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An Examination of Planning and Implementing Brain-Based Strategies in the Elementary Classroom

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Abstract

Brain-based learning can positively impact student motivation, attitudes and academic achievement. Much of the research is situated in a quantitative paradigm designed to measure motivation, attitudes toward learning, and academic achievement. The purpose of the study was to investigate the extent to which teachers are aware of brain-based learning theory and applying the concepts of the theory to their teaching. The qualitative study utilized brain-based learning theory as a research framework. The study employed a semi-structured, face-to-face interview method to gain a better understanding of what information teachers currently know about brain-based learning and what they need in order to create classrooms that implement curriculum using brain-based learning theory. The study also explored the extent to which teachers learned about brain-based learning theory in their teacher preparation programs. The study has implications for pedagogy as well as curriculum choices in school districts and teacher preparation programs. Findings include evidence that teachers had little knowledge of brain-based learning theory unless they had engaged in professional development specific to brain-based learning. However, teachers often unknowingly implemented brain-based learning strategies. Findings also include evidence that teachers did not recall learning about brain-based learning theory in their teacher preparation programs. The study includes recommendations for general education teachers, higher education faculty and future research.

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Dedication

This dissertation is dedicated first and foremost to my loving family, who supported and encouraged me throughout the entire process. This achievement would not have been possible if not for the love and support of my husband, who encouraged me to pursue this degree from the start. Thank you, Mike, for understanding how much it meant to me to accomplish this goal, and for your unwavering support during the last two and a half years. I could not have done this without you.

I would also like to dedicate this dissertation to my amazing committee. Thank you both for your knowledge and guidance throughout the process. I am a better writer and researcher thanks to your support and coaching. I have the utmost respect and admiration for you both, and I cannot thank you enough for being such a wonderful, supportive committee.

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Biographical Sketch

Gina DiTullio is a 24-year veteran educator. Her educational career began at Monroe Community College where she completed an associate degree. She went on to finish her bachelor's in English Literature, minoring in elementary education at Nazareth College of Rochester. During that time, she was inducted into the National English Honor Society her junior year and served as president her senior year. Gina also holds a master's degree in elementary education from The College at Brockport, State University of New York, and a master's degree in educational administration from St. John Fisher College.

Gina earned her National Board Certification and was inducted into the Pi Lambda Theta honor society during her 14-year tenure in the Rochester City School District where she worked as a general education elementary teacher, mentor, and instructional specialist. In 2008, Gina was offered a job as an assistant principal at Monroe One BOCES. She continues to work at Monroe One BOCES, supervising special education classrooms.

Gina completed her doctorate in executive leadership from St. John Fisher College in 2018. She was inducted into the Kappa Delta Pi honor society for academic excellence during her doctoral program. Gina is planning to continue writing for publication and has plans to write a book that would add to the field of education's understanding about how to apply brain-based strategies in the elementary classroom

Abstract

Brain-based learning can positively impact student motivation, attitudes and academic achievement. Much of the research is situated in a quantitative paradigm designed to measure motivation, attitudes toward learning, and academic achievement. The purpose of the study was to investigate the extent to which teachers are aware of brain-based learning theory and applying the concepts of the theory to their teaching.

The qualitative study utilized brain-based learning theory as a research framework. The study employed a semi-structured, face-to-face interview method to gain a better understanding of what information teachers currently know about brain-based learning and what they need in order to create classrooms that implement curriculum using brain-based learning theory. The study also explored the extent to which teachers learned about brain-based learning theory in their teacher preparation programs.

The study has implications for pedagogy as well as curriculum choices in school districts and teacher preparation programs. Findings include evidence that teachers had little knowledge of brain-based learning theory unless they had engaged in professional development specific to brain-based learning. However, teachers often unknowingly implemented brain-based learning strategies. Findings also include evidence that teachers did not recall learning about brain-based learning theory in their teacher preparation programs. The study includes recommendations for general education teachers, higher education faculty and future research.

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Chapter 1: Introduction

Engaging the Brain

The human brain weighs around 3 pounds, is mostly made up of water, fat and protein and is so soft that it can be cut with a butter knife (Jensen, 1998). The most noticeable feature of the human brain is the folds. These folds make up the cerebral cortex and allow for maximum surface area (Jensen, 1998). The human brain has the largest area of cortex that is not designated for a specific function (Jensen, 1998). This means that the human brain has an enormous capability for learning.

Since the brain is the main organ of learning, there is an interest on the part of educators to learn about brain structure and function as it relates to the learning process. The ability to learn is an important part of human evolutionary history. Humans who could problem-solve and adapt to changing environments lived long enough to pass down their genes to the next generation and humans who were unable to adapt and learn perished. Thus, the prefrontal cortex evolved, and humans became smarter (Medina, 2014). Children were, and still are born with brains that are not done developing but have the capacity to learn just about anything (Medina, 2014). This capacity for learning led to the eventual development of the roles of teacher (adult) and learner (child).

Although brain-based learning theory emerged over 30 years ago, it is still considered recent, especially compared to its predecessors in the field of psychology. Neuroscience is also a relatively new and growing field since advances in medical neuroimaging technology provided a window into a living, active brain. Much has been learned in the last 30 years regarding the structure and function of the human brain. The neurobiological research has also helped provide evidence to support psychological theories which up to now could only be observed through human behavior (Tokuhama-Espinosa, 2011).

Neuroscience is a term used to describe any or all the sciences dealing with the structure and function of the human brain. Since the professions of teaching and neuroscience both involve matters of the brain, it is only natural that there is an interest in bridging these two fields of study. Over the past 20 years there has been a significant increase in the level of neurological research available due to advances in the technology associated with medical imaging of the human brain (Given, 2002). According to Hohnen and Murphy (2016), there is a global movement to integrate the fields of cognitive neuroscience and education as the brain is at the center of all learning.

The brain is the main organ used during learning. For that reason, there has been an interest on the part of educators in learning more about the biology of the human brain and how to best use that knowledge to enhance teaching and learning. While there is not consensus in the literature that there should be integration of the two fields, there is a large body of research examining the implications that neuroscience could potentially have on best practice in the classroom (Hohnen & Murphy, 2016). Zadina (2015) argues that while some critics believe it is too early for neuroscience to inform curriculum, we have actually reached “the tipping point” (p.73) in the discussion of neuroscience informing curriculum and teaching practices. Zadina points to the large body of literature that has developed on the neuroscience of learning saying that:

Scientists have moved beyond studying only what has clinical implications and

> have begun looking at the effects of bilingualism, the arts, and physiology on the normal brain and on the underlying components of learning. Neuroscience research is now substantial enough to warrant curriculum reform in several areas, including the impact of language learning, exercise, the arts, and sleep on learning (Zadina, 2015, p. 73).

Others in the field agree with Zadina (Foster, West, & Bell-Angus, 2016; Martin-Loeches, 2015; Schwartz, 2015). Schenck and Cruickshank (2014) explained that through advances in neuropsychology, cognitive neuroscience and brain imaging we now know much more about memory and learning. This new knowledge has significantly influenced the redesign of many of the models of learning and disproved assumptions and neuromyths. For example, some neuromyths that have been disproven include the myth we use only 10% of our brain, or that individuals are left-brained or right-brained. There is also evidence that previous interpretations of learning styles are seriously flawed (Schenck & Cruickshank, 2014). New models of learning, like inquiry and experiential learning have emerged in part from more recent brain research.

Collaboration between two very different disciplines can pose many challenges even in an effort to construct new and better knowledge of learning. As previously stated, there is a danger that cognitive neuroscience research findings could get overgeneralized, misinterpreted and as a result perpetuate neuromyths. Some critics point out that neuroscience and education speak very different languages and have different goals, so they appear to belong in two very separate worlds (Martin-Loeches, 2015; Nixon, 2012).

Schrag (2013) would agree with that assessment, stating that human activity cannot be reduced to a person's biological processes. Schrag (2013) argues that a teacher needs to understand how long students can be expected to concentrate for a given period, but does not need to understand the neurological underpinnings of the brain that regulate fatigue. Critics also argue that there is a standard format for presenting scientific findings at conferences and many scientists use that same format when presenting to teachers, failing to understand the perspectives and needs of educators (Zadina, 2015). The lack of joint understanding can lead to misinterpretation of scientific findings or overgeneralization of the information.

History of Brain-Based Learning

As far back as the 1800s humans have wondered how much of the capacity to learn was derived from genetic makeup and how much was derived from an interaction with the environment. Francis Galton began the conversation when he questioned whether it was nature or nurture that had the most influence over our intelligence (Tokuhama-Espinosa, 2011). This provocative question began a debate between the biology and behavioral psychology fields that continues to this day.

Piaget entered the discussion in the early 1900s with an influential theory which he described as stages of cognitive development. Piaget was originally trained in biology and philosophy but considered himself a genetic epistemologist (Tokuhama-Espinosa, 2011). Piaget's stages of development described a process of maturational thinking that developed over time (Tanner, 2016). His work directly impacted the work of educators because he directly linked developmental stages to curriculum design (Tanner, 2016).

Piaget's work is still relevant today and has helped to inform brain-based learning theory along with the work of another influential psychologist named Vygotsky.

Vygotsky's social development theory included an idea about how the brain can reach optimal potential for learning. Vygotsky described it as the "zone of proximal development," where the new content and skills being taught are neither too hard nor too easy (Murphy, Scantlebury, & Milne, 2015). Vygotsky argued that if the learning content is too easy, students will become bored and lose interest, but if the learning content is too difficult, students will become frustrated and give up. Vygotsky also believed that a strong social community was necessary for optimal learning. Therefore, teachers need to scaffold content and skills that are in the zone of proximal development as well as build in several opportunities for students to interact with peers. This was the predominant theory until advances in medical imaging technology in the 1970s.

During the 1970s, technology took a big step forward. The development of medical imaging technologies such as the computed tomography (CT) and positron emission tomography (PET) scans revolutionized medical imaging (Jensen, 2000). These technologies were soon followed by the development of magnetic resonance imaging (MRI) and functional magnetic resonance imaging (fMRI) (Tokuhama-Espinosa, 2011). For the first time, scientists could analyze the brain while it was alive. This technology provided a window into the human brain and began a field of study known as cognitive neuroscience that soon revolutionized neurology (Jensen, 2008a). There were those who felt that education was on the brink of a revolution, armed with an arsenal of information which could potentially transform every aspect of education (Fuller & Glendening, 1985; Jensen, 1998; Neve, Hart, & Thomas, 1986).

The brain research movement began in the late 1980s with the creation of the Brain, Neurosciences, and Education Special Interest Group within the American Education Research Association (Schwartz, 2015). One of the leading voices in the movement to integrate neuroscience and education was Hart who wrote about his studies using a theory he referred to as proster theory (Neve, Hart, & Thomas, 1986). Proster theory was generated from many disciplines, some of which are: anthropology, archaeology, evolutionary science, neurosciences, computer science and educational experience (Hart, 2002). The name "proster" is derived from combining the words program and structure (Neve, Hart, & Thomas, 1986).

Hart (2002) imagined that the human brain functioned much like a computer. Proster was likened to a collection of stored programs, related to a pattern, which could be used as alternatives (Hart, 2002). For example, a proster would need to be created in order to decode the word “pat” and another for the word “put” (Haglund, 1981). Hart imagined that millions of prosters could be created by adulthood (Haglund, 1981).

Proster theory included other ideas as well. For example, one of the main principles of proster theory was that the human brain functions best when there is an absence of threat (Neve, 1985). There was also an emphasis on communication, understanding that students must read, write, listen, and speak with one another to learn, so developing communication skills was essential (Neve, 1985). Another guiding principle of proster theory is a focus on reality (Neve, 1985). Hart’s theory was partially based on the idea that students would be more engaged in learning that was perceived to be based in some real-life problem that needed to be solved (Hart, 2002). Hart’s work helped to lead the way for others to connect neuroscience to educational practices in the decades that would follow.

In the 1990s during the term of President George H.W. Bush, there was an initiative called Mind, Brain, and Behavior launched by Harvard in response to Bush's proclamation that the 1990s were going to be the Decade of the Brain (Schwartz, 2015). Since that time, there have been several advances in the fields of cognitive neuroscience and education. By the end of 2004 the International Mind, Brain, and Education Society (IMBES) was formed, and in 2007 the first issue of the *Mind, Brain, and Education* journal, was published (Schwartz, 2015). In the fall of 2007, IMBES held its first international conference which was host to 14 countries and addressed over 25 topics (Schwartz, 2015). The mission of IMBES is to bridge the gap between biology, education and the cognitive and developmental sciences (Schwartz, 2015).

It has been over 20 years since the idea of brain-based learning first emerged (Zadina, 2015). Since then, there has been a significant increase in neurological research available due to advances in the technology associated with medical imaging of the human brain (Given, 2002). Educators were trying to make inferences from this cognitive neuroscience to inform classroom practice, thus beginning a movement to integrate the two fields. However, it is unclear where teachers are learning about brain-based teaching theory (Zadina, 2015).

The movement was later joined by scientists to help inform teacher professional development, but scientists lacked the classroom teaching experience to effectively bridge the work (Zadina, 2015). While much has been written about the impact neuroscience can have on educational practice, the revolution some anticipated still eludes educational reformers. The lack of progress has been partially due to changes in educational policy.

Educational Policy in the US

The election of Ronald Reagan in 1981 brought with it the perception that there was something wrong with the state of education in the United States (Hurley, 2007). Reagan's secretary of education, T.H. Bell, selected a committee to write a report which was entitled *A Nation at Risk* (Hurley, 2007). The report made several recommendations, one of which was nationwide high-stakes testing to hold schools accountable to the public (Hurley, 2007). Some states, like New York, already had high-stakes testing integrated into the education system, while other states did not.

In 2000, George W. Bush embraced the notion of high-stakes testing through the creation of No Child Left Behind (NCLB). The law allowed states to utilize tests that contained primarily multiple-choice questions. This type of test was not in line with the performance-based curricula and assessments that were being used (Hurley, 2007). In other words, the testing methods did not align with the teaching methods. This disconnect ultimately caused curriculum to shift back to a more traditional approach, and the testing sometimes showed misleading results (Hurley, 2007). No Child Left Behind was ultimately not a highly successful educational policy because the focus on testing caused teachers to focus on rote memorization and lower-level skills aligned to the tests.

In 2009, 48 state leaders came together to develop common college and career-ready learning standards in mathematics and language arts education. Educators from K-12 as well as higher education and other experts collectively determined what every child should know and be able to do when they graduate from high school (US

Department of Education, 2012). Along with the standards came terms like “grit” and “rigor.” Claims that the standards for students in America had been too low to compete in a global economy encouraged those who sought to increase the difficulty of concepts taught at each grade level (Peterson, Barrows & Gift, 2016). Proficiency levels were raised and assessed by high-stakes testing at elementary, middle, and high school.

Content was moved down the grade-level continuum 2 years in some cases with content that was formerly taught in tenth grade being taught in eighth grade, for example. This tactic is more in line with a survival of the fittest approach rather than a brain-based learning approach. Students were placed in courses that contained extremely challenging content and expectations for proficiency were raised significantly (Berliner, 2011). Teachers were unable to promote brain principles since the focus was now on passing the new rigorous standardized tests. Brain-friendly classrooms providing a low threat and high challenge while solving authentic cross-curricular problems were replaced with practices that focused on test preparation and content memorization (Berliner, 2011). While standards have been raised, student learning outcomes have not necessarily improved.

High-stakes tests have been a large part of the implementation of Common Core State Standards and related Common Core Assessments. Common Core assessments have driven teacher evaluation, school funding and in some cases, led to schools being taken over or shut down entirely (Jochim & McGuinn, 2016). However, these assessments have not resulted in the intended outcomes for which they were designed. According to the National Assessment of Educational Programs (NAEP), the rate of student achievement gains in the US was actually greater before high-stakes testing became national policy (Berliner, 2011). What was intended to be sound educational policy that would result in improving the American education system has not yielded the intended results. High-stakes testing has slowed the growth of academic achievement in the US despite the pressure it brings to schools, teachers and students (Welner, 2014).

This phenomenon may be, at least in part, due to the stress that constant testing causes students and teachers. Similar to Vygotsky's zone of proximal development, brain research shows that humans learn best in a state of relaxed alertness, where the challenge is high, but the threat is low (Tokuhama-Espinosa, 2011). High-stakes testing creates a classroom environment where the challenge is high, but the threat is also high because there are potentially negative consequences for the schools, teachers, and students attached to test scores which do not meet the required proficiency levels.

Another consequence of the Common Core assessments is the narrowing of state curricula. There is evidence that lower performing schools have increased the amount of time spent on instruction in reading and mathematics by roughly 40% (Berliner, 2011). Conversely, the amount of time spent on instruction in social studies and science has decreased by about 33% (Berliner, 2011). Rooney (2015) found in a two-year ethnographic study that teachers experienced the narrowing of curriculum as a burden, knowing that the curriculum was not adequately taught to students. In addition, the time that students spend in subjects such as music, art, physical education, and in recess has also decreased by about 30% as well (Rooney, 2015). Despite this, students have not made significant gains in reading or mathematics.

Problem Statement

There is a gap in the literature regarding how elementary teachers are knowingly and unknowingly planning and implementing brain-based learning strategies in the classroom. There is also a gap in the literature regarding where teachers learn about these strategies and their implementation. The empirical literature has shown that brain-based learning strategies can significantly impact student motivation, attitudes and academic achievement (Akyurek & Afacan, 2013; Duman, 2010a, Duman, 2010b; Ozden & Gultekin, 2008; Yagcioglu, 2014) so it is important to understand the degree to which brain-based learning is being used in classrooms and how teachers are learning about brain-based learning theory and strategies.

During many years of changes in governmental education policy, there was ongoing neuroscience research and efforts to collaborate with those in psychology and education. The attempts at collaboration became what is known as brain-based learning. Brain-based learning theory attempts to connect what is known in the fields of psychology, neuroscience and education (Tokuhama-Espinosa, 2011). Cognitive neuroscience still has much to contribute to education but bridging the two disciplines has its challenges. Neuroscientists lament that much is known about how to improve learning and they believe that the field of education is not responding (Zadina, 2015). Aldrich (2013) asserts that most educational practitioners are likely unaware of or indifferent to the outcomes of that neuroscientific research. However, when polled, an overwhelming majority of teachers agreed that it is important for educators to understand the neurological underpinnings of cognition and behavior to be effective in the domain of teaching (Serpati & Loughan, 2012).

Serpati and Loughan conducted a study in 2012 in which a survey was used to evaluate teachers' perceptions of the importance of neuroeducation. The Serpati and Loughan study revealed that teachers agree that it is important to understand cognitive neuroscience to better understand learning, cognition and behavior (2012). Organizations such as International Mind Brain and Education Society have evolved to address these concerns and promote the transdisciplinary collaboration of the two fields, but with less success than hoped for (Kosaraju, Gorman, & Berry, 2014).

With the changes in education laws and teacher accountability practices, there is less flexibility with applying brain-friendly learning strategies in classrooms. American elementary students continually face scrutiny in academic achievement levels compared to other developed countries. Many American elementary students struggle to learn using traditional methods, and teachers struggle to teach using more progressive methods. There is evidence that brain-based learning strategies could improve student attitudes toward learning, increase engagement, and potentially improve academic achievement (Akyurek, & Afacan, 2013; Duman, 2010; Neve et al., 1986). However, there is little information available on whether elementary teachers are knowingly or unknowingly including brain-based strategies in their lessons.

In addition to a lack of flexibility in classrooms to implement brain-based strategies, there is also less flexibility in undergraduate teacher training programs to incorporate classes which focus on brain-based learning. Teacher training programs are very important in shaping the pedagogy of new teachers. These programs require a certain number of hours to meet minimum requirements to obtain teacher certification. For example, New York requires that potential teachers complete 32 credit hours in their content area and pass the required exams for certification (Teacher Certification Degrees, 2017). Once the minimum requirements are met through mandated course work, there is little time left for classes that focus on using a brain-based approach to teaching and learning since teacher preparation programs are often overtaxed with state certification requirements. This situation creates a gap in the knowledge base of young teachers, leaving them on their own to learn about brain-based strategies and how those strategies can enhance teaching and learning.

Due to limited research on the application of brain-based learning strategies, there is no way to know how many teachers in the field are familiar with the theory and able to effectively apply strategies aligned with brain-based teaching. There is also very little research on whether teachers are using a method of lesson planning that is aligned with brain-based learning theory, such as Jensen's seven stages of brain-based planning. The gap in the literature also calls into question whether teacher training programs are disseminating information about brain-based theory to pre-service teachers.

