachers with the knowledge and understanding needed to effectively utilize neuroscience findings in the classroom. Addressing this challenge requires collaborative efforts between researchers, educational institutions, and policymakers to ensure that educators have access to up-to-date information and training in neuroscience. (Rato et al., 2011)

Resistance or skepticism from educators towards incorporating neuroscience into education is another notable challenge. Convincing educators of the benefits and relevance of neuroscience-based approaches can be difficult, particularly when they are not fully convinced or

open to change. Overcoming this challenge requires effective communication and the provision of evidence-based examples that demonstrate the positive impact of neuroscience on educational practices. Building awareness and understanding among educators about the practical implications and potential benefits of neuroscience research is crucial for fostering acceptance and adoption of these approaches.

Additionally, the changing nature of neuroscience research poses a challenge for educators. Staying updated with the latest findings and understanding how to effectively apply them in the classroom can be time-consuming and demanding, given the constraints and responsibilities faced by educators. Bridging the gap in communication and understanding between neuroscientists and educators is essential to ensure that educators are equipped with relevant and timely information to incorporate into their teaching practices.

In conclusion, integrating neuroscience findings into educational practices requires addressing these challenges. Providing clear guidance, accessible resources, and ongoing professional development opportunities for educators will facilitate the translation of neuroscience research into practical strategies. Bridging the communication gap and fostering awareness among educators about the benefits and relevance of neuroscience-based approaches is crucial for encouraging their adoption. By addressing these challenges, we can promote a more effective and informed use of neuroscience in education, ultimately enhancing teaching and learning outcomes.

Limitations of the Study

It is important to acknowledge the limitations of this study. Firstly, the study relied on self-reported data from teachers, which may be subject to biases and inaccuracies. Moreover, the study was conducted within a specific educational context and may not be generalizable. Additionally, the study only focused on the integration of cognitive neuroscience into teacher education programs and does not explore other aspects of the relationship between neuroscience and education. Furthermore, the study may not have been able to capture all the potential challenges and effects of incorporating educational practices based on neuroscience.

Recommendations

Professional development opportunities play a crucial role in equipping educators with the knowledge and skills to integrate neuroscience findings into their teaching practices. Collaborative initiatives that bring together educators and neuroscientists can provide valuable guidance and support. Workshops, seminars, and mentorship programs can facilitate meaningful collaboration and knowledge exchange between these two fields.

To address the need for practical guidance and access to reliable information, institutions can provide educators with resources specifically tailored to integrating neuroscience into education. These resources may include curated literature, online courses, and practical strategies for applying neuroscience principles in the classroom.

Ethical considerations raised by the teachers underscore the importance of ensuring that neuroscience-informed strategies prioritize student well-being and privacy. Training programs

and resources should emphasize the ethical guidelines and informed consent necessary for the implementation of these strategies in educational settings.

Advocacy efforts can raise awareness about the benefits of integrating neuroscience into education and garner support for the development of policies that facilitate collaboration between neuroscientists and educators. By engaging with policymakers and educational leaders, advocacy initiatives can promote the allocation of resources and the establishment of frameworks that support the integration of neuroscience findings in curriculum development and instructional practices.

The acknowledgment of misconceptions surrounding the integration of neuroscience and education highlights the need for targeted communication and professional development efforts. Providing educators with accurate and nuanced information about neuroscience principles can help dispel misconceptions and build confidence in applying these concepts in the classroom.

By implementing these strategies, educators can be better equipped to integrate neuroscience findings into their teaching practices, ultimately enhancing student learning outcomes and promoting a more informed and evidence-based approach to education. Recognizing the potential benefits of neuroscience in education is the first step towards fostering a collaborative and informed educational landscape that uses the insights from neuroscience to create impactful learning experiences for students.

Implications for Future Research

One key recommendation for bridging the gap between neuroscience research and educational practice would be to foster stronger collaboration and communication between

educators and neuroscientists. This could involve creating more opportunities for joint research projects, professional development workshops, and conferences where educators and neuroscientists can share knowledge, identify shared goals, and develop practical strategies together.

Neuroscientists should work to translate their complex findings into more accessible resources that teachers can easily understand and implement. This might include developing evidence-based lesson plans, classroom activities, and training that demonstrates how specific neuroscience principles relate to effective teaching and learning practices. Conversely, educators can provide valuable feedback to researchers about the real-world constraints and needs they face in the classroom. This input can help guide neuroscience studies toward questions and applications that are most relevant and impactful for educational settings.

Another important step is investing in professional development programs that build educators' capacity to critically engage with neuroscience research and apply those insights in their teaching. This training could cover topics like the basics of brain structure and function, how learning and memory work, strategies for supporting students with diverse neurological profiles, and methods for assessing the effectiveness of neuroscience-informed interventions.