Theoretical Rationale

The study is directly connected to brain-based learning theory. The study will investigate brain-based learning strategies being used in elementary lesson planning. The researcher will use Jensen's seven stages of brain-based planning as the lens through which to explore whether elementary teachers are knowingly or unknowingly including brain-based strategies in their lesson planning.

Brain-based learning theory is appropriate for the study for several reasons. First, brain-based learning combines the fields of psychology, neurology, and education to explore strategies for teaching and learning that are most consistent with how the human brain naturally learns. Second, brain-based learning theory creates a bridge between neuroscience and education which allows teachers to understand not only the what, but also the why of the chosen pedagogy. Third, Jensen's seven-stage process for lesson planning provides a framework for lesson planning which allows for lessons to be designed with the neurobiology of the human brain in mind (Jensen, 2008a). Jensen's seven-stage process will allow the researcher to evaluate lesson plans for alignment with elements of brain-based learning theory.

Brain-based learning theory is a combination of cognitive neuroscience, psychology, and education theories. Jensen (2008a) describes it as "the engagement of strategies based on principles derived from an understanding of the brain" (p. 4). Brain-based learning theory is meant to bridge the gap between purely psychological models of learning and purely biological models of learning. It is meant to be a transdisciplinary approach that allows educators to design learning experiences consistent with the way the brain is biologically designed to learn (Tokuhama-Espinosa, 2011).

Brain-based learning theory draws from research in neurobiology, cognitive psychology, and education to make recommendations about how a brain learns best (Jensen, 2008a). It is not meant to be a recipe to follow, or a quick fix for learning difficulties, but rather a way to help teachers make better decisions and reach more learners (Jensen, 2008a). Brain-based learning theory informs teaching practice and defines the optimal state for learning. This optimal state is described by Jensen (2008b) as being intrinsically challenged with material that is not too hard or too easy, containing a moderate level of stress, and filled with curiosity and anticipation.

Brain-based learning theory allows the teacher to understand what she is doing and why (Neve et al., 1986). When teachers can focus on producing learning rather than covering content or following a manual they can focus on providing learning environments that promote learning for all students. This finding implies that the current lockstep structure of the traditional classroom may require modification if the central focus is how each learner individually learns best.

Jensen (2008a) provides a seven-stage process (Table 1.1) for lesson planning which can be used when attempting to create a learning environment that is aligned with a brain-compatible approach. Teachers can use this framework to ensure that they are considering brain-based learning theory when planning lessons. The framework is meant to reflect the stages of learning and are organized into a sequence that makes sense to the brain (Jensen, 2008a).

The seven stages somewhat resemble a typical Madeline Hunter lesson plan but include information about how to ensure brain-based learning theory is incorporated. A typical Madeline Hunter lesson plan also contains seven steps: review of previous learning; the anticipatory set where the stage for new learning is set and previous knowledge is activated; lesson objectives are set stating what students will be able to do by the lesson's end; teacher provides input and modeling where new information is presented to students; check for understanding using quick formative assessments; guided practice so students can get help while applying new learning; allow students to engage in independent practice, which is typically given as homework (Hunter, 1976). This basic lesson planning format is still commonly taught in undergraduate teacher preparation programs.

Table 1.1

The Seven Stages of Brain-Based Planning

Stage	Description	Examples
Stage 1: Pre-exposure	Provides the brain with an overview of the new learning and helps the brain develop better conceptual maps	1. Post an overview of the new topic 2. Figure out what students already know about the topic and begin lesson planning there 3. Build strong, positive rapport with learners
Stage 2: Preparation	Create curiosity or excitement. Similar to the "anticipatory set" but goes a bit further in preparing the learners.	1. Create a real-world grounding experience 2. Create personal connections to the topic for each learner 3. Provide something concrete or experiential to build from
Stage 3: Initiation and Acquisition	Provides immersion; allows learners to be momentarily overwhelmed with new information and creates a desire to make sense of it	1. Provide concrete learning experiences 2. Provide choice and opportunity for students to explore 3. Offer group or team projects that encourage creativity
Stage 4: Elaboration	Processing stage; requires genuine thinking and urges students to make intellectual sense of new learning	1. Provide an open-ended debriefing 2. Have learners design an evaluation rubric 3. Have students do the teaching
Stage 5: Incubation and Memory Encoding	Downtime and review time	1. Provide time for unguided reflection 2. Have learners take a walk and discuss the topic 3. Ask learners to discuss new learning with peers or family members
Stage 6: Verification and Confidence Check	Learners confirm their learning for themselves as well as the teacher	1. Have learners present their new learning to others 2. Ask students to interview and evaluate each other 3. Quiz students, or have them quiz each other
Stage 7: Celebration and Integration	Engage emotions; make it fun and instill the love of learning	1. Provide class sharing time 2. Facilitate class-designed celebration 3. Incorporate the new learning into future lessons

Note. Adapted from Eric Jensen's *Brain-Based Learning: the new paradigm of teaching*, second edition, p. 215-217. Copyright 2008 by Corwin Press.

Jensen's seven stages of lesson planning follow a structure similar to the Madeline Hunter model. Stage 1 is pre-exposure (Jensen, 2008a). This stage requires the teacher to provide some sort of introduction or overview of the new learning. This pre-exposure helps the brain access prior knowledge and develop better conceptual maps before digging into the new content.

Stage 2 is preparation. During this stage is when the teacher should create curiosity or excitement before the lesson (Jensen, 2008a). Teachers may already know this stage as an "anticipatory set" but Jensen goes a bit further in this stage to prepare the student for new learning by adding to conceptual maps, providing some context, or creating a real-world grounding experience (Jensen, 2008a). Stage 2 is also the hook that engages students emotionally in the learning.

Stage 3 is the initiation and acquisition stage. Jensen (2008a) suggests that teachers provide complete immersion into the topic, initially overloading students with ideas and details and then allowing students to make meaning and discover connections through interactions with one another. This should include multisensory activities which allow students to interact with one another, questioning and exploring the new concepts (Jensen, 2008a). Students are allowed to construct their own meaning while learning the content and concepts.

Stage 4 requires a teacher to elaborate student learning by providing some sort of open-ended debriefing so that students can tie everything together (Jensen, 2008a). This is the stage where the new information is processed and may include small group discussions, video, mind maps, or any other interactive experience which would allow students time to make sense of their learning (Jensen, 2008a).

Stage 5 allows for memory encoding. This stage emphasizes the need for students to reflect on their learning during a quiet, individual activity (Jensen, 2008a). Students may be asked to journal about their learning, walk in pairs to discuss their learning, listen to music, or quietly discuss new learning with a friend (Jensen, 2008a). Encoding allows the new learning to be stored in the memory.

Stage 6 allows students to verify their learning. Students can do this by presenting to others, interviewing or evaluating each other, writing about what they have learned, creating a role-play or skit, or completing a quiz (Jensen, 2008a). This stage is not only important for the teacher to verify that learning has occurred but is also important for the students to self-monitor learning and understandings.

Stage 7 is celebration and integration of learning (Jensen, 2008a). This stage engages emotions and instills the love of learning. The last stage is important because the goal is to connect a positive association with the learning process. Stage 7 can incorporate any number of activities, such as celebrations, sharing time to demonstrate and acknowledge learning, and inviting others to provide an audience for project presentations. Celebration and integration of leaning demonstrates to students that there was value in what they learned.

The seven stages of lesson planning rely on a complex, integrated, interdisciplinary curriculum that provides for learner choice and values and respects each unique student (Jensen, 2008a). Thus, if this lesson design were to be put into practice, the type of learning activity as well as learning outcomes would need to be clearly defined at the start. This type of lesson planning would not be appropriate for every lesson taught, so attention should be paid to the type of learning outcomes that the teacher is hoping to achieve. The framework provided by Jensen provides an appropriate lens to evaluate brain-based lesson planning practices.

Statement of Purpose

The purpose of the study is to investigate the extent to which teachers are aware of brain-based learning theory and are applying the concepts of the theory in planning and teaching practices. There is a gap in the literature regarding how elementary teachers integrate brain-based teaching strategies into the lesson planning process and what guides teacher decisions regarding the implementation of these strategies. The study gained a better understanding of what information teachers currently have and what they need in order to incorporate brain-based learning theory in the classroom.

The study used face-to-face interviews with elementary teachers to determine the extent to which teachers were aware of the principles of brain-based teaching and learning and were knowingly or unknowingly applying those principles in the classroom. Interviews of elementary teachers were conducted using the 12 Principles of brain-based learning outlined by Caine and Caine (1994) and the seven stages of lesson planning by Jensen (2008a) to examine current lesson planning strategies and the level to which lessons align with brain-based learning.

The study also used interviews of school of education faculty to determine the extent to which the principles of brain-based learning were being incorporated into teacher preparation programs. These semi-structured interviews examined how much of what teachers know and understand regarding brain-based teaching and learning may be accessible in local teacher preparation programs.

The literature suggests that there is a lack of communication between the field of cognitive neuroscience and the field of education. While there are those who suggest that there are dangers in having the two fields collaborate (Nixon, 2012; Schrag, 2013), there are many others who suggest there are multiple benefits to such a collaboration (Degen, 2014; Martin-Loches, 2015; Schwartz, 2015; Zadina, 2015). The study explored the current understanding of teachers regarding planning practices aligned with brain-based learning strategies and added to the understanding of the implications of brain-based learning theory to educational practice. The study also examined teacher understanding of the concepts and educational implications of brain-based learning theory.

Research Questions

The study may enhance the body of knowledge about the emerging field of neuroscience and education, or neuroeducation. The study investigated the level of knowledge that currently exists with elementary teaching professionals as well as investigated teacher practices being used that are aligned with brain-based learning theory.

The study addressed these research questions:

1. What do current elementary teachers know about brain-based teaching strategies?
2. How are elementary teachers knowingly or unknowingly applying brain-based learning theory to their lessons?
3. To what extent is brain-based learning theory part of the curriculum in Western County, New York elementary teacher preparation programs?

Answers to these questions can have a significant impact on the strategies that teachers are incorporating into core content lessons. Answers may also impact the design of teacher lessons, as well as the design and focus of teacher preparation programs.

Potential Significance of the Study

There has been a significant increase in the past 20 years in the body of empirical research regarding the implications of neuroscience on education. There has also been an increase in the desire to collaborate between the fields of neuroscience, psychology, and education. Collaboration has resulted in the emergence of a new field called neuroeducation or brain-based learning. Educators want to better understand how to teach young, impressionable minds. The literature provides evidence that brain-based learning may provide a framework that teachers could use to successfully bridge the perceived gaps.

The qualitative nature of this study adds to the existing literature by providing information about what is happening in classrooms and whether teacher preparation programs are incorporating brain-based learning. Findings from this study inform the literature as to what professional development may be needed to increase teacher understanding and increase the use of brain-based learning in general education classrooms. A gap remains between what is known in the literature regarding brain-based teaching and learning strategies and what is being implemented in a typical classroom setting. The study may have significant impact on the practice of teaching and learning, causing elementary teachers to reconsider outdated teaching methods and help them integrate knowledge of how the human brain constructs knowledge while learning.

The study may also have a significant impact on the design of elementary teaching and planning practices by providing information about what brain-based strategies teachers are knowingly and unknowingly implementing in the classroom. Because there is evidence that applying strategies aligned with brain-based learning can significantly improve student motivation, attitudes, and academic achievement, it is important to gather more information regarding what extent teachers are applying brain-based strategies to the planning process as well as classroom design.

The study's findings have implications for teacher professional development as well as pre-service teacher training programs, eventually affecting practice and student achievement. Understanding to what extent brain-based learning strategies are taught to preservice teachers may help inform what changes could benefit the curriculum of pedagogy classes at the college level. This information may also have implications to preservice as well as in-service teachers at the undergraduate and graduate levels.

Definitions of Terms

Brain-based learning: Education that moves beyond pedagogy alone to include the use of information about how the brain learns to teach better. Sometimes referred to as *neuroeducation* in more recent literature (Tokuhama-Espinosa, 2011).

Cerebral cortex: The deeply folded outer layers of the cerebral hemispheres that is responsible for perception, awareness of emotion, planning, and conscious thought; also called the neocortex (Wolfe, 2010).

Cognitive Neuropsychology: A branch of study that aims to understand how the structure and function of the brain relates to specific psychological processes (Tokuhama-Espinosa, 2011)

High-stakes Testing: Standardized testing used to sort and rank students and schools. School funding is often tied to performance on high-stakes testing (Berliner, 2011).

Magnetic Resonance Imaging: A technique for imaging soft tissue in the brain, using magnets and radio waves (Wolfe, 2010)

Neuroeducation: A term coined to describe the combination of neuroscience knowledge and its application to education (Tokuhama-Espinosa, 2011)

Neuromyth: misconception, misunderstanding, or misuse of information about the brain, which leads to false conclusions (Tokuhama-Espinosa, 2011)

Chapter Summary

Neuroscience research has provided more information about the structure and function of the human brain in the last 30 years than in the previous hundred. With this new neuroscience information, there is a new interest in understanding the implications there may be to the field of education. While there is not agreement about how much neuroscience should be shared with educators, there is an interest on the part of teachers to understand the research findings and implications to education.

The interest in bridging the fields has led to the development of a learning theory which combines the fields of education, psychology, and neuroscience to inform teaching and learning. This theory is often referred to as neuroeducation but is most commonly known as brain-based learning. Brain-based teaching and learning strategies provide a framework for the development of classroom environments that are supportive of the way a human brain is naturally wired to learn.

Although educational policy in the US has managed to move teaching practices in a narrower direction, there is not good evidence that it has led to increased student learning outcomes. In fact, the opposite has proven to be true. With changes in laws such as NCLB (No Child Left Behind) and RTTT (Race to the Top) as well as ESSA (Every Student Succeeds Act), the curriculum and standardized testing have led to a narrowing of curriculum but have not yielded increases in student achievement data (Welner, 2014). What has consistently shown a positive impact on student achievement, as well as student attitudes and motivation is a brain-based learning approach (Jensen, 2008b).

Brain-based learning has been demonstrated to have a positive effect on student learning, however there is little information available on whether elementary teachers are knowingly or unknowingly using brain-based strategies in the classroom. Due to limited research on the application of brain-based learning strategies, there is no way to know how many elementary teachers are familiar with the theory and able to effectively apply strategies aligned to a brain-based learning.

This study investigated the extent to which teachers are aware of brain-based theory and are using brain-based learning strategies in the classroom. Through the lens of brain-based learning theory, the study provides a better understanding of what information teachers currently have and what they need to implement curriculum using the framework of brain-based learning. This qualitative study used semi-structured interviews to gather and analyze data in pursuit of valid answers to its research questions.

The study adds to the literature by providing a better understanding of what strategies teachers are knowingly and unknowingly using in the classroom that are aligned with brain-based teaching and learning. The study may impact teacher practices, as well as teacher preparation program curricula. The study findings may also have implications to lesson planning practices and curriculum design.

Chapter 2 will include a comprehensive review of the literature, including studies conducted to explore the possible effects of brain-based learning on academic achievement, student motivation and student attitudes toward learning. Chapter 3 of the dissertation will describe the research methods used to collect and analyze the data. Chapters 4 and 5 will describe the study findings, discuss themes, and summarize study findings and recommendations.

Chapter 2: Review of the Literature

Introduction and Purpose

The purpose of this chapter is to explore the literature regarding the application of brain-based learning on academic achievement, motivation, and attitudes toward learning. First, the chapter provides background regarding the ongoing debate in the fields of education and neuroscience. Second, the chapter explains brain-based learning and describes the main elements of the theory. Next, the chapter identifies the 12 principals of brain-based learning outlined by Caine and Caine (1994) which guided the later work of Jensen. Finally, the chapter discusses the salient empirical findings of the literature, describing related studies that have been conducted worldwide.

There is not agreement as to whether neuroscience research can provide useful information about teaching and learning. There is also little known about what brain-based strategies are being used in elementary classrooms. Some researchers believe cognitive neuroscience has little to offer those in education (Bruer, 1997; Donoghue, 2016; Horvath & Nixon, 2012; Schrag, 2013), while others support and promote efforts to improve education using neuroscience research and brain-based learning theory (Degen, 2014; Caine & Caine, 1994; Goswami, 2008; Jensen, 2000; Licari, 2015; Mason, 2009; Nouri, 2016; Zadina, 2015). The benefit of brain-based teaching and learning to academic achievement remains widely debated.

The study sought to answer the following research questions:

1. What do current elementary teachers know about brain-based teaching strategies?
2. How are elementary teachers knowingly and unknowingly applying brain-based learning theory to their lessons?
3. To what extent is brain-based learning theory part of the curriculum in Western County, New York elementary teacher preparation programs?

While studies have shown the benefits of brain-based learning, there is still not agreement about how much neuroscience knowledge teachers require to effectively teach content and skills.

The Ongoing Debate: Neuroscience Research Applied to Education

In 1997, Bruer wrote an article discussing the dangers of moving too quickly from the relatively new field of neuroscience to broad applications in education. Bruer (1997) cautioned that the distance between current cognitive neuroscience research was not easily traversed to education because experiments were done mostly on rats and primates, and the subsequent findings were not necessarily applicable to education. Bruer also warned about the potential creation and propagation of neuromyths (Bruer, 1997).

A neuromyth is created when empirical scientific research is overgeneralized or misinterpreted by educators. Educators can sometimes mistake correlation for causation, as Goswami (2008) points out, inadvertently propagating neuromyths. The misinterpretation of complex neuroscience research can lead teachers to make untenable leaps from research to practice for several reasons. Zadina (2015) pointed out that teachers often do not read the scientific literature but receive information second and third hand from a presenter who may or may not have any training in neuroscience.

Zadina (2015) went on to say that even if teachers did read the literature, educators are not trained in how to evaluate the quality of scientific research or judge the validity of the findings. To the untrained eye, bad research can look like good research.

Answering questions regarding the mind, brain, and education requires joint interactions between scientific research and practical knowledge, where practice informs research and research informs practice. The answers may lie, at least in part, in the literature. Some studies in the empirical literature support the potential benefits of brain-based learning to education, providing evidence that a brain-based learning approach can improve student attitudes and increase student motivation toward learning (Akyurek & Afacan, 2013; Duman, 2010b; Mullender-Wijnsma et al., 2015; Ozden & Gultekin, 2008; Saleh, 2011; Shsabatat & Al-Tarawneh, 2016). Other studies show that brain-based learning can significantly increase academic achievement. Still more studies demonstrate how neuroscience research findings can inform education policy and effect teaching practice (Duman, 2010b; Gabriel, 1999; Gearin & Fien, 2016; Mullender-Wijnsma et al., 2015; Yagcioglu, 2014). The literature would seem to support the need to explore brain-based learning and neuroeducation in more depth.

What is Brain-Based Learning?

Brain-based learning developed from three collaborating fields of study: cognitive neuroscience, cognitive psychology, and education. It is sometimes referred to as mind, brain and education science, cognitive neuroscience, developmental neuroscience, social or affective neuroscience or neuroeducation (Dubinsky et al., 2013). The goal of brain-based learning is to align teaching and learning with how the human brain is biologically organized for learning (Tokuhama-Espinosa, 2011).

Jensen (2008a) described brain-based learning as "learning in accordance with the way the brain is naturally designed to learn" (p. 4) and suggested that it requires the "active engagement of purposeful strategies based on principles derived from neuroscience" (p. 4). Brain-based learning takes into consideration both the biology and psychology of human learning. It is not meant to be a recipe for learning; rather, brain-based learning is intended to be a theory that helps teachers create learning environments that enhance optimal brain function.

Brain-based classrooms tend to be socially stimulating, emotionally safe, and appropriately challenging learning environments. Caine and Caine (1994) suggested that teachers who utilize brain-based learning theory present content in thematic instruction and interdisciplinary patterns. Brain-based classrooms are interactive learning environments that accept students as individuals and encourage creativity, conceptual understanding, and connections (Jensen, 2008b). Three main elements of brain-based learning are typically present in a brain-based classroom: relaxed alertness, orchestrated immersion, and active processing (Caine & Caine, 1994). These elements are considered essential for brain-based learning to occur.

Main Elements of Brain-Based Learning

There are three main elements of brain-based learning that come out of the work of Caine and Caine (1994): relaxed alertness, orchestrated immersion, and active processing. Relaxed alertness is a term that Caine and Caine (1994) used regarding student emotion during learning. All learning has an emotional impact on students. That impact can be positive or negative depending on the circumstances surrounding learning and the students. Caine and Caine (1994) suggested that teachers create learning experiences that are high in challenge but low in threat to facilitate a positive learning experience. For students to engage in long periods of uncertainty when grappling with new learning concepts, students need to feel safe and secure, so they are willing to take risks. Learning happens when students are pushed beyond their comfort zone but feel safe enough to engage in the challenge presented (Caine & Caine, 1994).

Orchestrated immersion is a term that refers to the global processing of new information. Caine and Caine (1994) referred to orchestrated immersion as a teacher's ability to take information from the page and bring it to life. The focus of orchestrated immersion is creating a learning experience where students are almost overwhelmed with information so that they are forced to engage the local memory system in their exploration of the content (Caine & Caine, 1994). These learning environments contain a mix of predictable and unpredictable elements that are challenging, meaningful, and coherent for the brain (Caine & Caine, 1994).

Active processing is a term that is used to describe the act of making meaning of the learning experience. Caine and Caine (1994) defined this as the act of processing the learning experience. When students are engaged in active processing, they are reflecting, looking for patterns, comparing what they know to what they see or hear and making connections (Caine & Caine, 1994). Caine and Caine (1994) described it as the consolidation and internalization of information that is both meaningful and coherent. It is the path to understanding, not just memory.

Another principle of brain-based learning is the mind-body connection. In addition to increased attitudes, motivation, and academic achievement, studies also demonstrated that physical education and movement throughout the day can enhance learning (Gearin & Fien, 2016; Mullender-Wijnsam et al., 2015; Stevens-Smith, 2016). Given (2002) refers to this as the "physical learning system" (p. 8). Given (2002) suggests that the physical learning system likes challenging academic tasks and needs to be actively engaged in the learning process. Jensen (2008a) also connects biology and neurology suggesting that exercise not only enhances circulation, but also has been shown to spur the production of nerve growth as well as release dopamine which helps regulate emotions. Therefore, movement throughout the school day can enhance learning and potentially increase academic achievement.

Studies by Mullender-Wijnsma et al., (2015), Donnelly and Lambourne (2011) and Sattelmair and Ratey (2009) support arguments that brain-based learning has a positive impact on student learning outcomes. Studies showed that teachers who employ brain-based learning create a classroom environment that is more conducive to learning compared to classrooms which employ a more traditional approach (Jensen, 1998). It is apparent from a review of the empirical literature that several studies have been conducted on the effectiveness of brain-based learning on student achievement (Akyurek & Afacan, 2013; Duman, 2010a, 2010b; Neve, Hart, & Thomas, 1986; Saleh, 2011; Samur & Duman, 2011; Shabatat & Al-Tarawneh, 2016).

The application of brain-based learning strategies in classrooms has social-emotional as well as academic benefits. Studies such as the one conducted by Akyurek & Afacan (2013) proved to increase student attitudes and motivation toward the subject when brain-based learning strategies were incorporated into typical classroom instruction. This finding was consistent in studies that were conducted with younger students (Samur & Duman, 2011) as well as older students (Saleh, 2011; Shabatat & Al-Tarawneh, 2016).

Duman (2010a) found that students in test groups that received instruction using brain-based learning strategies demonstrated a significant increase in academic achievement compared to students in control groups who received more traditional instruction. These findings were confirmed in similar studies conducted with adult learners (Dubinsky, Roehrig & Varma, 2013).

From Twelve Principles to Seven Stages

Jensen's research was influenced by the earlier work of Caine and Caine. There are 12 basic principles of brain compatible learning that were originally outlined by Caine and Caine (1994). The principles were designed to provide guidelines for selecting programs and methodologies to use in the classroom which are aligned to a brain-based or brain compatible approach. Caine and Caine (1994) designed the 12 principles as a framework meant to guide teachers in the selection of appropriate brain-based strategies. Similarly, Jensen (2008a) provides his seven stages as "a toolbox rather than a template" (p. 214).

The principles outlined by Caine and Caine (1994) discussed the biological and neurological characteristics of the human brain and how those characteristics can impact learning. For example, Cain and Caine (1994) asserted that the brain is a parallel processor that is always doing many things at one time, simultaneously processing thoughts, emotions, and imagination. Caine and Caine (1994) also posit that learning engages the entire physiology. This would imply that everything that affects physiology, such as stress, nutrition, hydration, exercise, and relaxation, would affect the capacity to learn. Each principle describes the neurological function and then describes implications to education to create a frame of reference for teachers to use during lesson design.

Jensen (2008a) took the framework from Caine and Caine (1994) and used it to create a lesson planning guide for teachers that allows for the flexible implementation of brain-based concepts. Jensen's seven stages integrate the 12 principles. For example, during pre-exposure Jensen (2008a) suggested creating a strong immersion into the content and making it interesting. Jensen (2008a) also discussed the importance of allowing some student choice during this stage as well as creating positive emotional experiences for students directly relating to Caine and Caine (1994) and their suggestion to link thoughts and emotions.

Caine and Caine (1994) outlined several concepts for educational practice as well. First, there is a need for teachers to understand the principles and how to apply that understanding to lesson design so learning experiences are purposefully designed to engage and motivate learners (Caine & Caine, 1994). The learning environment needs to be familiar and stable, implying rules and routines are well established, but there is still a good deal of novelty and discovery which satisfy the need for challenge and curiosity (Caine & Caine, 1994). Strategies also imply the need to create a learning environment which enables students to move throughout the day and physically and socially engage in the learning process (Caine & Caine, 1994). Jensen (2008a) outlined similar concepts during both the preparation and initiation and acquisition stages in his seven stages. Jenson (2008a) discussed using novelty and interdisciplinary tie-ins to engage student curiosity, using concrete, challenging learning experiences, and providing choice for learners.

Lesson design requires the consideration of all 12 principles although not all may apply to one lesson. Jensen's later work with the creation of seven stages of brain-based planning (Appendix G) is an appropriate framework to evaluate the alignment of elementary classrooms with brain-based learning. Jensen contends that ". . .the brain is involved in everything we do at school, so to ignore it is irresponsible" (Jensen, 2008a, p. 7). While Jensen does not promote using brain-based exclusively (2008a), the literature shows that brain-based strategies incorporated into lessons can have a significant impact on student attitudes, motivation, and academic achievement.

Effects of Brain-Based Learning on Attitudes and Motivation

Teachers are aware that students who are intrinsically motivated and genuinely interested in learning tend to get the most out of instruction. If students are not motivated, teachers can expect at best that students will memorize the content long enough to pass the course assessment and, at worst, that students will disengage from the learning process altogether. Studies show that brain-based learning can increase student attitudes and motivation toward the subject matter as well as increase student engagement (Akyurek & Afacan, 2013; Duman, 2010a; Saleh, 2011). Increased student motivation may in turn lead to increased student achievement, especially in subjects where students typically struggle.

Science content can be complex, abstract, and difficult to understand. Three studies specifically examined the effect of brain-based learning on student attitudes and motivation toward difficult science content. One such study investigated the effectiveness of a brain-based teaching approach on high school students' motivation toward Newtonian physics (Saleh, 2011). Saleh (2011) noted the difficulty that secondary Malaysian students had with conceptual understandings in physics resulting in a lack of interest toward the subject. Teachers in the experimental group used positive relationships, low threat, concrete examples, and opportunities to explore abstract concepts, as part of a brain-based approach (Saleh, 2011). Using a Likert scale to measure learning motivation mean scores, Saleh (2011) found that the students in the experimental group who received a brain-based approach had more confidence and motivation toward the subject compared to the control group.

Saleh (2011) included 100 students in the quasi-experimental study, with 50 in the experimental group and 50 in the control group. Students were randomly selected from four different schools to participate in the study (Saleh, 2011). The experimental group was given instruction using a brain-based teaching approach and the control group followed a more conventional method (Saleh, 2011). The brain-based teaching approach was established using the 12 principles outlined by Caine & Caine (1994) and the seven instructional phases outlined by Jensen (2008a). All students received instruction in Newtonian physics, which is considered in Malaysia to be among the most difficult subjects to learn (Saleh, 2011).

Before the intervention, both groups obtained almost equivalent physics learning motivation mean scores on the Likert scale pretest, with the control group receiving a 2.13 mean score and the test group receiving a 2.15 mean score (Saleh, 2011). After the intervention, the experimental group obtained a mean score on the same Likert scale of 2.82, representing a gain of 0.67, while the control group received a score of 2.41 representing a gain of 0.28 (Saleh, 2011). Findings indicated that the experimental group had gains in motivation that were considered statistically significant ($p < 0.05$) and approximately twice those of the control group, causing Saleh (2011) to conclude that a brain-based teaching approach could significantly impact student attitudes toward learning challenging science content.

A similar study was conducted by Akyurek and Afacan (2013) with eighth grade students in Turkey during a complex science unit regarding cell division and heredity. Like Saleh (2011), Akyurek and Afacan questioned if students who received instruction using a brain-based learning approach would have increased motivation and improved attitudes toward the complex subject (Akyurek & Afacan, 2013). Student attitude data were collected using an attitude and motivation questionnaire. Similar to Saleh (2011), Akyurek and Afacan (2013) used a Likert-type scale to measure student attitudes and motivation before and after the study as pretest, posttest analysis of the data. Students were divided into three groups, two control and one test group, using a research model from true experimental design. Students were separated by equalization to ensure validity and objectivity. Results corroborated Saleh's (2011) findings demonstrating a statistically significant influence on both student attitudes toward the science content and increased student motivation in the test group compared to students in the control group (Akyurek & Afacan, 2013).

Akyurek and Afacan's findings were also present in studies that did not directly measure student attitudes and motivation. For example, in studies conducted to determine the effect of brain-based learning on academic achievement, researchers anecdotally observed students engaging more actively in the lessons (Duman, 2010a) as well as developing more positive attitudes toward the content (Shabatat & Al-Tarawneh, 2016). Although the researchers were focused on student achievement, there were unintended findings regarding attitudes and motivation that concurred with the findings of Saleh

(2011) and Akyurek and Afacan (2013). In fact, similar results were found in research conducted on the effect of learning styles and brain-based learning on student achievement. Duman (2010a) noted in the study findings that because brain-based teaching strategies allowed students to enter a state of relaxed awareness, students were observed to have improved self-concepts and increased motivation. Even though this aspect was not directly measured as part of the study, it was anecdotally observed and included in the study findings.

Student motivation and attitudes toward subjects, especially those that are abstract in nature and typically cause difficulty, can be improved using brain-based learning strategies. When students engage in learning that aligns with brain-based concepts such as creating a state of relaxed-alertness, orchestrated immersion in the content, and active processing of learning, attitudes and motivation will likely increase (Jensen, 2008). This is probable because the learning environment created by utilizing brain-based theory is low threat/ high challenge, interesting, and socially engaging (Tokuhama-Espinosa, 2011).

Effects of Brain-Based Learning on Academic Achievement

Now more than ever, there is a focus on teacher accountability in US schools by means of student achievement. Standardized tests are given at every grade beginning in the third grade and continuing through high school. Akyurek and Afacan, along with several others, showed that brain-based learning can have a positive effect on student achievement (Akyurek & Afacan, 2013; Duman, 2010a, 2010b; Neve, Hart, & Thomas, 1986; Saleh, 2011; Samur & Duman, 2011; Shabatat & Al-Tarawneh, 2016). Hart and his colleagues were among the first to directly study the effects of brain-based teaching on the learning outcomes of children in a school setting (Neve et al., 1986). The findings of that case study conducted as a pilot program in an elementary school were significant enough to cause the board of education to adopt the practices school-wide in the span of 3 years, transforming the school model from a traditional paradigm to a brain-based paradigm (Neve et al., 1986). Results in student achievement were significantly improved after the transformation.

Since then, studies have been conducted on the effects of brain-based learning. The studies involving the effects of brain-based teaching on academic achievement located for the present literature review were conducted within the last 7 years in Malaysia, Turkey, and Jordan. All studies used either quantitative methods to examine pre-and posttest scores of control and experimental groups or mixed methods to gather both student achievement data as well as student attitude data. The results indicated statistically significant results ($p < 0.05$) in the increase of academic achievement of students in experimental groups receiving brain-based instruction regardless of student age, gender, or content (Duman, 2010a, 2010b; Ozden & Gultekin, 2008; Saleh, 2011; Samur & Duman, 2011; Shabatat & Al-Tarawneh, 2016).

Science content can be particularly difficult to learn as it is abstract in nature. A brain-based learning approach to science can provide an environment where student emotions are regulated, collaboration is encouraged, and various models are provided to aid learning (Akyurek & Afacan, 2013). Studies such as the one conducted by Akyurek and Afacan (2013) related to motivation and attitude toward learning assume that if there is an increase in motivation and attitude toward learning there will also be an increase in student achievement. There are studies which examined this relationship between attitude and learning outcomes, and those study findings supported the assumption that there is a connection between the two.

Saleh (2011) found that a brain-based learning approach to teaching high school aged students Newtonian physics could significantly increase motivation and attitude. The findings of the study also confirmed that students who received science instruction in a brain-based approach also received statistically significant increases in learning outcomes. Using a pre-and posttest quasi-experimental method, students were found to have a similar mean pretest score with the control group scoring a 6.52 and the experimental group scoring a 6.42 (Saleh, 2011). The control group posttest mean score was a 14.48, which represented a gain score of 7.76, while the experimental group posttest mean score was a 19.62, which represented a gain score of 13.20. An independent sample t-test was used to analyze the data confirming findings that a brain-based approach to learning complex science content significantly improved ($p < 0.05$) student learning outcomes (Saleh, 2011).

A more recent study conducted with ninth grade chemistry students supported the findings of Saleh (2011). Shabat and Al-Tarawneh proved the many brain-based strategies used with the experimental group increased student achievement. Some of these strategies included: increased interaction between students, establishing relationships between previous and new knowledge, using concept maps and charts, and brain-storming to activate prior knowledge (Shabat & Al-Tarawneh, 2016). Students were provided with opportunities to work in groups, use concept maps to link major and minor themes together, and activate prior knowledge using a chart called a KWL chart. A KWL chart is an acronym for a strategy that allows students to record what they already know or think they know, what they want to know and then what they have learned. This allowed students the opportunity to link previous and later knowledge together (Shabat & Al-Tarawneh, 2016).

Using a similar approach to Saleh (2011), Shabat and Al-Tarawneh (2016) randomly selected a total of 64 students in two classes for the study. One class was designated as the control group and received more traditional instruction in chemistry, while the other class was designated as the experimental group and received the brain-based teaching-learning program (Shabat & Al-Tarawneh, 2016). The experimental group that received the brain-based teaching/learning program outperformed the control group by one third standard deviation on the posttest ($p < .05$) (Shabat & Al-Tarawneh, 2016) corroborating Saleh's 2011 study findings.

Another study conducted in Turkey in 2008 looked at both student achievement as well as retention of science content. The randomized experimental study by Ozden and Gultekin (2008) investigated the effects of brain-based learning in a fifth-grade science course on both academic achievement as well as retention of previously acquired knowledge. Like the studies done by Saleh (2011) and Shabatat and Al-Tarawneh (2016), the researchers used true experimental methods to gather both pre and posttest data on students in fifth-grade science classes. The study was carried out with two intact classes selected at random by drawing lots. The experimental group received a brain-based learning approach and the control group received a more traditional approach.

Students receiving a brain-based learning approach were exposed to a variety of strategies based on the three fundamentals of brain-based learning: orchestrated immersion, relaxed alertness and active processing. During the orchestrated immersion phase, students were exposed to presentations, cartoons, comic strips and documentary films to help students grasp the information (Ozden & Gultekin, 2008). During the phase of relaxed alertness, students were placed in heterogeneous groups and encouraged to collaborate with one another (Ozden & Gultekin, 2008). In addition, students were encouraged to ask questions, discuss group work, and find multiple ways to represent learning concepts (Ozden & Gultekin, 2008). During active processing, students engaged in role play, simulations and dramatization techniques to ensure retention and application of new knowledge (Ozden & Gultekin, 2008).

The brain-based experimental learning group substantially outperformed the control group ($p < 0.05$). These findings corroborated the findings of other studies which also examined the effects of brain-based learning on student achievement and demonstrated a significant positive effect (Saleh, 2011; Shabatat & Al-Tarawneh, 2016). Unlike those studies, the study done by Ozden and Gultekin (2008) went one step farther and examined the retention level of science material learned during the study. After a three-week postponement period, a retention test was administered to both the control and experimental groups of students (Ozden & Gultekin, 2008). Results of this study found a significant difference between the control and experimental groups in favor of the group who received a brain-based learning approach (Ozden & Gultekin, 2008). This study corroborated the findings of other studies with regard to the positive effect brain-based learning has on academic achievement (Saleh, 2011; Shabatat & Al-Tarawneh, 2016).

Other studies refer to several brain-based strategies as being effective for increasing student achievement. The strategy of making connections was cited as having a positive effect on academic achievement (Ozden & Gultekin, 2008; Saleh, 2011; Shabatat & Al-Tarawneh, 2016) as well as using graphic organizers, concept maps, and KWL charts to determine what students know, want to know, and have learned (Dubinsky, Roehrig, and Varma, 2013; Samur and Duman, 2011). Similarly, studies that saw improved academic achievement in science also referred to using strategies aligned with brain-based learning where students were comfortable to take risks and were in a state of relaxed alertness (Saleh, 2011; Shabatat & Al-Tarawneh, 2016; Samur and Duman, 2011). Students had opportunities to work together and engage socially to solve problems and make connections to previous learning (Ozden and Gultekin, 2008; Saleh, 2011; Samur & Duman, 2011). These strategies, aligned with brain-based learning, support the theory that our brains are parallel processors that learn best when multiple areas are activated at once using a multisensory approach (Jensen, 2008a).

Learning English as a foreign language can be just as challenging for students as learning science content. Two studies conducted in Turkey examined the use of brain-based learning strategies on the performance of students in English class. Participants in the quantitative study conducted by Samur and Duman (2011) were high school students, and participants in the qualitative study conducted by Yagcioglu (2014) were university level students. Similar to previous studies, three main factors necessary for a classroom environment complementary to learning were identified: relaxed alertness, orchestrated immersion and active processing (Caine & Caine, 1994). Using true randomized experimental methods, Samur and Duman (2011) proved that students exposed to brain-based learning approaches outperform students in the control group in both student engagement and English language learning outcomes.

Studies on English acquisition in the high school and college setting concluded that a brain-based learning approach resulted in higher academic achievement. Samur and Duman (2011) conducted a randomized, true experimental study examining the scores on pre and posttest assessments. The treatment group received instruction in English that was designed in accordance with brain-based learning theory. The classroom environment was arranged to reduce the perception of threat, chunking learning into 10 to 15-minute blocks of time with breaks in between for the use of word games, puzzles, and short games to keep students engaged (Samur & Duman, 2011). Students were taught in an environment that was rich in visual aids, examples and non-examples, mind maps, and other graphic aids meant to increase student engagement and help make connections from previous learning to new learning (Samur & Duman, 2011).

Using the qualitative strategy of a case study, Yagcioglu (2014) examined the effect of a brain-based learning approach on university level students learning English as a second language. Yagcioglu (2014) found that students who learned English using a brain-based approach were more interested during class and enjoyed classes more than students who learned in a more traditional manner. While the student populations, sample sizes and methods of these studies differed, the results were similar.

Similar strategies were used in the qualitative study conducted by Yagcioglu (2014). The importance of this study is that it arrived at the same conclusion as Samur and Duman (2011) using a different method and a different student population. The students in the Yagcioglu (2014) study were college age and learning English as a second language. Yagcioglu (2014) wondered if brain-based learning could help to increase student motivation and outcomes for students who were learning English as a second language. As in the experimental study conducted by Samur and Duman (2011), participants were provided instruction in a classroom environment that included several strategies considered to be aligned with brain-based learning theory. For example, students were surveyed about their interests and then those answers were used to increase interest during lessons (Yagcioglu, 2014). Students in this study were also provided lessons that allowed for student collaboration and high levels of interest and engagement using games, skits, photos, and concept maps, as well as other visual aids (Yagcioglu, 2014).

Through observations and coding of student work, Yagcioglu (2014) found that students improved fluency and accuracy in speaking English. Students who received a brain-based learning approach also increased their ability to learn and retain new vocabulary (Yagcioglu, 2014). Findings also showed that students enjoyed the activities and were more engaged and interested during classes (Yagcioglu, 2014). The qualitative data collected by Yagcioglu (2014) concurred with the quantitative findings of Samur and Duman (2011) in that there was a significant increase in student learning that could be attributed to the implementation of brain-based teaching and learning strategies. Yagcioglu (2014) provided a different perspective in that the data described students' personal feelings during the study providing a richer description of student attitudes toward learning in a brain-based classroom.