Ultimately, the goal should be to create a two-way flow of information and collaboration where neuroscientists and educators work as equal partners to bridge the research-practice gap. With shared understanding, trust, and a commitment to integrating multiple perspectives, the field of educational neuroscience can thrive and have a meaningful impact on student learning and achievement.

Conclusion

The teachers' positive perceptions of the relationship between neuroscience and education resonate profoundly, highlighting the transformative potential that lies within the integration of these fields. Their recognition of the value of studying the brain and its cognitive functions, coupled with their optimistic outlook on the impact of neuroscience on educational outcomes, underscores the significant role it can play in advancing teaching methodologies and enhancing student engagement and motivation.

The teachers' collective belief in the power of neuroscience to inform instructional strategies and address individual differences among students speaks to the profound relevance and applicability of this interdisciplinary approach. Their perspectives serve as a compelling call to action, urging educators, researchers, and policymakers alike to embrace and leverage the insights gained from neuroscience to create more effective and personalized learning experiences.

By emphasizing the teachers' favorable perceptions of neuroscience and education, this research illuminates a path forward—a path paved with the promise of unlocking new frontiers in education, empowering both educators and learners to reach unprecedented heights of knowledge, understanding, and achievement.

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Appendices

Appendix A: Questionnaire

1. Gender:

   Level of education:

   Years of experience:

2. Have you participated in any programs/courses related to learning and the brain?

3. How would you define the term "education"?

4. How would you define the term "neuroscience"?

5. How did you obtain your current knowledge about neuroscience and education? Please check all that apply:

a) Formal education or professional training

b) Workshops/ conferences/ seminars

c) Books or research articles

d) Online resources/websites/blogs/videos/tutorials

e) Not applicable

6. Are there any specific resources or professional development programs you have found useful in learning about the connection between the brain and education?

7. List any teaching practices you have encountered that connect the brain to education. Please indicate your perception of the potential usefulness of these ideas.

8. Has your institution implemented any teaching or learning techniques based on neuroscience? If yes, please describe the approach. Additionally, share whether you or others in your institution have found these techniques useful and explain how.

9. On a scale from 1 to 5, how important are the following issues in applying neuroscience to education:

1 = Not Important at all and 5 = Extremely Important.

a) Communication between interested parties (teachers, administrators, researchers) ____

b) Relevance of neuroscience findings for educational practices___

c) Accessibility of neuroscience information for educators____

d) Ethical considerations related to implementing brain-based educational strategies____

10. What do you perceive as the primary challenges in linking neuroscience and education? Please provide any specific obstacles or difficulties you have encountered or anticipate in integrating neuroscience findings into educational practices.

Appendix B: Interview Questions

1. Can you tell me about any prior knowledge or exposure you have had to the field of neuroscience and its potential applications in education (neuropedagogy)?

   Follow-up: *How do you think neuroscience can contribute to our understanding of teaching and learning?*
2. Have you come across any specific concepts or principles from neuroscience that you believe could be relevant and beneficial to implementing in educational settings?

   Follow-up: *Can you explain how you perceive these concepts could positively impact teaching and learning practices?*
3. In your opinion, how significant is the connection between neuroscience and education? Do you think it has the potential to improve educational outcomes? Why or why not?

   Follow-up: *Can you provide any examples (anecdotes if possible) that support your viewpoint on the impact of neuroscience on education?*
4. Have you engaged with any neuroscience-informed teaching strategies or techniques in your classroom? If so, can you describe the specific strategies you have implemented and their effects on student learning?

   Follow-up: *Have you observed any challenges or difficulties while implementing neuroscience-informed strategies? If yes, how did you address them?*
5. How do you believe a greater understanding of the brain and its functioning can aid in addressing individual differences and meeting diverse learning needs of students?

   Follow-up: *Can you provide any examples or experiences where this understanding has been helpful in tailoring instruction or support for individual students?*

6. As an educator, what potential ethical considerations do you see when applying neuroscience findings and principles in the classroom?

   Follow-up: *How do you navigate these ethical considerations in your teaching practice?*

7. How do you think knowledge of neuroscience can influence instructional design and curriculum development?

   Follow-up: *Can you provide any specific examples of how you have incorporated neuroscience principles into your instructional design or curriculum?*

8. How do you envision the role of professional development in bridging the gap between neuroscience and education?

   Follow-up: *Have you engaged in any professional development opportunities related to neuroscience and education? If yes, how have they impacted your teaching practice?*

9. In your experience, what are some common misconceptions or challenges that educators face when trying to incorporate neuroscience findings into their teaching practices?