Studies regarding the impact of brain-based learning on student achievement support the conclusion that brain-based teaching strategies can have a significant impact on student learning outcomes (Duman, 2010a, 2010b; Neve et al., 1986; Saleh, 2011; Samur & Duman, 2011; Shabatat & Al-Tarawneh, 2016; Yagcioglu, 2014). Regardless of the age of students or the content, brain-based learning can in fact increase student motivation and attitude toward learning as well as increase academic achievement. A meta-analysis on the effect of brain-based learning on academic achievement by Gozuyesil and Dikici, (2014) supported those findings. The results of the analysis suggested that brain-based learning leads to greater academic achievement than more traditional teaching methods.

The meta-analysis study consisted of 31 studies. Studies were contributed from Turkey (19), USA (9), Taiwan (1), Pakistan (1), and Malaysia (1). According to the meta-analysis, 83.34% of the studies indicated that the effectiveness of brain-based learning was positive (Gozuyesil & Dikici, 2014). According to the random effects model, data yielded the standard error of 0.110 with 95% confidence and an effect size of 0.649 (Gozuyesil & Dikici, 2014). The data led to the conclusion that brain-based learning has a positive effect on the academic achievement of K-12 students regardless of gender, age, or nationality (Gozuyesil & Dikici, 2014). These findings indicate that brain-based learning theory can inform educational practice.

How Brain-Based Learning Research Can Inform Education

Based on the available studies on attitude, motivation, and academic achievement, it seems evident that a brain-based learning approach can inform educational practice. Studies showed that when brain-based learning principles outlined by Caine and Caine (1994) and Jensen (2008a) were put into practice, classroom climate improved which led to increased academic achievement. Studies often referred to specific strategies that were used to create a brain-based learning environment. Most referenced the three main factors of relaxed alertness, orchestrated immersion, and active processing.

When there is a desire to create a state of relaxed alertness, consideration needs to be given to specific factors. For example, in order to create a state of relaxed alertness, the classroom should provide a low threat, high challenge environment (Jensen, 2008). Studies exploring the impact of brain-based learning referred to strategies such as playing classical music, allowing students to ask questions and collaborate, and making instruction personal and meaningful (Duman, 2010b; Dubinsky, 2013; Saleh, 2011; Samur & Duman, 2011). Relaxed alertness allows for an optimal state of learning to occur and is slightly different for each student.

Studies also refer to strategies that engage the entire physiology, such as visual aids, scent, collaboration, movement, discussion, and song (Akyurek & Afacan, 2013; Duman, 2010b; Gabriel, 1999; Mullender-Wijnsma et al., 2015). This concept relates to orchestrated immersion. One such study found that classrooms that were scented with pleasant fragrances had a positive effect on student learning (Gabriel, 1999). This could imply that using a mild, pleasant scent, like chocolate or baby powder, and engaging the olfactory sense could increase mood and enhance the learning environment. Jensen (2008a) suggests that smell is typically underutilized in the learning environment. Jensen also suggests that using scents like peppermint, basil, lemon or cinnamon can enhance mental awareness, while other scents such as lavender, orange or rose can be calming (2008).

Other studies referred to the link between motion and learning (Mullender-Wijnsma et al., 2015). Educational benefits of physical activity are derived in part from brain-based theory. Medina (2014) described physical movement as “cognitive candy” (p. 31). When humans engage in any form of exercise, a mood enhancing neurotransmitter is released, which has been shown to enhance the production of new cells in the brain (Jensen, 2008a). Studies like the one done with American third grade students (Mullender-Wijnsma et al., 2015) seem to support those findings. Students in the one-year study who received the physical intervention program scored higher on both mathematics and reading assessments in comparison with the control group who did not receive the intervention (Mullender-Wijnsma et al., 2015). This study along with others (Donnelly & Lambourne, 2011; Sattelmair & Ratey, 2009; Shephard & Trudeau, 2005) support the mind-body connection and the importance of engaging students in physical activity throughout the school day.

Studies also frequently refer to active processing when employing a brain-based teaching approach. Caine & Caine (1994) describe this as the focus on meaningful learning, as opposed to rote memorization of facts. Medina (2008) stated this concept in simple terms, writing that humans do not pay attention to boring things. In order to maintain student attention and engagement, studies using brain-based learning engaged students in periods of direct instruction roughly ten to 15 minutes long, followed by periods of hands-on practice, collaborative problem-solving or small group work (Akyurek & Afacan, 2013; Mullender-Wijnsma et al., 2015; Ozden & Gultekin, 2008; Saleh, 2011). These strategies along with others like questioning, connecting with the content and making personal analogies enhance active processing (Tokuhama-Espinosa, 2011).

While brain-based learning is not intended to provide a cookbook approach to teaching and learning, it can inform educational practice. This has led some researchers to question what is currently being done in the field that is aligned with brain-based learning and how teachers generally feel about the potential benefits of neuroscience to inform education (Duman, 2010a; Jensen, 2008; Kayalar & Ari, 2016; Serpati & Loughan, 2012). Studies have also been done on possible models of teacher education programs in relation to applying the concepts of neuroscience to teaching practice (Dubinsky et al., 2013).

Brain-Based Learning and Teacher Education

Brain-based learning was originally intended to inform the education of school-aged students, and it is evident through a review of the empirical literature that it can provide a framework to enhance student achievement. But, how do teachers feel about the combination of neuroscience and education? There are some who have taken brain-based theory and applied it to research the effect of a brain-based learning approach with pre and in-service teachers. The next series of studies sought to understand teacher attitudes toward brain-based learning as well as explore the effectiveness of a brain-based teaching approach when used with pre and in-service teachers. (Dubinsky et al., 2013; Duman, 2010a; Kayalar & Ari, 2016; Serpati & Loughan, 2012).

Attitudes and beliefs about teaching and learning are developed early. Teacher preparation programs can have a profound influence on how new teachers perceive learning and in turn, how they learn to design and implement instruction. Studies conducted with pre-service teachers found that their attitudes toward brain-based learning were positive (Duman, 2010a; Kayalar & Ari, 2016). Duman (2010a) conducted a true experimental study in which he presented material on measurement and evaluation with pre-service teachers at a university in Turkey. Students were randomly divided into two groups, in which one group served as an experimental group and received a brain-based learning approach and the other group served as a control group and received instruction in a more traditional lecture approach (Duman, 2010a).

The purpose of the Duman (2010a) study was to investigate the effects of a brain-based learning approach on the achievement and attitudes of student teachers. For this reason, Duman (2010a) chose to conduct a mixed method approach to gather richer information about how students felt regarding the brain-based approach and were used to support the quantitative data. In addition to pre and posttests which compared the academic achievement of the students with the material on measurement and evaluation, students were also asked questions about how they felt during the learning process (Duman, 2010a). Duman (2010a) found that students who were taught the same content with a brain-based teaching approach had a statistically significant increase in academic achievement scores on the posttest, even though the pretest scores were not significantly higher than peers in the control group. Results of the qualitative study demonstrated that students felt relaxed and supported allowing them to engage more deeply with the content (Duman, 2010a). In addition, Duman also found that throughout the brain-based learning activities in class, students were active participants and asked more questions than peers in the control group (2010a). Duman (2010a) stated that the findings of this study could potentially inform future teacher preparation courses. Duman (2010a) suggested that study findings can be used to design different courses in the field of education in order to increase participation, engagement, and student learning outcomes.

Pre-service teachers can be more impressionable because of a lack of experience. Teachers with years of experience can be more difficult to persuade. Serpati and Loughan (2012) surveyed 221 US teachers using a Likert scale as well as open-ended questions to ascertain the attitudes of in-service teachers toward the collaboration of neuroscience and education. Specifically, Serpati and Loughan (2012) aimed to directly address claims mentioned in theoretical literature, such as a high level of teacher enthusiasm for the role of neuroscience in education, or that an understanding of the brain for educational program development is important. To do this, Serpati and Loughan (2012) developed a questionnaire designed to identify what teachers regard as beneficial in neuroeducation. Serpati and Loughan (2012) then identified free-response questions regarding what teachers considered beneficial about brain-based learning and explored teachers' experiences and opinions on how brain research could assist classroom practice.

The responses were overwhelmingly positive and could even be described as enthusiastic. Serapti and Loughan (2012) reported that 94% of teachers surveyed agreed it is important for teachers to understand the neurological foundations of learning and cognition as well as behavior. Other data gathered from coding for themes revealed that teachers generally agreed that brain-based learning (or neuroeducation) has potential and is worth pursuing (Serpati & Loughan, 2012). Teachers in the study also rated relevance to the classroom and information accessibility high in terms of importance to the application of neuroscience in education (Serpati & Loughan, 2012). Study participants were also interested in finding out what common teaching practices should be eliminated and how teacher behaviors could affect the neurobiology and neuropsychology of students (Serpati & Loughan, 2012). The Serpati and Loughan (2012) study corroborated claims in the literature that brain-based learning not only has the potential to influence and improve instruction, but also has the acceptance of teachers who seem enthusiastic about the possibilities of brain-based learning.

A different qualitative study done with in-service teachers in Turkey yielded similar results. The study was conducted to determine and interpret teachers' views of brain-based teaching methods used in classrooms (Kayalar & Ari, 2016). The 27 middle and high school teachers in the Turkish study were all language instructors who used brain-based teaching to some degree (Kayalar & Ari, 2016). When asked through interviews about brain-based learning strategies applied in their classrooms, themes emerged. One theme was in the creation of environments where students were encouraged to collaborate and express ideas without fear of criticism by the teacher or peers (Kayalar & Ari, 2016). This theme demonstrated teacher awareness of creating classroom environments that support relaxed alertness, a key condition for brain-based learning to occur.

Another theme that emerged from the Kayalar and Ari (2016) study regarded the use of orchestrated immersion in the acquisition of language. Teachers interviewed shared that students who try to memorize vocabulary in isolation often make many mistakes when trying to use those words in conversation (Kayalar & Ari, 2016). Teachers who participated in the survey also shared that the classrooms were structured to immerse students in learning language through meaningful content, visual supports, examples and contextual application of new vocabulary (Kayalar & Ari, 2016).

The Kayalar and Ari (2016) study corroborated the findings of Serpati and Loughan (2012) in that teachers saw value in creating classroom environments that applied brain-based learning strategies. Although the teachers were in different countries, all had opinions about the potential for neuroeducation to positively effect student learning. Like Duman (2010a), teachers in the Kayalar and Ari (2016) study reported a positive correlation between teacher attitudes and motivation and the use of brain-based learning strategies. These findings could lead to the development of brain-based teacher training programs that may impact practice and increase collaboration between the fields of neuroscience and education.

Some researchers wonder if the gap between neuroscience and the field of education is still too wide to traverse. Twenty years ago, Bruer (1997) argued that the bridge between neuroscience and education was too far to join and suggested that an alternate route be established through the field of cognitive psychology. This appears to continue to be a sound strategy. Hovarth and Donoghue (2016) recently revisited Bruer's argument while offering their own ideas about how to close the gap. Hovarth and Donoghue (2016) suggested that all brain research must be behaviorally translated before educational methods can be applied. Dubinsky et al. (2013) and her colleagues suggest another route connecting the field of neuroscience and education. Dubinsky et al. (2013) proposes using the neurobiology of learning, specifically plasticity, to transform teacher preparation and teacher professional development.

The goal of professional development is to change the practice of teachers, and to ultimately improve student learning. The case study of Brain U, a summer professional development workshop designed for middle and high school science teachers, explored the efficacy of neuroscience concepts in transforming teacher practice (Dubinsky et al., 2013). The goal of Brain U was to change the way teachers think about learning by immersing teachers in learning that aligned with brain-based learning practices.

Educators who participated in the study were found to be more aware of how their behaviors could change student brains. Teachers indicated that they were more likely to change their teaching strategies to incorporate more active, student-centered lessons (Dubinsky et al., 2013). Teachers also shared that gaining an understanding of the intricate biological system of the brain allowed them to have more positive attitudes toward their students' abilities to change and learn (Dubinsky et al., 2013). Attitudes toward teaching and learning appeared to improve as teachers learned more about the human brain through neuroscience education, corroborating the findings of Serpati & Loughan (2013).

The Brain U case study demonstrated several positive outcomes. Not only were teacher attitudes improved in the study (Dubinsky et al., 2013), but student attitudes also reflected a positive change. Learning about neuroscience concepts as they relate to teaching not only increased teacher confidence, but also had the effect of transforming pedagogy and views on student learning (Dubinsky et al., 2013). Teachers and students in the study also reported increased metacognition and understanding of their role in the learning process (Dubinsky et al., 2013). Brain U could not be successful without the partnership and true collaboration of both educators and neuroscientists. The Brain U case study provides a successful model for the potential collaboration of the fields of neuroscience and education. Brain U also demonstrated the potential to improve teaching and learning for preservice and in-service teachers alike.

Overall, teachers were found to be open and generally enthusiastic about brain-based learning and neuroeducation. Attitudes toward the potential for science and research to inform the field and potentially improve teaching and learning were positive and reflected a tone of optimism. While there is not necessarily agreement about how much teachers need to know to effectively deliver instruction, there is agreement in the empirical literature that at least some benefit is highly likely when educators become aware of brain-based learning and the basic underpinnings of neuroscience as it applies to learning (Dubinsky et al., 2013).

Gaps in the Literature

There were some noticeable gaps in the literature on brain-based learning and educational implications. All of the studies reviewed focused primarily on the effects of brain-based learning on attitudes, motivation, and academic achievement using quantitative methods to obtain data. As suggested by Akyurek and Afacan (2013) the number of studies in brain-based learning is limited worldwide, however the research available proved that a brain-based learning approach had a positive impact on student achievement and increased student motivation and attitudes toward learning (Duman, 2010a; Saleh, 2011).

There are few qualitative studies on brain-based learning. Qualitative studies primarily focused on examining the attitudes and motivation of teachers using a brain-based approach to learning. Given the potential to improve educational outcomes, a question regarding the failure of the educational field to research the possible effects of brain-based learning in the classroom still looms. There are even fewer studies regarding professional development models that could be useful in training educators in neuroscience, even though teachers have a high level of interest in learning about brain-based learning, according to Sperpati and Loughan (2012). Randomized, experimental studies could help determine which professional development models are improving teaching and learning outcomes.

The literature primarily included studies conducted with middle school, high school and college level students. Of all the studies located for the literature review, only one was conducted with elementary level students. There was a noticeable gap in the literature regarding the age of students included in studies, as elementary students were underrepresented in the available literature.

The literature is also lacking in studies that investigate how brain-based learning is being used in the general education setting and what strategies teachers are using. This information would be helpful in knowing what next steps may be necessary to help bridge the gap between the fields of neuroscience and education. This information could also potentially inform teacher training programs and school instruction and curriculums.

Chapter Summary

Although brain-based learning theory emerged over 30 years ago, it is still considered recent, especially compared to its predecessors in the field of psychology. Neuroscience is also a relatively new, and growing, science field since advances in medical neuroimaging technology provided a window into a living, active brain. Because of these technological advances, much has been learned regarding the structure and function of the human brain. The neurobiological research has also helped provide evidence to support psychological theories which up to now could only be observed through human behavior.

Neuroscience has also been thought to have implications to education. Studies conducted on student motivation and attitudes find that there is a statistically significant improvement in students who learn using a brain-based learning approach compared to students who learn using a more traditional approach. Likewise, findings on academic achievement have also shown statistically significant results. Students who were given instruction in difficult science content or a foreign language using a brain-based learning approach scored consistently better than peers who received instruction in the same content using a more traditional approach.

Moreover, one study by Ozden and Gultekin (2008) took the findings on academic achievement with fifth grade students one step farther. In addition to examining the effect of brain-based learning on academic achievement, Ozden and Gultekin (2008) retested the students in the study after a three-week postponement period to examine the rate of retention. The study findings also suggested that in addition to increasing academic achievement, a brain-based approach can also significantly increase retention.

Qualitative studies provided the literature with information about how students felt as they engaged in a brain-based learning process. Qualitative student data regarding motivation and attitudes revealed that students felt engaged in the learning process, and used words like "enjoyable" to describe the experience (Duman, 2010a). Findings in the qualitative studies also emphasized that students felt learning was meaningful and challenging, but not threatening (Saleh, 2011). Students were observed to be more relaxed and more willing to take risks with their learning in the groups who received a brain-based learning approach, compared to the control groups.

There is a need to continue to explore the effects of brain-based learning on academic achievement across grade levels. Further research is also suggested on the effects of brain-based learning on critical thinking, problem solving, emotional management, and attitudes toward cooperative group work (Ozden & Gultekin, 2008). In addition, Samur and Duman (2011) recommended that a qualitative data analysis describing the brain-based learning classroom could add to the existing body of literature. Brain-based learning could be the bridge that links neuroscience and education.

Chapter 2 provided a comprehensive examination of the literature regarding the impact of brain-based learning strategies on attitudes, motivation, and academic achievement. Chapter 3 will describe the research design methodology for the study. In addition to describing the research context and participants, Chapter 3 will also discuss the research methods, instruments and how data were collected and analyzed.

Chapter 3: Research Design Methodology

Introduction

This chapter describes the research design for the study, explaining the rationale for the research model selection. The chapter then defines the criteria for the research context and describes the research participants and how they were selected. Last, the chapter describes how the data were collected and analyzed along with procedures for data collection.

Qualitative research is described in the literature as having an emphasis on some lived experience the researcher plans to explore. Creswell and Poth (2018) describe qualitative research as a philosophical discussion about the lived experiences of individuals. Researchers who choose qualitative methods seek to gain a better understanding of the lived experiences of participants around a particular topic. A qualitative research methodology was chosen for the study because it allowed for the investigation into what elementary teachers know about brain-based learning, how teachers at the elementary level knowingly or unknowingly apply brain-based learning theory into their lessons, and to what extent brain-based learning is a part of teacher training programs. In addition, qualitative research allowed the researcher to study the research problem in the context in which it naturally occurs.

The aim of the qualitative research approach is to understand the lived experience as it relates to the research problem. Creswell (2014) described qualitative research as interpretive research, where the researcher is involved in a "sustained and intensive experience with participants" (p. 187). The researcher grounds herself with the research problem and a main research question or questions. The problem identified is a disconnect between proven instructional practices aligned with how the brain naturally learns, and more traditional practices which are aligned with standardized assessments.

The research questions for the dissertation study were:

1. What do current elementary teachers know about brain-based teaching strategies?
2. How are elementary teachers knowingly and unknowingly applying brain-based learning theory to their lessons?
3. To what extent is brain-based learning theory part of the curriculum in Western County, New York elementary teacher preparation programs?

The motivation to choose a qualitative research approach was derived from the research questions. The literature contains several quantitative studies that demonstrate brain-based teaching strategies are effective at improving student motivation and attitudes toward learning as well as increase academic achievement. Therefore, the research questions for the study sought to explore the experiences of elementary teachers with the planning and application of brain-based teaching strategies in the classroom. Qualitative research methods allowed for the use of semi-structured interviews to investigate the extent to which teachers were knowingly or unknowingly applying brain-based learning theory and strategies in their lessons, how they learned about brain-based learning theory and strategies, and the extent to which that knowledge was obtained from a teacher training program.

Research Context

The research study examined the educational practices of elementary teachers in suburban districts as they relate to brain-based learning theory. The qualitative research was conducted with seven general education elementary teachers in an area of New York State that will be referred to in this dissertation as Western County. Western County has a population of about 747,000 residents (US Census Bureau, 2016). About 117,000 of those residents are between the ages of 5-17 and can be described as school-aged (US Census Bureau, 2016). The median household income in 2016 was $52,553, and 11% of households were below the poverty level (US Census Bureau, 2016). Western County is home to 20 K-12 school districts ranging in size and covering rural, suburban, and urban areas (NYS Department of Education, 2016). According to the New York State Department of Education (2013), 24% of students served in Western County public schools are African American, 11% are Hispanic, 59% are White, and 6% are other or mixed race.

In addition to teacher interviews, the study also included a total of four faculty members from public and private colleges in the same area of Western County to examine the extent to which teachers learn about the implementation of brain-based strategies in teacher preparation programs. The Western County region is also home to over 21 colleges and universities which serve over 110,500 students (The State University of New York [SUNY]). These colleges and universities are both private and public. Public colleges in New York had a total enrollment over 436,000 in the fall of 2016 (SUNY). Private colleges in New York range in enrollment between 2,800 and 15,000 (National Center for Education Statistics, 2016). These colleges and universities serve a student body that ranges between 48% and 84% White (National Center for Education Statistics, 2016). The private colleges and universities offer a range of undergraduate and graduate programs (National Center for Education Statistics, 2016).