   Follow-up: *How do you think these misconceptions can be addressed, and the challenges overcome?*

10. Can you share any personal reflections on the potential benefits and limitations of integrating neuroscience and education in improving teaching and learning experiences?

    Follow-up: *What do you think would be necessary to promote deeper collaboration between the fields of neuroscience and education for further advancements?*

Appendix C: Consent Form

THE AMERICAN UNIVERSITY IN CAIRO
INSTITUTIONAL REVIEW BOARD

Documentation of Informed Consent for Participation in Research Study

Project Title: BRIDGING THE GAP BETWEEN NEUROSCIENCE AND EDUCATION: WHAT ARE TEACHERS' PERCEPTIONS OF APPLYING "NEUROPEDAGOGY" TO HIGH SCHOOL CLASSROOMS?

Principal Investigator:

Hanan Rashwan

Email: hananrashwan@aucegypt.edu

Mobile number: 01113831800

* You are being asked to participate in a research study.
The purpose of the research is to explore teachers' perceptions of the challenges that obstruct linking neuroscience to education, and to emphasize the benefits of linking the two. The findings may be published and presented. The expected duration of your participation is two weeks.

* The procedures of the research will be as follows:
The first stage of research is a survey that was designed to gain insights into educators' perspectives on the integration of neuroscience and education. The data collected from the survey will provide a broad understanding of teachers' beliefs about the benefits of studying neuroscience for teaching and learning. After this data is collected and analyzed, follow-up interviews will be conducted with a subset of the teachers. Through these interviews, teachers will have the opportunity to share their experiences and perspectives on how they can incorporate neuroscience knowledge into their teaching practices.

* There will not be risks or discomforts associated with this research.

* There will not be benefits to you directly from this research.

* All information provided for the purpose of this research will be treated confidentially.

*Any questions or concerns about the research should be directed to Hanan Rashwan at 01113831800.

*Participation in this study is voluntary. Refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may discontinue participation at any time without penalty or the loss of benefits to which you are otherwise entitled.

Signature _____

Printed Name _____

Date _____

Appendix D: Institutional Review Board Approval

THE AMERICAN UNIVERSITY IN CAIRO
INSTITUTIONAL REVIEW BOARD

Case# 2023-2024-147

To: Hanan Rashwan
Heba ElDeghaidy
Nadia Fouad

From: **Heba Kotb**
Chair of the IRB
Date 9/3/2024

Re: IRB approval

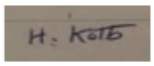
This is to inform you that I reviewed your revised research proposal entitled

"BRIDGING THE GAP BETWEEN NEUROSCIENCE AND EDUCATION: WHAT ARE TEACHERS' PERCEPTIONS OF APPLYING "NEURO-PEDAGOGY""

It required consultation with the IRB under the "expedited" category. As you are aware, there were minor revisions to the original proposal, but your new version addresses these concerns successfully, your proposal involves no new data collection. This approval letter was issued under the assumption that you have not started your research project.

Please note that IRB approval does not automatically ensure approval by CAPMAS, an Egyptian government agency responsible for approving some types of off-campus research. CAPMAS issues are handled at AUC by the office of the University Counsellor. The IRB is not in a position to offer any opinion on CAPMAS issues, and takes no responsibility for obtaining CAPMAS approval.
This approval is valid for only one year. In case you have not finished your research within a year, you need to apply for an extension.

Thank you and good luck.



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Institutional Review Board
The American University in Cairo
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Appendix E: CAPMAS Approval

الجهاز المركزى للتعبئة العامة والإحصاء
الإدارة العامة للأمن

صادر رقم	١٤٢٨
تاريخ	٢٠٢٤/٥/١٢
مرفقات	لا يوجد

الجهاز المركزى
للتعبئة العامة والإحصاء
الإدارة المركزية لشئون مكتب رئيس الجهاز
الإدارة العامة للأمن

الموضوع : .....

المرفقات : .....

القيد : .....

التاريخ : / /

السيد الأستاذ الدكتور/ مستشار الجامعة الأمريكية بالقاهرة

تحية طيبة وبعد ،،،

بالإشارة لكتاب سيادتكم الوارد للجهاز فى ٢٠٢٤/٤/١ ومرفقاتة بشأن طلب الموافقة على قيام الباحثة / حنان كمال احمد رشوان – المسجلة لدرجة الماجستير / قسم الدراسات التربوية بكلية العلوم الإنسانية والإجتماعية / الجامعة الأمريكية بالقاهرة – بإجراء دراسة ميدانية بعنوان: (سد الفجوة بين علم الأعصاب والتعليم : ما هي تصورات المعلمين لتطبيق "تعليم علن الأعصاب" على الفصول الدراسية في المدارس الثانوية ؟)

وذلك وفقا للإطار المعد لهذا الغرض.