Ethics and Confidentiality Considerations

Approval for the study was obtained from the Institutional Review Board at St. John Fisher College prior to the research. Permission was also obtained from the intermediate educational unit which provides services to the teachers who will volunteer for the study. The researcher completed the National Institute of Health's Protecting of Human Research Participants online training prior to conducting the study. Participants were informed of the study purpose, confidentiality, rights, and data collection methods. Participant names and identifying information remain confidential and do not appear on any transcripts, analysis or on the final study. Participant confidentiality was maintained throughout the research process by assigning pseudonyms to participants, schools and universities. When not in use, transcripts, recordings and all related interview documents were secured on a password protected hard drive in an office and were placed in a locked file. All research materials will be kept there for at least 3 years after completion of the study and the successful defense of the dissertation, after which they will be destroyed.

Research Participants

Permission to conduct the study was verified by the intermediate education unit, pending IRB approval. The purpose of the study was presented to school administrators in the Western County area by the shared assistant superintendent. Elementary school administrators were asked to share the purpose of the study as well as the name and contact information of this researcher with potential teacher participants. Research participants were asked to directly contact the researcher if they were interested in participating in the study. After the researcher obtained a list of possible teacher volunteers, those teachers from suburban elementary schools in the Western County area of New York State were invited to participate via email using an introduction letter (Appendix B). A consent form (Appendix F) explained the study purpose and participant rights as well as the risks and benefits of participating in the study. The study included elementary teachers at both the primary and intermediate levels representing a mix of suburban districts to ensure equity. The study included interviews with seven elementary teacher volunteers. Neither participants' gender nor years of experience were considered for exclusion from the study. Next, college faculty research participants were secured.

After examining college websites, faculty who met the inclusion criteria were invited to participate in the study via email (Appendix E) in the hopes of obtaining at least three to four volunteers. Faculty from both public and private colleges that offer teacher preparation programs in the same geographic area as the elementary school teacher volunteers were invited to participate. A qualitative method using semi-structured interviews was conducted with faculty volunteers to determine the extent to which brain-based learning theory is incorporated into teacher training programs. A consent form (Appendix F) explained the study purpose and participant rights as well as the risks and benefits of participating in the study. Participants at the college level were considered for the study based on their direct affiliation with teacher training programs.

The researcher has a preexisting relationship with the schools in rural and suburban areas of Western County which allowed for better access to the research participants. Participants were solicited based on suggestions from their administrators.

Once a list of potential participants was generated, participants were contacted via email in which the study purpose was identified. Once participants were identified, they were contacted by the researcher to set up a time and location to conduct an interview (Appendices D and E). As part of the interview process, elementary teacher participants were asked to bring a lesson plan that incorporated multiple modalities of teaching and learning. Upon completing the interview, volunteers received a small gift card in appreciation of their time.

Researcher Connection and Field Notes

The researcher is considered the primary instrument in a qualitative study. Creswell (2014) emphasizes the need to clarify the bias that researcher may bring to a qualitative study. The researcher for the study is an educator with almost 25 years of experience in both general and special education. This experience and perspective allowed the researcher to bring a wealth of knowledge to the study, helping to understand and interpret study findings. The practice of using field notes was employed as a tool to help explore and examine the researcher's thoughts and feelings about the study and the developing themes (Saldana, 2016). The researcher's role is essential to a qualitative study. The facilitation of interviews is important, and the researcher's observations, reflections, and analysis of data are also essential to the research process.

Instruments Used in Data Collection

The primary purpose of the study is to investigate the extent to which teachers are aware of brain-based learning theory and are applying the concepts of the theory in planning and teaching practices. The secondary focus of the study was to examine the extent to which teachers are learning about brain-based learning theory in teacher preparation programs. The use of a semi-structured qualitative interviewing technique allowed the researcher to have a two-way conversation with both the teacher and faculty participants.

According to Creswell and Poth (2018), the researcher is the primary instrument for a qualitative study. The researcher developed semi-structured interview questions to address the primary focus of the study which is to explore the experience of elementary teacher participants with planning and implementing brain-based teaching and learning. Interview questions were developed using the framework of brain-based learning theory provided by Caine and Caine (1994) combined with Jensen's (2008) seven stages of brain-based planning. Caine and Caine's 12 principles provide a more holistic overview of brain-based learning, while Jensen's seven stages of brain-based planning provide a more specific framework to examine the planning process. Semi-structured interview questions were also developed to address the secondary focus of the study, which was to determine the extent to which brain-based learning is incorporated into teacher training programs. Interview questions regarding the content and curricula of teacher preparation programs also used Caine and Caine's 12 principles of brain-based learning and Jensen's seven stages of brain-based planning as a framework.

After obtaining permission and consent, potential research participants were contacted via phone or email and invited to participate in semi-structured, face-to-face interviews. The interviews took place in a mutually agreed upon location, and 60 minutes were allotted for each interview. The researcher obtained audio recordings of the interviews using a handheld digital voice recording device. Teachers were invited to bring lesson plans for review by the researcher during the interview as possible evidence of brain-based learning implementation in planning practice. The researcher also maintained field notes during the interview process to provide meaning and understanding of the interviews after the interview process. A preliminary analysis of the field notes fostered self-reflection and revealed emergent themes. Each participant was assigned a pseudonym to ensure confidentiality after which the recordings were submitted for transcription.

Before the questions began, the researcher reviewed the brain-based learning handouts with teachers and faculty members. The first handout outlined Caine and Caine's 12 principles of brain-based learning (Appendix A) providing some background and context on brain-based learning for the interview participants. The second handout outlined Jensen's seven stages of brain-based planning (Appendix G) and provides examples of what may happen at each stage. The handouts served as a reference to familiarize participants with brain-based teaching and planning before the beginning questions. During the interviews, the handouts were referenced to help teacher participants make connections between which methods are being used during planning and implementing lessons that align with brain-based learning theory. The handouts were also referenced during faculty interviews to help define Jensen's brain-based planning stages and provide examples that potentially helped faculty connect courses and pedagogy with brain-based learning theory.

To ensure confidentiality all consent was voluntary and research participants were informed of their rights to end participation at any time during the interview. Participant names and identifying information will remain confidential and do not appear on transcripts, analysis or on the final study.

Data Analysis

Each interview was listened to multiple times and compared to the field notes taken during the interview to ensure consistency. Transcriptions were used for coding purposes. First, grounded in the theoretical framework of brain-based learning, a priori codes were developed by the researcher to examine the extent to which elementary teachers are knowingly or unknowingly implementing brain-based learning strategies. Data were then coded a second time using a process of open coding as outlined by Saldana (2016). The researcher allowed categories to emerge without the constraints of predetermined categories during the second coding process to determine emergent themes that may have been missed the first time. Once the data were coded, the data were analyzed for themes (Saldana, 2016). A process for member checking was used with participants. Member checking helped to clarify any questions from the transcripts (Creswell, 2014).

Part of the interview process included a review of lesson planning documents provided by participants. Lesson plans were examined and referred to during the interviews to provide evidence of elements aligned with brain-based learning and Jensen's seven stages of brain-based planning. Teacher participants were occasionally asked to refer to the lesson plan during the conversation to provide examples of brain-based strategies that were either knowingly or unknowingly aligned to brain-based learning theory. A priori coding was used to analyze the lesson planning documents after the interviews to enhance the qualitative interview data.

Qualitative data collected from college faculty semi-structured interviews were also recorded and transcribed. Data were then coded using the same open coding techniques that were used with teacher interview data. Data were then analyzed for themes as the researcher investigated the extent to which teacher preparation programs incorporate brain-based learning theory into the curriculum.

Peer debriefing was used to enhance the accuracy of the qualitative data. A peer was asked to code the data to ensure interrater reliability. According to Creswell and Poth (2018), the term *reliability* often refers to the constancy of responses of multiple coders in qualitative research. To ensure that the themes developed aligned with the study once the data was collected, a peer was asked to code the data with the researcher to provide interrater reliability. This strategy added validity to a qualitative study (Creswell, 2014). After saturation was achieved, a narrative was produced to describe the researcher's interpretation of the data analysis as it pertains to the research questions.

Procedures

1. Verified permission to conduct the study at the intermediate educational unit, pending IRB approval.
2. Obtained permission for the study from Institutional Review Board at St. John Fisher College.
3. Obtained names and contact information of potential participants from Western County school district administrators.
4. Invited prospective participants via email communication utilizing Appendices D and E.
5. Communicated with prospective participants by telephone or email, as preferred by participants, to confirm date, time and location of interview.
6. Obtained informed consent from participants utilizing Appendix F.

7. Conducted in-person interviews with participants using teacher interview protocol outlined in Appendices B and C.
8. Peer coding process was used to ensure interrater reliability.
9. Completed data analysis.

Summary

Research studies show that brain-based learning strategies are significantly effective in increasing student motivation, attitudes toward learning and academic achievement. This research study utilized a qualitative approach to investigate what participants know about brain-based strategies, how participants gained that knowledge, and to what extent those strategies are used in planning and practice. Interview data were collected with a recording device, and transcribed. Teacher interview transcriptions were coded using an a priori coding process and faculty interview transcriptions were coded using an open coding process. The data were then analyzed for themes to better understand what brain-based strategies were being implemented in elementary classrooms in Western County. Lesson plans were reviewed during the interview and referred to as written evidence to support the qualitative interview data.

Qualitative data collected from college faculty interviews were recorded, transcribed, and then coded using open coding technique. Data were analyzed for themes as the researcher investigated the extent to which teacher preparation programs incorporated brain-based learning theory into the curriculum. After saturation was achieved, a narrative was produced to describe the researcher's interpretation of the data analysis as it pertained to the research questions. Chapter 4 will provide a review of the study results, including a description of the themes that emerged during the data analysis process.

Chapter 4: Results

Introduction

Teaching and learning strategies that are aligned with brain-based learning theory have been shown to increase student motivation, improve attitudes toward learning, and increase student learning outcomes (Ozden & Gultekin, 2008; Saleh, 2011; Shabatat & Al-Tarawneh, 2016). It is unclear to what extent pedagogical practices in a typical elementary classroom are aligned with brain-based learning theory. Therefore, this qualitative study was designed to investigate what strategies elementary teachers are either knowingly or unknowingly implementing in a typical classroom setting that align with brain-based learning theory, and how they came to use those strategies. The research questions investigated by the study were:

1. What do current elementary teachers know about brain-based teaching strategies?
2. How are elementary teachers knowingly or unknowingly applying brain-based learning theory to their lessons?
3. To what extent is brain-based learning theory part of the curriculum in Western County, New York elementary teacher preparation programs?

Data Analysis and Findings

This section includes a demographic summary of study participants as well as a description of the data collection process. In addition, the section provides a summary of the themes that emerged through the process of data analysis. Findings are arranged by research question and the corresponding themes.

Demographic Summary

Data for this study were collected using a semi-structured interview process. Seven elementary teachers were interviewed to obtain the answers to all three research questions. All seven elementary teacher participants were located in suburban school districts in Western County, New York. Four higher education faculty associated with schools of education were interviewed using a semi-structured interview process to obtain the answer to research question three. All relevant participant demographic information is included in Table 4.1.

Each elementary teacher participated in a face-to-face, semi-structured interview using an interview protocol (Appendix B) to guide the interview process. Each teacher was introduced to the concepts of brain-based learning theory using a summary of the 12 principals of brain-based learning (Appendix A) and the seven stages of brain-based planning (Appendix G). These appendices helped to provide some background and context for teacher participants before they were asked the interview questions. Using a similar process, each participant from a higher education faculty participated in a face-to-face, semi-structured interview using an interview protocol (Appendix C) to guide the data collection process. Each higher education faculty participant was introduced to the concepts of brain-based learning employing the handouts outlining the 12 principles of brain-based learning and the seven stages of brain-based planning (Appendices A and G) and using the same process as the teacher participants.

During the interviews, two recording devices were used to ensure that all of the responses were captured. Recordings were saved on a password protected hard drive and then sent to a transcription service. Transcripts were also saved to a password protected hard drive so that they could later be printed for coding purposes. When not in use, printed transcripts were placed in a locked file cabinet. In addition to transcriptions of interviews, lesson plans were collected and reviewed. In an effort to triangulate the data collection, the researcher also used field notes to capture the moods and more subtle aspects of the conversations not captured by the recordings.

Data analysis used a combination of both a priori coding and open coding methods. A priori codes were developed for research questions 1 and 2, and an open coding process was utilized for research question 3, as there were no appropriate a priori codes. The transcripts were read several times and the recordings were reviewed several times. Once saturation was achieved, codes were analyzed to develop themes for each research question.

Table 4.1

Research Participants

Pseudonym	Grade Level	Background Information
Gail	Kindergarten	Veteran primary teacher who had more than ten years of experience teaching kindergarten and over 20 years of teaching experience at the elementary level.
Anne	Grade 2	Young teacher with less than 10years of experience. Anne was organized, with a very tidy room and a clearly designated place for everything. Anne spoke with enthusiasm about her classroom.
Julie	Grade 5	Veteran teacher with over 25 years of experience. Julie was trained in brain-based learning and teaching strategies and was purposefully planning for their implementation in her lessons.

Pseudonym	Grade Level	Background Information
Jamie	Grade 4	Veteran teacher with over 20 years of experience in elementary education. Jamie's room was full of furniture and educational materials. The shelving was overflowing, every free spot of wall space was covered and there were stacks of materials and books around the room. Jamie did not have a lesson plan to provide for the interview, nor did she use any type of lesson planning book.
Marlea	Grade 3	Marlea had less than ten years of experience teaching. She was very organized and purposeful in her planning. She had a place for everything and could explain why she had arranged the room in that manner. She was very thorough in her explanations of which strategies she used and why she had chosen them.
Alexandra (Alex)	Grade 4	Alex was a veteran teacher with almost 30 years of experience. She defined herself as a traditional teacher and spoke of her experiences co-teaching with a colleague who employed strategies that were more in line with brain-based learning as making her uncomfortable.
Sue	Grade 5	Sue was a veteran teacher who stated that she was very unsure about brain-based learning. She described engaging students in many activities that could be considered brain-based but stated that she had no real experience with the terminology.
Jenna	Higher Ed	Jenna was a faculty member of a private institution of higher education. She was one of the education department heads and was very well-versed in brain-based learning theory and its application to teaching and learning as she described the many ways she incorporated strategies into her teaching.
Melanie	Higher Ed	Melanie was a faculty member of a public institution of higher education. She was faculty in the school of education and primarily taught reading instruction to undergraduate and graduate students. Melanie shared that she had little experience or knowledge of brain-based learning.
Catherine	Higher Ed	Catherine was a faculty member of a private institute of higher education. She had received a master's degree in Mind, Brain and Education (MBE) from Harvard University, and was well-versed in the topic of brain-based teaching and learning strategies.
Marlene	Higher Ed	Marlene was a faculty member of a private institute of higher education. She stated that she had little experience with the terminology of brain-based learning but did articulate where some of the concepts were applied to the teaching of reading instruction.

Note. Table 4.1 contains the pseudonyms, grade level or affiliation with an institute of higher education, and some background knowledge regarding their experiences with brain-based teaching and learning, as well as the researcher's impressions of the participants.

In Table 4.1, the research participants are listed and described briefly. The first section of the table describes the elementary teacher participants. All grade levels except first were represented by the teacher participants. The second portion of the table describes the higher education faculty participants. Two of the four higher education faculty were familiar with the concepts and terminology of brain-based learning theory and were able to discuss how they implemented brain-based learning theory and strategies into the existing teacher preparation curriculum. Research participants participated in interviews for the qualitative study.

The present qualitative study used a semi-structured interview research process to gather research data from eleven participants. After data were collected, a combination of both a priori and open coding processes were used to analyze the interview transcripts. Themes were developed for each research question once coding was completed. The findings are reported in the next section.

Findings

The research sought to answer three research questions by analyzing qualitative data for themes. The first research question sought to understand what current elementary teachers know about brain-based teaching strategies. After completing the data analysis process, three themes emerged: *teaching the whole child, engaging in different ways,* and *a home away from home*. The second research question sought to discover how elementary teachers were knowingly or unknowingly applying brain-based learning strategies to their lessons. Four themes emerged during the data analysis process: *setting the stage, priming the pump, making it meaningful, making it stick.* Research question three sought to understand to what extent brain-based learning theory was part of teacher preparation programs in the Western County area. Two themes emerged during data analysis: *I don't remember learning this* and *retrofitting the existing curriculum*.

Table 4.2

Research Questions and Themes

	Research Question 1: What do current elementary teachers know about brain-based teaching strategies?	Research Question 2: How are elementary teachers knowingly or unknowingly applying brain-based learning theory to their lessons?	Research Question 3: To what extent is brain-based learning theory part of the curriculum of Western County, New York elementary teacher preparation programs?
Theme 1	Teaching the whole child	Setting the stage	I don't remember learning this
Theme 2	Engaging in different ways	Priming the pump	Retrofitting the existing curriculum
Theme 3	A home away from home	Making it meaningful	
Theme 4		Making it stick	

Note. Table 4.2 contains the research questions guiding the study and the corresponding themes that emerged during the process of data analysis.

Table 4.2 states the themes as they relate to each research question. The first section of the table restates the research questions. The second section of the table lists the themes that emerged during the process of data analysis as they pertain to each research question. Three themes emerged for research question 1, four themes emerged for question 2, and two themes emerged for question 3. The themes allowed for the study findings to be summarized and interpreted.

Brain-based Learning: What do Elementary Teachers Already Know?

Research question 1 *What do current elementary teacher know about brain-based teaching strategies?* focused on investigating how much current elementary teachers already knew and understood about brain-based learning strategies. Elementary teachers were introduced to the concept of brain-based learning by reviewing the principles outlined by Caine and Caine (1994) in Appendix A. Then, participants were introduced to the seven stages of brain-based planning by Jensen (2008a) that are outlined in Appendix G. The purpose of reviewing Appendices A and G was to familiarize participants with the basic constructs and principles of brain-based learning so that participants could think about how their current teaching strategies may be aligned with brain-based learning. While many participants claimed to know little about brain-based teaching and learning, they described implementing strategies that were in fact aligned with some basic brain-based learning concepts and principles.

When the seven elementary teacher participants were asked to discuss their understanding of what brain-based learning theory was, only one participant, Julie, could say with certainty that she had a working understanding of brain-based learning theory. This understanding was gained through her work in study groups and workshops that had been offered by the teacher center in the 1990s, stating, ". . . I did a lot of brain-based strategies with Jensen when I taught in the city school district."

Julie, a veteran fifth-grade teacher with over 20 years of teaching experience stated, "I learned through the training, I was a participant in . . . at least three to four collegial learning circles surrounding brain-based learning and strategies…there were different grants and we offered trainings at other schools." Her experience with brain-based learning theory and the corresponding strategies for creating a brain-friendly classroom allowed her to be deliberate in her use of brain-based learning strategies when planning and implementing lessons.

The other six elementary teacher participants reported knowing little about brain-based learning theory and some reported never hearing the term. Alex, for example, said, “So . . . I don’t know a whole lot about it” and Gail said, “I don’t know how much experience I have in brain-based learning, per se, but I try to plan with the whole student in mind. . .” The theme of planning for the whole child, including the cognitive, social, emotional and physical domains, was described by all teacher participants either directly or indirectly.

Theme 1: teaching the whole child. One of three themes that emerged from the discussion about what teachers already knew about brain-based learning theory and strategies was that of teaching the whole child. Four out of the seven teacher participants described not only teaching content, but also addressing the physical, social and emotional development of students. Gail, a veteran kindergarten teacher who intuitively implements many brain-based strategies shared that she was “somewhat familiar with it” and then went on to say, “But, just [what] the nature of little children is, you incorporate the entire child. You’re not just lecturing to them because they won’t learn anything that way.” Gail associated brain-based learning with instruction that considered the complexity of young children and addressed the cognitive, physical, social, and emotional domains.

Anne, a young second-grade teacher with less than ten years’ experience had a similar understanding of brain-based learning:

> My understanding of brain-based learning is that you're taking into consideration the whole child. And not just necessarily thinking about what I have to get them to know, but how are they going to best be able to absorb the content. When I'm planning a lesson or thinking about it, I think of the multiple intelligences.

The association of multiple intelligences also began to emerge either directly or indirectly as teachers shared their understandings of brain-based learning theory and strategies. All seven teacher participants directly or indirectly associated brain-based learning with multiple intelligences theory.

Jamie, a veteran fourth-grade teacher also referred to the multiple intelligences as being part of her understanding of brain-based learning theory and strategies:

> Well, remember when multiple intelligences were all the rage? I think that's what pops into my mind first when I think about that. Just trying to hit each individual student's need, not only just, you know, the auditory, the kinesthetic, all the different multi-modal ways of instructing kids. Trying to reach them from whatever either their interests are, or what their talents are, or what their strengths and needs are. . .

This association with multiple intelligences and brain-based learning was common among participants interviewed. All seven participants either directly referred to the multiple intelligences or referenced multiple intelligences indirectly by using words associated with the multiple intelligences theory such as kinesthetic, artistic, or musical.

Anne also shared, "I think of the kinesthetic learners and the visual learners, the audio learners, musically-based learners and how I can incorporate the most modalities of learning in a lesson." Anne also shared how she had incorporated movement into her daily lessons, “We have incorporated movement into the minilesson whenever we can, like making them do horizontal versus vertical and actually showing me, somehow associating a kinesthetic aspect with new vocabulary with something else.” The idea of using physical movement throughout the day was reported by all the teacher participants in one way or another. The concept of a brain break came up in four participant interviews. Jensen (2008a, p. 215) refers to this as a brain “wake up.”

Julie, the experienced fifth-grade teacher who was well versed in brain-based learning theory described her use of movement brain breaks:

> I really try to get them up and out of their seats every 15 to 20 minutes, whether it’s getting up, going over to the group, meeting for a few minutes and then they go back to their seats; doing that, going to the different group, moving around. I just think the movement is very vital.

Julie had a clear understanding of her students’ needs to move throughout the day. Anne also used movement with her second-grade class, incorporating movement deliberately throughout the day during lessons such as the math lesson she described:

> And so, at that time I actually had them stand up and if they thought it was going to be more inches in that single paintbrush, they had to stand on that side of the room; and if it was going to be more centimeters, they had to stand on this side of the room just so they could . . . a way to get them up and moving.

Anne also reported that she has used movement breaks more often in a deliberate way:

> It seems like a newer trend of the brain breaks. Working for 20 minutes at a time and then doing some sort of movement or some sort of brain break to better…help them absorb the content and stay attentive and focused to what they need to.

Gail, a veteran kindergarten teacher, also spoke about using brain breaks deliberately during her instruction to incorporate movement.

> . . . anytime we switch [between activities] I have a brain break there. Whether it's a song, whether it's dancing around, whether it's just doing some jumping jacks. Whatever it is, I have them moving to get that brain back in line and get them physically ready to sit again.

Sue, a veteran fifth-grade teacher who had very little knowledge or experience with brain-based learning also spoke of using brain breaks. "Yeah, that's a big push in our district…I think it's just because kids can get so stressed and overwhelmed, just little activities here and there that we do . . . just kind of a little brain break." Sue also talked about mindfulness techniques used in her school district to address the social emotional well-being of students at all levels, such as breathing exercises and yoga stretches. The term brain break was directly used by four of the seven elementary teachers interviewed for this study.

Another idea that emerged regarding the whole child theme was the inclusion of inquiry in math and science lessons. Inquiry-based learning presents students with a problem to solve, rather than giving students a solution to replicate or directly teaching content. Inquiry-based learning was a term that was frequently used when discussing what elementary teacher participants thought they knew about brain-based learning strategies. In six out of seven interviews, teacher participants either directly referred to the term inquiry, or indirectly referenced inquiry by describing the learning activity as an exploration, or a "notice and wonder" activity. For example, Sue described using a STEM (science, technology, engineering and math) problem to engage her students in whole-child learning, “. . . it might be like we’re doing a STEM activity this Friday on structures, and just kind of giving them some straws and paperclips. What can you do with these things?” Sue went on later in the interview to add, “I know that’s a big push right now; our STEM problem-solving; kind of giving them a problem, seeing if they can solve it.” Sue stated that she was not as confident or comfortable with these types of activities, but she was implementing inquiry science lessons into her math and science units of study.

Marlea described how she integrates inquiry into her third-grade mathematics lessons to engage students socially, physically, and cognitively in the learning process. Marlea described these lessons as “notice and wonder” activities, rather than inquiry-based learning activities:

> On the screen I put, you know, a bunch of wheels to a bike. Then the next image was all of those wheels then were grouped. And, how, what do you think, what did you notice about the first image to the second image? What do you notice happened between these two? What do you think they have to do with each other? And then the vocabulary that comes out of that. Well, it looks like they were all grouped equally. . . Okay, and then we would begin, like a division lesson.

Marlea presented students with a visual problem to solve and asked questions to get students thinking about what they already knew that could help them. Then, students were given the problem to solve and allowed to work together. All of these elements are aligned with brain-based learning concepts in that they allow students to move around the room, work together and talk through problems, ask questions, and model the problem using visuals or manipulatives. Inquiry-based learning engages the entire physiology

(Caine & Caine, 1994) allowing students to engage with learning activities physically, cognitively, socially, and emotionally. While Marlea was comfortable using this technique to engage her third-grade students in math activities, Alex was not.

Alex spoke with some trepidation about implementing similar activities in a co-taught fourth-grade classroom. Alex did not know about brain-based learning until we reviewed the appendices and had this to say about teaching with a colleague:

> Well, I just learned a great deal from what you went over. It's interesting because I work with a gifted teacher one day a week and this is totally what she does. And I'll be very honest with you, it makes me nervous because she immerses them into . . . it's math. And very little direction, very little pre-teaching. She goes over the question, and lets them go in groups, partners, however they wanna do it to solve it. And she circulates, we circulate around but it's just not my style of teaching. . . so, other than that, I don't know a lot about it.

Alex described an inquiry mathematics lesson which allowed students to become completely immersed in a problem, using prior knowledge and teamwork to find a solution. Alex stated that she was uncomfortable with allowing students to struggle through the problem and preferred to provide more traditional, direct instruction. Her colleague was described to be much more comfortable allowing students to feel that struggle and make their own meaning before engaging the whole class in direct teaching.

Gail also referred to using inquiry as a way of teaching the whole child. Gail, a veteran kindergarten teacher, described an activity referred to as "genius hour" that is part of the school's inquiry program. During this time, students are engaged in problem-solving and inquiry-based activities. Gail described Genius Hour in her classroom:

> We were starting our push and pull unit, and had a lesson, or a whole unit, on pushes and pulls, with big excavators and tractors and other big tools. So, I had a bunch of trucks that I introduced to them. Toy trucks and stuff, that they could use during free play. And then I did the lesson. And the cool thing, when they make that connection. Hey, I was just playing with that truck!

Gail intuitively understood that her students needed the experiences of moving physical objects and seeing what would happen before she presented the direct lesson. A similar fourth-grade STEM lesson was described by Jamie.

Jamie shared that her students were sitting in groups because it occurred to her that while she observed her students working together, the students did not appear to know how to collaborate with one another. Jamie decided that her students needed to learn how to "strike that balance between the collaboration and the independence." She described a lesson where students had been put into four groups, and had limited materials creating planned interdependence within each group. Students were asked to design a ramp using Matchbox® cars. The toy car had to go down the ramp and stop in the middle of the floor to a spot marked by a piece of tape.

Jamie also described other STEM (science, technology, engineering, and math) lessons where students were asked to take one piece of paper and design the tallest free-standing structure that they could. Jamie describes these activities in terms of their content, but also in terms of the social and emotional skills necessary to succeed. "The point is, and reminding them, because we have the essential skills up here that we're focusing on; it's about showing integrity, it's about self-management, it's about all of these things, this activity is just the vehicle to get to it."

Jamie described the lesson objectives in terms of the content and skills that she wanted students to learn. But, she also described the lessons in terms of the social and emotional skills that she intended for her students to learn as well. Jamie put the emphasis on the social emotional skills when she explained that the lesson was just a way to help develop those qualities in students, saying, ". . . it's about showing integrity; it's about self-management. . . this activity is just the vehicle to get to it."

Theme 2: engaging in different ways. When teachers described what they thought about when they heard the term brain-based learning, they all spoke about engaging students in different ways that ensured all students could access the learning objectives and content in a meaningful way. Learning strategies such as group work, partner work, collaboration, communication, and providing choice were very common, appearing in all seven transcripts between 14-22 times total. All seven teacher participants also referenced creating lessons or units of study that allowed for students to learn in a low-threat, high-challenge environment. Jensen (2008a) also referred to these strategies in Stage 3, initiation and acquisition and in Stage 4, elaboration of the planning process. In both stages, students are presented with novel learning experiences which may include group or partner projects, and opportunities to collaborate and communicate in the problem-solving process.

Gail described her use of group and partner work in her kindergarten classroom in an effort to reach each child:

> I try to incorporate different ways to learn. If I know that children are very independent in this, after I teach my group lesson, I send them off and they work independently on it. I have iPad apps that we can use as reinforcement as well.

> Children who are struggling more, I'll work with a small group. I'll partner them up with a child who's here (indicating a lower level), a child who's here (indicating a higher level), and they'll work together.

Gail also talked about using choice in a variety of different ways in her classroom:

> I also give them a lot of choices. They don't have to do everything. If they want to go to paint, they can. If they want to build it with the Geoboards, they can. Whatever they want to use. Because if they have that choice, then they think, oh, I'm controlling my learning. It's not someone telling me what I have to do.

Gail clearly sensed that giving students choice would allow them some control over their learning and allow for higher levels of engagement. Gail also shared her opinion that giving choice would ultimately allow students to engage in the learning process in different ways that were more strength-based in nature.

Jamie referenced her use of choice with her fourth-grade class during a research assignment. In preparation for the arrival of science kits about animals, she described a writing assignment and presentation that students were assigned:

> So, you're gonna research an . . . extreme organism. And let's try to find something that's a little bit more unique, kind of modeling after the TV show. You know, people know about cheetahs, people know about elephants, you know, let's find different ones. . . one was a blob fish. . . giving them the flexibility to find out the things that they wanted to, even a page for interesting facts, something that maybe doesn't fit into that category.

Jamie established the parameters for the task and set the expectations, but she allowed students to choose which organism was most interesting to them and encouraged students to be creative in how they presented their learning to the class when the final projects were finished. Students could work in partners and help each other with their research and their drafting as well as the creation of projects. This required collaboration and communication and created a task that was challenging, but not threatening as students had the ability to work together and access the teacher for help.

Julie also spoke about using choice to increase engagement, “I want them to feel like they have a wide range of options so that they’re going to be more invested in their learning and what they’re doing.” Julie described how she used choice to engage students in homework, “I tell them, work hard for 20 to 30 minutes. If there are particular skills or concepts that they’re feeling confident with, I’m like, move on to the next one.” Julie described a process for planning in which she purposefully incorporated choice and allowed students to engage in high-challenge, low-threat learning experiences, “. . . the kids could do a research paper. They could do a news broadcast. They could do a play. They could have a sense of autonomy and choice. . .”

Marlea spoke to purposefully designing lessons that required her third-grade students to collaborate and develop their communication skills, “. . . but the reason I have them set up in these kinds of groups is because it’s equally important to work with people, communicate with people, listen to people . . .” She went on to add, “I just think about, how am I going to engage the students? How am I going to make them be involved? Whether it’s through working with partners or manipulating things.”   Marlea understood that students would be more invested and engaged in the learning process if they were required to work collaboratively on challenging tasks in a highly supportive environment that allowed for communication and was thoughtful in her planning process to include activities designed to extract these behaviors.

Anne also described how she engaged her second-grade students in group work and partner work through the use of the workshop model:

> I have been trying to do more small-group work, which seems like. . . there's something in here about learners being able to talk with one another and reflect on what they just learned so I've been trying to add that to the closure of a lesson with more reflection in small group.

Anne explained that she used small group work often with her second-grade class because it allowed them to be social and orally reflect on their learning, "I think all kids are very social, this group is very, very social, so giving them that reflection time is important."

All elementary teacher participants described how they used strategies such as group work, partner work, and choice to actively engage their students in learning. Even those who reported to know little about brain-based learning theory were purposefully designing lessons that incorporated communication and collaboration and provided choice. All seven teachers also described ways that they created an environment that was safe and supportive, both physically and emotionally.

Theme 3: a home away from home. Creating a low-threat environment for learning means allowing students to feel safe to take risks. Research participants discussed how to create an engaging classroom environment that is safe and supportive of all students. Strategies such as maintaining consistency of structure, creating excitement and utilizing lighting and music to create a calm mood in the classroom.

Marlea, a third-grade teacher, talked about how she used the room organization to help create a calm environment, “But I try to have it organized. I don’t like a lot of chaos and I feel like it’s calming because everything is always in its spot and they’re not looking at piles and things out of place.” Marlea’s room had large windows that allowed a lot of natural light into the room, “These blinds can go down. I choose to have them up even though recess is right out here. But, I enjoy the light. I am thankful for it.” Marlea also had soft music playing in the background during the interview:

> Another part of the way that I set up the room, you could probably hear the guitar music. It might be that, it might be a smooth jazz. Something is always playing in the background for them and the kiddos enjoy that.

Marlea discussed how the music was part of the routines of the classroom and the students had come to expect and enjoy it, “. . . and even though it’s just instrumental, you see them tapping their foot or recognizing the beat of a certain song.”

Anne, a second-grade teacher also spoke about using lighting and music in similar ways to create a calm environment. “Lighting wise, I typically have the florescent off and it’s mostly the softer lighting. . . A lot of lamps. And that’s purposeful, too, just for setting a calmer learning environment.” She went on to share how she uses music to enhance the classroom environment, “I have a CD player over in the back corner, so I’ll have classical music playing in the background. It’s honestly never totally silent in here. . .”

Gail, a kindergarten teacher, also shared how she uses music in a similar fashion, “But I also always have music playing to keep their brains going and to keep them focused on something. . . In the morning when they first come in, I have Disney music playing. They hum along and sing along." Gail spoke about her own research into the effects of music and found a connection to learning:

> I've actually done research where I've learned that math, classical music helps their brains develop. So, I have classical music playing. . . So, it's just playing softly in the background. And if I don't turn it on, they ask me for it, because they're used to it. They like it.

Gail also talked about creating excitement to create an engaging learning environment, "I try to make it exciting. Like that math lesson I told you about, with the marshmallows. It incorporates their name, so that gets them excited." Later in the interview, she added another example of how she creates excitement to increase engagement:

> I use a gingerbread man. He's traveling, and he sends us stuff. That's how I introduce it. So, when he went to Mexico, he sent us a sombrero and he sent us a piñata. So that the children can actually see and touch some of this stuff. When he went to Italy, he sent us pizzelles. . . in Holland, we make wooden shoes, so he sends us these things so that we can see them.

Gail added, "Occasionally, depending on the lesson, I just leave things around the room for the kids to find." In this way, she created some excitement when she was introducing new units of study. Students could find interesting items that seemed out of place and ask questions about them, leading to a class discussion.

Julie, a fifth-grade teacher with quite a bit of experience with brain-based learning discussed how she created a safe learning environment for her students:

> I will give my answer keys and my work to my kids because I want them to see how something is done, whether it's in math, science, social studies, it doesn't

> matter to me. If they don't know how to approach something, I think it's so much more valuable that they're talking with a neighbor. Even if they're looking at what someone is doing over here, I think if that's the way that they're pulling in the information then I'm really okay with that.

Julie was speaking to shifting her focus to the learning and emphasizing the need for students to understand the content and concepts rather than focus on grades. In this way, she created an environment where students felt more comfortable taking risks and being wrong during the learning process.

Julie also spoke of putting her students more in charge of their learning to facilitate a safe learning environment:

> I want the kids to be in charge of their learning. . . I think kids can do that so beautifully for each other, and so I really like to rely on the kids helping each other. I need to be a bystander. I need to step in where they need some clarification. But I think the kids are way more engaged. It's just like the reciprocal teaching model, if they're in charge of their learning and I am facilitating that.

Sue also described how she felt about the importance of creating a safe learning environment:

> And my goal really is to connect with every child in a way that they know it's a safe place to take risks, it's okay to be wrong. Sometimes our best learning comes from making mistakes, and that's the environment where you aren't going to be made fun of for being wrong. And that we're going to help each other grow as learners.

The theme of creating a home away from home using lighting, music, consistency of structure, and excitement was consistent throughout all six participant interviews. If participants did not speak directly to the creation of a safe, supportive, and engaging learning environment, they spoke indirectly about how they affected the mood of the classroom and allowed students to feel a sense of calm and safety while learning new content.

Brain-based Learning: How are Elementary Teachers Applying it to Lessons?

Research question 2 *How are teachers knowingly or unknowingly applying brain-based learning to their lessons?* examined how elementary teachers were using strategies aligned with brain-based learning either purposefully or intuitively. Research participants were asked questions that were directly aligned with Jensen's (2008a) seven-stage planning process to investigate this answer. Teacher participants were also asked to describe the setup of their classroom and why they chose that arrangement.

Theme 1: Setting the stage. The first theme of the second research question was aligned to Stage 1, pre-exposure, of Jensen's (2008a) seven-stage brain-based planning framework. During stage one, teachers provide students with an overview of the new learning concepts before teaching begins, helping the brain develop connections and concept maps. The concepts that appeared in the coded data were technology integration, hands-on activities, and visual aids such as word webs, charts or concept maps.

Visual aids assist with setting the stage for learning. Julie said, "I post these posters [at] the beginning of the year and I will periodically go through them again." The posters were there to help students learn rules, procedures and cross-curricular concepts and skills. Julie also incorporated color as a visual aid for students, "I . . . activate different parts of the brain with color. I do it with pens, note-taking, marker, highlighting things. I try to do it in a variety of ways." Another way that Julie used visual aids to prepare students for new learning was using posters during a gallery walk:

> . . . we do a lot of gallery walks. We have pictures hung all around the room, and the kids have little sticky notes with them and they travel from poster to poster. They talk about what they see, questions they have. They have little discussions within their group and they leave their sticky notes on each of the pictures as they walk, and it's related to our historical fiction unit . . .

Julie was well versed in the use of brain-based theory and purposefully integrated many strategies into her lessons. This example shows how she was able to incorporate the use of visual aids and a gallery walk to get students thinking and talking about a new unit of study.

Study participants also spoke about using movement and hands-on activities to introduce units of study. Gail, a kindergarten teacher, described how she introduced a subtraction unit:

> We're working on subtraction; well, I can subtract human beings. So, I call five kids up. Okay, there are five friends standing in line. Two friends decided they don't want to wait and go sit down. And then they go off and sit down. How many friends are left? So, to introduce subtraction, which is what we did last week, [I] just incorporate them into it, otherwise they are sitting on the carpet, bored.

Having students actively participate in an example of the learning concept is another way to provide pre-exposure to a unit and actively engage students' brains.

Integrating instructional technology to introduce a concept was also referenced by six of the seven teacher participants. Sue, a fifth-grade teacher, spoke of how she would use technology and hands-on activities to activate students' thinking about a new concept before a lesson:

> I need to think about how I'm going to introduce it, so sometimes it's a video clip; sometimes it might be like we're doing a stem activity this Friday on structures, and just kind of giving them some straws and paperclips. What can you do with these things?

Alex also shared how she incorporated technology into the pre-exposure stage of her teaching:

> The Smart Board is wonderful . . . I do find a lot of things that are of interest to the kids. Brain Pop is a video series that our district provides and as goofy as it is, the kids love it . . . I try to find some kind of Smart Board activity whether it's a video or a learning game.

Setting the stage for learning also involved incorporating essential questions and having student generate their own questions about the topic. Once the stage is set for learning, teachers can turn their attention to preparing students for the new learning in Stage 2, preparation (Jensen, 2008a).

Theme 2: priming the pump. Jensen (2008a) refers to the second stage as preparation. Jensen (2008a) describes this stage as the point which a teacher would create curiosity and excitement by providing context, a real-world experience, and by activating prior knowledge. Caine and Caine (1994) posited that the search for meaning is a basic, innate function of the human brain, because it is survival oriented. The preparation stage could utilize KWL charts to help elicit what students think they know about a topic and generate questions that students would like the answers to. This stage could also include some sort of hook or novel activity to generate excitement and wonder. The most common strategies for priming students' minds for new learning discussed by participants were: generating prior knowledge, creating curiosity, and providing context for the new learning.