يرجى التكرم بالإحاطة بأن الجهاز المركزي للتعبئة العامة والإحصاء يوافق على قيام الباحثة / حنان كمال احمد رشوان - بإجراء الدراسة الميدانية المشار إليها بعالية وفقا للقرار رقم (١٠٧٥) لسنة ٢٠٢٤ اللازم في هذا الشأن وعلى إن يوافى الجهاز بنسخة من النتائج النهائية كاملة فور الانتهاء من إعدادها طبقا للمادة رقم (٧) من القرار .

وتفضلوا بقبول فائق الاحترام ،،،

محمد إبراهيم بخيت

مدير عام الإدارة العامة للامن

الجهاز المركزي للتعبئة العامة والإحصاء
الإدارة العامة للأمن
رئاسة الجهاز

الجهاز المركزي
للتعبئة العامة والإحصاء

قرار رئيس الجهاز المركزي للتعبئة العامة والإحصاء
بالتفويض رقم (٢٠٢) لسنة ٢٠٢٤

في شأن قيام الباحثة / حنان كمال احمد رشوان – المسجلة لدرجة الماجستير / قسم الدراسات التربوية بكلية العلوم الإنسانية والإجتماعية / الجامعة الأمريكية بالقاهرة - بإجراء دراسة ميدانية بعنوان: (سد الفجوة بين علم الأعصاب والتعليم : ما هي تصورات المعلمين لتطبيق "تعليم عن الأعصاب" على الفصول الدراسية في المدارس الثانوية ؟)

رئيس الجهاز

- بعد الإطلاع على القرار الجمهوري رقم (٢٩١٥) لسنة ١٩٦٤بشان إنشاء الجهاز المركزى للتعبئة العامة والإحصاء.
- وعلى قرار رئيس الجهاز رقم (٢٣١) لسنة ١٩٦٨في شأن إجراء الإحصاءات والتعدادات والاستفتاءات والاستقصاءات.
- وعلي قرار رئيس الجهاز رقم (١٣١٤) لسنه ٢٠٠٧ بشأن التفويض في بعض الاختصاصات
- وعلي قرار رئيس الجهاز رقم (١٥٥٢) لسنه ٢٠٢١ بشأن التفويض في بعض الاختصاصات.
- وعلى كتاب الجامعة الأمريكية بالقاهرة - الوارد للجهاز فى ٢٠٢٤/٤/١ .

قـــــرر

مادة١: تقوم الباحثة / حنان كمال احمد رشوان – المسجلة لدرجة الماجستير / قسم الدراسات التربوية بكلية العلوم الإنسانية والإجتماعية / الجامعة الأمريكية بالقاهرة - بإجراء الدراسة الميدانية المشار اليها عالية.

مادة٢: تجري الدراسة علي عينة حجمها (١٠٠) مائة مفردة من معلمين المرحلة الثانوية بالمدارس الدولية وذلك بمحافظة بورسعيد .

مادة٣: تجمع البيانات اللازمة لهذه الدراسة بموجب الاستمارة المعدة لذلك " باللغة الإنجليزية" وعدد صفحاتها ثلاث صفحات معتمدة كل صفحة منها بخاتم الجهاز المركزي للتعبئة العامة والاحصاء

مادة٤: تقوم مديرية التربية والتعليم بمحافظة بورسعيد – وتحت إشراف إدارة الامن بها - بتيسير إجراء هذه الدراسة الميدانية على ان تقوم المديرية بتحديد الإدارات التعليمية وكذا أسماء المدارس المستهدفة – ومراعاة الضوابط الخاصة بتقييم درجة سرية البيانات والمعلومات المتداولة مسبقا بمعرفه كل جهه طبقاً لما جاء بخطة الأمن بها.

مادة٥: يراعى موافقة مفردات العينة - وسرية البيانات الفردية طبقاً لقانون الجهاز رقم (٣٥) لسنة ١٩٦٠ والمعدل بالقانون رقم (٢٨) لسنة ١٩٨٢وعدم استخدام البيانات التي يتم جمعها لأغراض أخرى غير أغراض هذه الدراسة.

مادة٦: يجري العمل الميداني خلال شهرين من تاريخ صدور هذا القرار .

مادة٧: يوافى الجهاز المركزى للتعبئة العامة والإحصاء بنسخة من النتائج النهائية لهذه الدراسة.

صدر في: ٣ / ٤/ ٢٠٢٤

محمد إبراهيم بخيت
مدير عام الإدارة العامة للامن