Activating prior knowledge is one of the first steps in the planning process. Every participant interviewed talked to some extent about how activating prior knowledge was used to prepare students for new learning. For example, Anne said, "In the activation of prior knowledge and the anticipatory set, I'll show sort video clips sometimes . . . videos I find are really helpful in activating prior knowledge. Photographs [too] depending on the unit." Anne also shared how she used KWL charts and brainstorming to activate prior knowledge and prepare her second-grade students for new learning:

> Yeah, so we do KWL charts, we do a lot with concept webs too. So, with our poetry writing unit, brainstorming what they already knew about poetry . . . for the weather unit in science they just did a picture splash or a word splash so activating what they already knew. . . and then we did share.

Gail discussed the limitations of KWL charts because they require the use of written words and her students are not at that stage yet, "In kindergarten, this year, I have not used a ton of KWL charts. I've done it, the same idea but different ways." Gail also described using a brainstorming technique with her kindergarten students which used questioning techniques to get her students thinking:

> So, if it's raining, what does it feel like outside? So, getting them to think about closing their eyes. We've done the five senses unit. So, I do a lot at this age with five senses. You're outside and it's raining. What are you feeling? What are you seeing? And then close your eyes, get a picture of it. What does it look like? What would you touch?

Sue stated that STEM activities implemented with her fifth-grade students create curiosity and excitement:

> . . . the STEM activities that we do create that. A problem that they can try to solve, I think that really gets them curious. Sometimes in the morning, I'll give them a riddle to start our day…and you can just tell they're just so excited . . .

Jamie shared how she used her own experience watching a fox hunt to get her fourth-grade students excited about learning:

> I'm 49 years old and I have never seen a fox hunt. And last night, I was watching a fox hunt, not once, not twice, not three times; I saw him hunt four times! And if you've ever seen a fox hunt, you will be amazed. And so, I explained to them how I didn't want to take a video because I wanted to really enjoy the experience and I said, BUT, I Googled a video and wait till you see this! They were floored when they saw that fox leap up into the air and drop straight down, head first, into the snow . . . and so now they're sparked.

The story that Jamie described not only created curiosity, but it provided a context for the new science content she was going to be presenting to the students.

Theme 3: making it meaningful. Theme 3, *making it meaningful*, connects to the concept of orchestrated immersion discussed by Caine and Caine (1994) in which students were immersed in a complex, authentic learning experience designed to be challenging and highly engaging. Similarly, Stage 3 of Jensen's seven stage planning process which he refers to as Initiation and Acquisition is described as providing immersion into the content causing students to feel momentarily overwhelmed. This overwhelmed feeling is followed by feelings of anticipation, curiosity, and an interest in developing meaning. Learners should be allowed to engage in exploration, experimentation, and authentic experiences in which students make personal connections to the new learning. Providing some choice during this stage is also important.

During the interview with Marlea, she gives an example of a math lesson in which she allows her third-grade students to explore their understanding of fractions using a clothesline:

> For instance, in math, we've been practicing fractions and we've done a clothesline activity where I just laid a bunch of fractions on the floor and they had to clothes pin them up on it wherever they thought, without ever having any knowledge of fractions at all, where they thought that they would fall on a number line, starting with whole numbers of zero and one. Where would the zero go? What would make sense there? And really having them kind of guide that practice and then rearranging things as necessary to make that connection.

Students were engaged in an authentic learning experience and asked to think and reason together to decide where to place the fractions on the number line. This lesson was also a concrete learning experience which engaged students physically, socially, and cognitively. Students also had to make personal connections to their new learning with their background knowledge and experiences with fractions to decide where to put the fractions and defend the decision.

Later in the interview, Marlea described another lesson in which students were immersed in a challenging and meaningful learning social studies experience:

> When we did the module on books around the world, so we learned through, especially this one, My Librarian is a Camel, it goes through each country and how they access books and the kids get to . . . see how kids get books differently. You know, some get to keep books for a month some kids get books by goat, we get to go to the library, and at the end of this . . . they get to create. So, there's a STEM project that we've created to go along with this, where they have to create a model that goes over three constraints, because a lot of these rural countries face landform obstacles to be able to get books to where they need to go.

Like the math lesson, Marlea allowed her students the opportunity to explore a social studies concept using multiple methods. In this case the lesson combined the reading of a non-fiction text with the creation of a vehicle that could traverse several landforms.

Similar to Marlea, Julie spoke about the importance of providing choice to make learning meaningful in her fifth-grade classroom:

> I do like there to be choice involved wherever possible. For me, choice comes in a lot with, through the literacy program, through ELA. I really avoid at all possible junctures where the kids are all reading the exact same thing . . . I want them to feel like they have a wide range of options so that they're going to be more invested in tier learning and what they're doing.

Theme 3, Making it Meaningful, emerged and consisted of terms in all seven transcripts related to providing choice. Data with codes referring to choice occurred 21 times. Making learning meaningful meant creating challenging units that included authentic, concrete learning experiences that allowed some choice and opportunities for students to interact socially with their peers. Making learning meaningful also requires students to make personal connections to the learning and engage emotionally.

Theme 4: making it stick. Theme 4 focused on strategies to help students retain new information and skills. The theme, making it stick, emerged and consisted of concepts such as providing frequent formative assessments, time to share learning with other students and time to reflect on the learning process. Teachers interviewed described using strategies such as carousel walks and journaling as well as student-generated rubrics to have students better cement new learning by actively engaging them in the last step of the process.

Research participants discussed using strategies to help students remember what they learned. Teachers described practices for student reflection, opportunities to share new learning and formative assessments during the learning process to help students solidify and remember new concepts and skills. Gail shared how she used discussion and reflection time at the end of a lesson to help her kindergarten students clarify their thinking and solidify their understandings of new math concepts:

> When we're done . . . I often ask them *what was one thing you learned today*? So, they're sharing their insights and that gets other children thinking as well, so when I close that lesson . . . and it helps me. What did they learn? Did they learn my objective? Did they do what I wanted them to do?

Alex, a fourth-grade teacher described using observation, quizzes, projects plays as means of assessing student understanding and allowing students to demonstrate their learning:

> So, my authentic assessment is just kind of ongoing. I do a lot of observation . . . I do give sometimes a written test, a project . . . lots of different things that we use a rubric for and we've done plays, we've done anything they can show me that they've learned what would be expected of them.

Student directed learning and reflection were also strategies Alex described during her interview regarding solidifying learning.

Alex also described using student-rubrics for hands-on science activities, stating, "We do rubrics that the kids come up with". Alex shared, "I think a lot of times when you answer their questions, that gets them a little more excited than just a generic *this is what we're gonna be learning today*." Alex also provided students time to reflect on their learning, "Let's talk about what we did yesterday, so about 10 minutes at the beginning and end of each lesson."

These strategies were reported for making new learning stick, as well as other strategies such as: using gallery walks, sharing time at the end of lessons and providing feedback. The strategies described by research participants focused on providing opportunities for student reflection, opportunities for students to verbally process concepts in small or whole group settings and leaving feedback to one another on student work during a gallery walk.

Brain-based Learning: Are Preservice Teachers Learning the Theory and Applications?

Research question 3, *To what extent is brain-based learning theory part of the curriculum in Western County, New York elementary teacher preparation programs?* examined how much of what teachers knew about brain-based learning was taught during their time at university. Two themes emerged from the data analysis: *I don't remember learning this* and *Retrofitting the existing curriculum*. Elementary teachers and higher education faculty were interviewed to examine research question three.

Theme 1: I don't remember learning this. All participants interviewed reported that they did not learn about the human brain and its role in learning during their teacher preparation programs at college. All participants also reported learning little to nothing regarding brain-based learning theory and its implications to instructional design and implementation. Gail, a veteran kindergarten teacher said:

> When I was in college, I don't recall doing a lot of brain-based learning. We talked about Bloom's taxonomy, which is out of my brain at this point, but the hierarchy of learning. Madeline Hunter was drilled . . . but I don't recall specifically learning about this.

Gail's experience was not unique. When Alex, a 30-year veteran teacher, was asked how much she remembered learning about brain-based learning, she replied, "I don't think it was . . . it was never called brain-based learning, you know? I think what I learned was more your old teacher school; this is what you do, this is how you do it." When probed to explain what "old teacher school" referred to, Alex stated that she was describing learning about a more direct teaching style wherein students are told exactly what to do, then students engage in guided practice, then independent practice and are assessed by a quick quiz or some other formative assessment at the end of the lesson. This sequence was considered a more traditional approach by Alex.

Jamie, another veteran teacher with over 20 years of experience had a similar experience. She was able to remember learning about Bloom's Taxonomy and Multiple Intelligences but had no direct recollection of learning about brain-based learning theory, "I would say probably Bloom's Taxonomy was the big one. Multiple Intelligences . . . those are the two that really stick out in my head." While Jamie described Multiple Intelligences theory to be closest to brain-based theory, she was unable to recall directly learning about brain-based learning theory or strategies that were aligned with brain-based learning.

Anne, who was a younger, second-grade teacher shared that she had some recollection of learning about certain elements of brain-based learning theory, but not learning about it directly:

> We did a lot with the planning, following the Danielson model . . . which stretches out the lesson or just the unit in a more brain-friendly manner. We talked about attention span. The need for brain-breaks . . . It wasn't in the classroom learning about it.

Anne stated that most of what she learned regarding strategies that were aligned with brain-based learning theory were acquired during her student teaching placement and not during any courses that she could remember taking during her teacher preparation program at either the undergraduate or graduate level.

Sue, a veteran fifth-grade teacher with over 20 years' experience teaching admitted to knowing nothing about brain-based learning, "I don't obviously know a whole lot about this. Like, I googled it, that's what I [know] . . . you know?" Sue stated that she had not learned about brain-based learning in her teacher preparation program nor during her 20 years teaching.

Every participant interviewed had no recollection of learning the terminology of brain-based learning in undergraduate or graduate teacher education programs. Higher education faculty currently working in teacher preparation programs were also interviewed to gain a better understanding of what brain-based concepts, if any, were currently a part of teacher education curricula.

Theme 2: retrofitting the existing curriculum. Four higher education faculty from three different universities and colleges were interviewed regarding the extent to which current teacher preparation curriculum contained elements of brain-based learning theory. All four higher education faculty spoke of teaching from more of a sociocultural framework than a neurobiological framework. Each higher education faculty participant was able to cite examples where aspects of brain-based learning theory was integrated into the curriculum, but only two of the four participants were deliberate in that integration. Even then, the amount of brain-based learning theory connected to content was limited.

Marlene, for example, said, "It often ends up that it gets constructed in a more sociocultural way." She described how teaching was framed through a sociocultural lens for students so that they could understand how life-experiences, culture, and socialization all impact how teaching occurs and what choices teachers make regarding curriculum and pedagogy. Marlene also shared that she taught from a more theoretical perspective, but felt that many brain-based concepts were integrated into one particular course:

> I do teach a course called Theoretical Foundations of Literacy and in that course, we deconstruct literacy as a multi-dimensional process and those four dimensions are linguistic, cognitive, sociocultural and developmental dimensions. In the cognitive domain is where we focus on memory, perception, strategies, background knowledge, in terms of schema. And so, it's integrated in the sense that that's where we're specifically talking about cognition and how we facilitate strategy use and comprehension in a cognitive sort of way.

Marlene described how the cognitive domain is addressed in the one course through the discussion of memory, perception strategies, and background knowledge. That course would become the foundation of the classes that came after it in the curriculum. Otherwise, when asked to describe any courses that include brain-based theory into the curriculum, Marlene stated, "I would say that has never been an explicit goal that I've had, and that's never been a phrase I have ever used."

Unlike Marlene, Catherine had received a Mind, Brain and Education (MBE) degree from Harvard University and purposefully integrated specific neurological concepts and their connection to teaching practices into her curriculum. Catherine was able to describe how she integrated her knowledge of neurobiology into a class on universal design for learning:

> Sure, so when I introduce Universal Design for Learning and that framework, we talk about the three, sort of major networks of the brain, being sort of pattern recognition and information processing, and sort of the recognition network,

> which is more, sort of, occipital lobe and back of the brain. And then we talk about the pre-frontal cortex and sort of strategic planning and those sorts of things, and then we talk about emotion and motivation being at the center of the brain; amygdala sort of stops so it's all sort of anchored in the fact that, at a really gross and sort of over-simplified level, there's like, this way of thinking about learning and the brain and that helps us to think about variability, right, that the kids vary on all of those dimensions and sometimes that results in lots of other different ways of learning and functioning and operating in our classrooms . . . and I do a thing on neuromyths there.

Catherine described having a strong working knowledge of the structures and functions of the human brain and how she would purposefully integrate that knowledge into foundational coursework aimed at pre-service special education teachers. Catherine's MBE degree was essential in providing her the ability to fully integrate brain-based learning theory and neuroscience research, even on a very basic level, into her classes.

Jenna, another higher education faculty member, also spoke about a class around universal design for learning, and another on differentiation that both utilized Jensen's work as part of the foundation for other classes to build on:

> Those two foundational courses are there and that's threaded throughout the rest of their coursework. We go back and review those foundational things, but the bottom line is the brain is the organ of education. We frame it as that so, understanding executive function, assessing if there are deficits there or weaknesses there, and what do we do with that and how do we strengthen that,

> and looking at things like memory and automaticity, but in an evidence-based kind of way.

Jenna was able to purposefully integrate her own understanding of brain-based learning theory, specifically referring to Jensen's work, and described how she helped her pre-service teachers understand the implications to teaching and learning. Jenna's understanding of brain-based learning was fully integrated into the foundational courses taught at the beginning of the curriculum, and then the concepts were revisited as the curriculum progressed. In this way, Jenna described a thoughtful integration of brain-based learning theory into the teacher preparation curriculum.

When participants were asked to discuss how brain-based learning theory could be added to the existing curriculum, all four spoke to a layering onto what was already there. Catherine shared that she felt it would be more of an integration of the principles of brain-based learning:

> So, I think it would be sort of at the level of principles. So, for instance, we talk a lot about the role of emotions and their, sort of, integration with cognition . . . I think there's aspects around patterning, highlighting salient patterns, examples and non-examples as key to learning; those kinds of things . . . So I think there's sort of a lot of these pieces that could be integrated, sort of infused throughout."

Similarly, Melanie spoke of having the brain-based learning theory and strategies blend with what was already being taught in her classes as she felt it would fit well with the content and strategies that were already in place:

> This may be just along with my whole philosophy of education, but I think having it blend naturally into the content we're teaching . . . all of us teach in this

> constructivist framework. I think it fits very well with the brain-based research. Maybe just being explicit about it but embedding it in all of those classes as opposed to just having one course that says, *Okay, this is what brain-based research tells us*.

Like Melanie, Marlene also stated that she felt brain-based learning could be fit into the existing curriculum, "I think it could probably be layered on top of instead of treated as something separate and different." In this way, the theme of *retrofitting the existing curriculum* with brain-based learning theory emerged as all four higher education faculty described how they imagined brain-based learning strategies and concepts could fit into the existing curriculum.

Summary

Overall, teachers interviewed for the study did not claim to know much about brain-based learning theory and strategies or their application to instruction. Only one of the seven teachers interviewed and two of the faculty interviewed had a working knowledge of brain-based learning theory and how to integrate the theory and associated strategies in teaching and learning.

While teacher participants were not confident that they could speak to brain-based learning, they were implementing several strategies that were aligned with brain-based learning theory. Teaching the whole child, which emphasized the cognitive, physical, and social-emotional domains was common, as was the use of multiple intelligences, inquiry learning, and brain-breaks. Teachers also reported creating a safe and supportive learning environment through high-challenge, low threat learning activities that allowed students to work collaboratively in small groups or with partners to problem-solve and make their own meaning.

Teachers interviewed for the study were acutely aware of the need for students to be physically engaged throughout the day and purposefully incorporated movement into the day by creating frequent transitions and using flexible seating so that students could stand, kneel, or sit. Teachers also were able to describe how they created curiosity and excitement when introducing new units of study. Strategies such as videos, KWL charts and mind maps, brainstorming, and experiments were all reported to be used in some capacity to increase engagement and excitement.

Participants spoke of using frequent assessments in a variety of forms to both check for understanding and allow students to reflect on their own understanding of new concepts through sharing out, gallery walks and journaling. Also, participants allowed for the use of student-generated questions to increase engagement and hopefully increase student learning outcomes. Teachers felt that if students were personally invested in answering their own questions, they would be more likely to remember what they learned.

Elementary teachers interviewed appeared to have limited or no exposure to brain-based learning during their college preparation programs. All reported that they had been exposed to learning concepts such as Bloom's Taxonomy, inquiry, multiple intelligences, or brain breaks, but none could recall any direct exposure to brain-based learning theory. Their understanding of brain-based theory was through a constructivist lens and the idea that one is teaching the whole child. If strategies aligned with brain-based learning theory were being used, in 6 out of 7 instances, it was inadvertent. Only one teacher participant had enough knowledge of brain-based learning to knowingly plan elements of instruction aligned with the theory.

College faculty interviewed for the study were able to find ways that the current curriculum supported the integration of brain-based learning theory. All faculty interviewed said that they felt it should not necessarily be a stand-alone class, but rather layered onto and integrated into the existing curriculum so that students could see how the theory informed the practice. Of the faculty interviewed, two of the four participants were able to clearly articulate a strong understanding of brain-based learning theory and how they were currently integrating it into the existing curriculum. The other two faculty participants emphasized a more sociocultural alignment to their current instructional practices.

Chapter 5 will summarize the implications of the study as well as discuss limitations and recommendations for future studies and for practice.

Chapter 5: Discussion

Introduction

The existing literature demonstrates the positive effects of brain-based learning strategies on student attitudes, motivation and academic achievement. Elementary students were underrepresented in the literature, as were qualitative studies describing how teachers apply brain-based learning strategies in an elementary classroom. The purpose of the study was to examine the extent to which teachers are aware of brain-based learning theory and are applying the concepts of the theory in planning and teaching practices. This chapter provides an overview of the study findings and their implications as well as limitations. In addition, the chapter makes recommendations for elementary teachers, higher education teacher preparation programs, and education policy makers. The research questions of the study were:

1. What do current elementary teachers know about brain-based teaching strategies?
2. How are elementary teachers knowingly or unknowingly applying brain-based learning theory to their lessons?
3. To what extent is brain-based learning theory part of the curriculum in Western County, New York elementary teacher preparation programs?

Multiple themes emerged during the process for data analysis. These themes provided the results of the study summarized in the findings. The implications and findings described in the next section aligned with the research questions.

Implications of Findings

There were three key findings resulting from this study. Finding one demonstrated that teachers know very little about brain-based learning theory and strategies. Finding two showed that teachers were often unknowingly applying strategies that were aligned with brain-based learning theory. Finding three concluded that brain-based learning theory is not a priority in teacher training programs. Study findings align with brain-based learning theory and are supported by the existing body of literature. Brain-based education is defined by Jensen (2008a) as “learning in accordance with the way the brain is naturally designed to learn” (p. 4). Brain-based learning theory is implemented when lesson design takes into consideration the structure and function of the human brain and how learning naturally occurs. The literature suggests that brain-based learning should be part of the lesson planning process (Akyurek & Afacan, 2013; Duman, 2010b; Jensen, 2008; Kayalar & Ari, 2016; Saleh, 2011; Shabatat & Tarawneh, 2016). Current studies refer to the earlier work of Caine and Caine (1994).

Caine and Caine (1994) proposed that teachers need to accomplish three main elements to effectively align instruction to brain-based learning theory. The elements include: orchestrating the immersion of students in complex learning experiences that are rich and real; creating a state of relaxed alertness for students where there is low threat and high challenge; creating learning experiences that require analysis and problem-solving where students actively process the experience (Caine & Caine, 1994). The three main elements and the 12 principles of brain-based learning described by Caine and Caine (1994) became the foundation for the development of brain-based learning strategies.

Brain-based learning strategies, when applied, show improved student academic achievement, as well as improved student motivation and attitudes toward learning. Teachers need to be purposeful in the planning and implementation of brain-based learning strategies. Jensen's seven stages of brain-based planning (2008a) was used as a framework to examine the lesson structure and teaching practices of research participants.

Finding 1: Elementary teachers in the study knew very little about brain-based learning. Research question 1 explored what current elementary teachers know about brain-based learning theory. Findings demonstrate that despite research supporting the benefits of brain-based learning, elementary teachers in the study knew very little regarding brain-based learning theory and specific elements of the theory. Elementary teachers interviewed for the study, with one exception, related brain-based learning to other theories such as multiple intelligences theory, inquiry learning theory and teaching the whole child.

Only one of the seven elementary teachers interviewed for this study was well versed in brain-based learning theory and could articulate how she implemented concepts and strategies aligned with brain-based learning into her lessons and classroom design. Her ability to articulate how she implemented brain-based learning theory into practice was due to her personal interest in reading books about brain-based learning and attending many professional development workshops on the topic of brain-based learning. The other six participants claimed to know very little about brain-based learning and attempted to relate it to more familiar theories, like multiple intelligences or whole child learning, once brain-based learning was explained.

The concept of teaching the whole child, or immersing students in inquiry learning experiences is aligned with brain-based learning theory. Brain-based learning theory describes this as active processing (Caine & Caine, 1994). Caine and Caine (1994) asserted that when students actively processed new information, they were able to internalize and store that information in the episodic memory. Stage 4: Elaboration and Stage 5: Incubation and Memory Encoding of the seven-stage planning process outlined by Jensen (2008a) describe a process wherein teachers provide complex, authentic learning experiences and time to reflect on and internalize new learning. Since there was alignment between some practices such as inquiry learning and brain-based learning, one would expect to find some understanding of brain-based learning theory and strategies, however that was not the case in this study.

In the school districts of the participants in this study, there did not appear to be a focus on brain-based learning strategies or a structure to encourage the use of the research in neuroscience education as it pertains to classroom practices and planning. In addition, there did not appear to be any theoretical structure supporting brain-based learning strategies and practices. With one exception, participants were unable to identify any professional development or training in the area of brain-based learning offered by the district. While there is a large body of literature and organizations supporting brain-based learning, elementary teachers demonstrated a limited awareness of brain-based learning.

This finding was somewhat surprising because brain-based learning theory has been in educational literature for over 30 years. There are many books and articles as well as research studies supporting the integration of strategies aligned with brain-based learning, yet there is very limited understanding of what exactly brain-based learning is and how it can be implemented into a typical elementary classroom. This finding is supported by the literature in which Zadina (2015) points out that teachers often do not read the scientific literature. Zadina (2015) also points out that even if teachers did read the literature, they are not trained in how to discern bad research from good research. None of the teachers interviewed were familiar with any of the research studies, and only one was aware of the multiple books that have been written about brain-based learning theory. There is a clear gap between what is known about brain-based learning in the field of neuroscience and how that information is being communicated to educators.

These findings imply that there needs to be more collaboration and communication between the fields of neuroscience and education. While studies exist that support the positive effects brain-based learning theory can have on student attitudes, motivation and achievement, many practicing teachers are unaware of brain-based learning theory and strategies. Increased education in the form of professional development could close that gap and help teachers better understand the theory as well as the practices associated with the theory. This, in turn, could increase student achievement and motivation to learn.

It may be necessary to explore models of professional development for teachers. Several studies stated a need to increase the level of training for in-service teachers on the implementation of brain-based learning (Dubinsky et al., 2013; Ozden & Gultekin, 2008; Serpati & Loughlan, 2012; Shabatat & Tarawneh, 2016). Research studies by Dubinsky (2013) and Serpati and Loughlan (2012) suggested that teachers could benefit from additional training in brain-based learning because teachers have a high level of interest in learning about neuroeducation. Professional development could also increase communication between the fields of neuroscience and education.

Current literature also highlights the need to increase communication between the fields of neuroscience and education. Studies such as those conducted by Cameron and Chudler (2003) suggested that while there is not agreement to what degree the fields should be bridged, it is important to increase two-way communication between neuroscience researchers and educators (Cameron & Chudler, 2003; Gearin & Fien, 2016). As suggested by Serpati and Loughan (2012), it would be helpful to explore the dissemination of information from neuroscience to education. Increased communication may increase the collaboration between education and neuroscience so that teachers can have more input into the kinds of research questions being posed by scientists. Research that is perceived by educators to be relevant may be more widely embraced by education.

Finding 2: Teachers Are Not Consistently Applying Brain-Based Learning in an Informed Way. Research question 2 explored how elementary teachers were knowingly or unknowingly applying brain-based learning theory to their lessons. The study found that teachers rarely knowingly apply brain-based learning strategies, but very often were unknowingly applying strategies that aligned with brain-based learning theory. As stated previously, teachers were found to be unaware of the literature supporting the use of brain-based learning strategies in the classroom but were often more aware of popular trends in education such as multiple intelligences, teaching the whole child, and inquiry-based learning.

All of the teachers interviewed seemed to incorporate brain-based learning strategies, but there was no clear alignment between their knowledge and their planning process. In addition, there was no clear organizational framework for lesson design and instruction. Only three of the elementary teachers interviewed produced a lesson plan that could be analyzed as part of the study. Of the lesson plans provided, only one was a district required format, and six teachers stated that they were not required to create lesson plans or keep a plan book. According to Tokumama-Espinosa (2011), the goal of brain-based learning is to align teaching and learning with how the human brain is biologically organized to learn. This would imply a certain level of understanding of the structure and function of the human brain as well as a conscious effort to create that alignment. In all but one case, the teacher participants were unknowingly designing instruction that contained some elements of brain-based learning but could not articulate specifically why they had chosen to implement those strategies or how they aligned with brain-based learning.

One example of teachers unknowingly implementing brain-based learning is the use of movement breaks and the purposeful integration of movement throughout the day. Teachers interviewed for the study had all integrated some sort of movement into the daily routine. Some research participants referred to this as a brain break, while others simply described their awareness of children's needs to move throughout the day. The brain breaks were teacher attempts to provide students with opportunities for movement. Studies in the literature reinforce the importance of kinesthetic activities for the human brain to process information (Mullander-Wijnsam, et al., 2015). Given (2002) refers to this as the physical learning system and suggests that it needs to be actively engaged in the learning process. Jensen (1998) also connects biology and neurology suggesting that movement and exercise have been shown to spur the production of nerve growth.

While the literature supports the use of frequent movement breaks throughout the day, teachers in the study were not aware of the research and described the integration of movement as the result of student observation. Some districts supported recess for students on a daily basis, while others did not. There was little consistency in district policy around the integration of movement breaks because there was a lack of awareness of the neurological research supporting the practice by both teachers and district leaders. This lack of awareness was also evident in the area of student engagement.

All of the teachers interviewed also discussed implementing strategies to increase student engagement. Many of those strategies were aligned with brain-based learning theory, such as using group and/or partner work, or providing choice. In a study on elementary students conducted by Ozden and Gultekin (2008), similar strategies were implemented with a test group receiving a brain-based learning approach. These strategies included group work where students were asked to collaborate with one another, allowing students to choose how they presented their learning, and actively engaging in the learning process through role play and simulations. Ozden and Gultekin (2008) found that the experimental group substantially outperformed the control group. These strategies support the theory that the human brain is a parallel processor that learns best when multiple areas are activated at once using a multisensory approach (Jensen, 1998).

Elementary teachers interviewed for this study concurred with the findings of Ozden and Gultekin (2008). Study participants described students as more engaged and excited during activities that required them to work in groups, discuss their learning, ask questions, and have some choice in the direction of a project or the way that new learning was presented. All but one study participant appeared to use these strategies based on their observations of students and their general understanding of best practices. This was at least in part due to the finding that there was a general lack of awareness of brain-based learning by teacher participants.

These findings imply there is lack of communication between the fields of neuroscience and education. Teachers in the study were intuitively arriving at the use of some brain-based strategies but were unaware of the research supporting the implementation of those strategies so they could not be purposeful in their implementation. Teachers will require direct instruction on brain-based learning, as well as information about organizations such as Mind, Brain, and Education (Tokuhama-Espinosa, 2011) whose mission is to bridge the fields of neuroscience, psychology and education. Teachers in this study were interested in learning more about brain-based learning theory and asked to keep the handouts for future reference.

A study conducted by Serpati and Loughan (2012) concluded that more experienced classroom teachers felt it was important for teachers to understand the basic neurological foundations of learning and cognition as well as behavior. Teachers in the study conducted by Serpati and Loughan (2012) also rated the relevance to the classroom as high in terms of the application of neuroscience research in education. Teachers in this study were also interested in learning more about brain-based learning and often commented after the interview that they would like to learn more about how to implement brain-based strategies in the future.

The findings also imply that there should be some sort of organizational framework for lesson design and instruction informed by brain-based learning theory.

Such a framework would ensure that teachers purposefully include brain-based learning strategies supported by research into their lesson design. Without a lesson framework, (McTigh et al., 2004) teachers in the study were unable to purposefully design meaningful learning experiences for their students that considered neurological processes and brain-based strategies. Teachers in this study described activities as being fun, or engaging, but they were unable to articulate the larger learning goals and the reasoning behind the lesson design. While an experienced teacher should not need to write a lesson plan for every lesson, there should be some framework available for ensuring the essential elements of a lesson are there. Ideally, the framework would include prompts or questions aligned to brain-based learning, such as Jensen's (2008a) seven stages of brain-based planning.

Finding 3: There is no Comprehensive Effort to Integrate Brain-Based Learning into Teacher Preparation Programs. Research question 3 explored to what extent current elementary teachers learned about brain-based learning theory and strategies in their teacher preparation programs. The literature shows that teacher attitudes toward teaching and learning develop early, and that teacher preparation programs can have a profound influence on how inexperienced teachers design and implement instruction (Kaylar and Ari, 2016). The study found that elementary teachers could not recall learning about brain-based learning theory in their undergraduate or graduate teacher preparation programs. Teachers who participated in the study could recall learning about certain strategies in their student teaching placements and fieldwork placements, but none could recall any classes that were aligned with brain-based teaching theory.

The study examined the current curriculum used at three different teacher colleges in the Western County area. All four faculty members interviewed reported a very limited integration of brain-based learning strategies in the existing teacher preparation curricula. Two of the four faculty members interviewed had a working knowledge of the current neuroscience research as it pertained to brain-based learning and made an effort to integrate some basic concepts into the courses included in the existing teacher preparation programs. The other two faculty participants reported that they implemented strategies that were somewhat aligned with the concepts of brain-based learning but did not purposefully plan the integration of brain-based learning. Faculty participants all agreed that preservice teachers could benefit from learning more about neuroscience research and brain-based learning theory. This would imply the need to add or integrate brain-based learning to the existing curriculum.

All four higher education faculty interviewed suggested that if there was to be more integration of brain-based learning theory, it would likely need to be layered onto the existing curricula. Faculty participants felt that brain-based learning theory would pair easily with the content that was currently included in classes being offered and felt that the integration would have to be explicitly connected especially regarding the terminology and concepts associated with neuroscience education. Because there is little room to adjust the required curriculum in teacher preparation programs, it would be difficult to add an entire class and additional credit hours. For this reason, explicitly linking brain-based learning theory and practices to existing curricula would be practical and advisable.

This finding implies that there needs to be a more conscious effort to integrate education of the human brain's structures and functions into the existing teacher preparation curricula. In addition, this finding implies that the neurological underpinnings of learning need to be more explicitly taught in association with the learning strategies. Teachers who understand the research and how that translates into practice will be better prepared to meet the diverse learning needs of students in a general education setting. Faculty in teacher preparation programs need to find ways to educate themselves about brain-based learning theory and the related strategies. Faculty also have to examine the existing curricula and make decisions about how to integrate brain-based learning. This may require a philosophical shift for faculty as three faculty reported that they taught from a sociocultural paradigm. The finding also implies faculty may require direct instruction on brain-based learning.

Limitations

There were two limitations to the study. The first limitation was that the study included only teachers from suburban districts. It would have added to the study to include the experiences of teachers from an array of district types to compare their experiences with brain-based learning.

The second limitation was that the study only included elementary teachers. Since there appeared to be a gap in the literature regarding studies conducted with elementary age students, teachers of middle and high school age students were not included in this study.

Recommendations

The findings of this study resulted in recommendations for institutions of higher education, general education instructional leaders, and future research. The following sections include four recommendations for general education instructional leaders, two recommendations for higher education faculty, and two recommendations for future research.

General education instructional leaders. This study led to four recommendations for teachers and leaders in general education. First, it is recommended that educational leaders, such as superintendents and assistant superintendents for instruction, examine existing policy around curriculum and testing practices. According to the principles of relaxed alertness and orchestrated immersion (Caine & Caine, 1994), teachers need to create a classroom environment that has high-challenge, low threat, and allows students to engage in rich, complex learning experiences. In the case of frequent high-stakes testing, there is a narrowing of the curriculum and an increase in the use of rigid, scripted programs (Berliner, 2011).

Welner (2014) asserts that the accountability approach to education is counterproductive and unwise, with a large body of research to support that conclusion. Teachers in this study were not asked specific questions about high stakes testing, but when they were discussing scripted programs that were required for test preparation, their demeanor changed, and they spoke with less enthusiasm. However, when teachers in this study were discussing units they designed that were cross-curricular and allowed for choice, creativity, collaboration and communication, they demonstrated more enthusiasm. Teachers in this study also described students as demonstrating a much higher level of engagement when they were immersed in learning that employed brain-based learning strategies. Therefore, it is recommended that existing curriculum and high-stakes testing practices be reexamined to ensure the integration of basic brain-based concepts.

The reexamination of curriculum and testing practices should be led by the superintendent or the assistant superintendent for curriculum and instruction. Using the theoretical framework of brain-based learning, districts can identify where the alignment to brain-based learning is strong and where the alignment is weak. In areas where the alignment is weak, with input from teachers, the curriculum should be revised to include units of instruction that are challenging, complex and require problem solving, collaboration and communication.

Second, it is recommended that school districts offer training in brain-based learning strategies to all teachers including basic education on the structures and functions of a typical human brain. Since the literature shows that the implementation of brain-based learning strategies can positively impact student attitudes, motivation, and academic achievement, it is recommended that teachers purposefully plan and implement lessons aligned with brain-based learning. To accomplish this, school district leaders, with input from teachers, need to establish a theoretical foundation for teaching and learning. Brain-based learning could serve as the theoretical foundation that can then be aligned with existing curriculum and policy. This requires professional development in brain-based learning theory for all teachers and administrators, specifically incorporating the three main concepts defined by Caine and Caine (1994): relaxed alertness, orchestrated immersion and active processing. Professional development should also include the 12 principles of brain-based learning outlined by Caine and Caine (1994) as well as the seven stages of brain-based planning outlined by Jensen (2008a) as both provide a framework for understanding brain-based learning theory and specific strategies that teachers can integrate brain-based learning theory into their lessons.

Dubinsky's Brain-U is a model that could be appropriate to use when considering professional development (Dubinsky et al., 2013). This study found that only one elementary teacher participant had a working knowledge of brain-based learning and could articulate how she was weaving the strategies into the design and implementation of instruction. Teachers who do not have any knowledge about brain-based learning cannot purposefully integrate the concepts and strategies into lessons and units of study. At best, they will intuitively arrive at the use of some of the strategies and concepts of brain-based learning unknowingly, as was the case in this study. If school districts cannot find anyone that is knowledgeable in the area of brain-based learning, it is recommended that they take advantage of training workshops and webinars that are available through organizations such as Association for Supervision and Curriculum Development; Mind, Brain, and Education; and Learning and the Brain (Tokuhama-Espinosa, 2011).

Third, it is recommended that school facilities design be examined through the lens of brain-based learning. Elements that impact learning such as lighting, flexible seating, music, scent and movement throughout the day should be considered when examining the physical space that students inhabit during the school day. Many teachers interviewed for this study spoke of incorporating flexible seating options, as well as using music and lighting to create a safe and supportive classroom environment. Environmental supports that are aligned with brain-based learning could potentially help in creating a state of relaxed alertness in classrooms, thus it is recommended that school districts examine those elements and how they could potentially be modified to create a space that is brain friendly (Jensen, 2000).

Fourth, it is recommended that districts require a standard lesson planning framework. Of the seven teachers that were interviewed for this study, only one was required to write daily lesson plans and only three could produce a lesson planning document for the researcher. When asked, teachers who did not plan out lessons said that they often felt unprepared and sometimes missed essential skills and content. While experienced teachers do not necessarily need to write a full lesson plan for each subject, they cannot purposefully integrate brain-based learning strategies when planning for instruction without a lesson planning framework. Districts who adopt a brain-based theoretical framework may find Jensen's (2008a) seven stages of brain-based planning could provide an appropriate outline for teachers to use when lesson planning.

Jensen's (2008a) framework for the seven stages of brain-based planning provides both the stages as well as examples of activities that might be included during each stage. For this reason, the stages provide a practical means of applying a process of planning for instruction that is aligned with brain-based learning theory. The stages described are also loosely aligned to the Madeline Hunter (1976) framework for planning that teachers in the study appeared to be more familiar with. Aligning the new Jensen (2008a) framework with the more familiar Hunter (1976) framework would assist teachers in making the shift to a brain-based approach.

Departments of education at institutions of higher education. This study led to findings that resulted in two recommendations for teacher preparation programs in higher education institutions. First, increase the amount of brain-based learning theory and strategies presented to preservice teachers in teacher preparation programs. This will require becoming more familiar with brain-based learning theory and the related teaching strategies in order to make decisions about what content to integrate into the existing curriculum. Two of the four higher education faculty interviewed were familiar with recent neuroscience research and were incorporating general concepts into foundational classes. The other two faculty participants were less familiar and could not say with certainty how brain-based learning theory and strategies or neuroscience research was being integrated into the curriculum. All four faculty participants felt that there could be a more direct integration of brain-based learning concepts into the existing curriculum, which leads to the second recommendation.

Departments of education in institutions of higher learning should examine the existing teacher preparation program curriculum to find ways to include more information about brain-based learning and neuroscience education. This recommendation requires departments of education to make decisions about how to best integrate the brain-based learning concepts and strategies. There was agreement among faculty participants that it would be relatively easy to examine and integrate brain-based learning into the existing curriculum rather than adding on a separate course. There is a natural alignment between the cognitive processes of learning that were already part of the curricula and the neurological processes and related teaching strategies aligned with brain-based learning. In order to effectively incorporate brain-based learning, education departments need to examine the Mind, Brain, and Education program at Harvard University (Tokuhama-Espinosa, 2011). This program could provide an appropriate model for the integration of current neuroscience research as well as foundational research in brain-based learning such as Caine and Caine (1994) and Jensen (2008a).

While the actual program created at Harvard University could not be replicated exactly, the framework used to create the curriculum could be used to create or enhance classes that would allow preservice teachers to learn about the child through the lenses of cognition, behavior, socialization/culture, emotion and physiology/neurology. Teachers would potentially have a better understanding of the basic structures and functions of a human brain, including basic cognition, memory systems and the role of emotions in learning. Teachers would also potentially have a better understanding of behavior and the importance of social development and cultural awareness in addition to a basic understanding of cognition. This knowledge could potentially assist new teachers in creating a classroom that supports the natural learning systems in the brain, which could lead to better learning outcomes for students.

Future research. First, future researchers should examine the extent to which middle and high school teachers are planning and implementing brain-based learning theory and strategies. Since this study focused on elementary teachers, it would also be helpful to explore the extent to which there is knowledge and implementation of brain-based learning at the middle and high school levels. This information would help to create a more thorough understanding of the level of awareness and implementation of brain-based learning theory and strategies on the K-12 continuum.

Second, future studies should include teachers in an array of types of districts including urban and rural settings. This study focused on teachers in suburban districts but including teachers from other types of districts would help with a broader understanding of what about brain-based learning theory is known and understood.

Conclusion

The qualitative study explored what current elementary teachers know about brain-based learning, how teachers were implementing brain-based learning strategies in planning and teaching practices, and to what extent that knowledge came from teacher preparation programs. Brain-based learning theory was used as the lens through which to explore and interpret the data. The findings revealed that elementary teachers were largely unfamiliar with brain-based learning but often unknowingly implemented strategies aligned with brain-based learning theory. Study findings also revealed that brain-based learning theory was minimally integrated into the curriculum of teacher preparation programs.

A qualitative methodology was used to explore the research questions associated with this study. Semi-structured, face-to-face interviews were conducted with seven elementary teachers and four higher education faculty. A gap in the literature showed that there were few qualitative studies describing what strategies were being implemented in a typical classroom. The study focused on elementary teachers because there was only one study in the literature that pertained to elementary students. Participants shared their understanding of brain-based learning, how they were implementing specific strategies and to what extent that understating was acquired in a teacher preparation program. In addition to interviews, the study included field notes and sample lesson plans to triangulate the data. The study uncovered several findings.

Study findings revealed that elementary teachers know very little about brain-based learning theory or the strategies associated with creating a brain-friendly classroom. Because of this lack of understanding, teachers were largely unaware when they were implementing brain-based learning strategies in their planning and instructional practices. In addition, study findings revealed little instruction regarding brain-based learning is incorporated into teacher preparation programs. However, higher education faculty all agreed that brain-based learning concepts and strategies could easily be incorporated into the existing curriculum because they are so closely associated with the principles of cognition already included. These findings have several implications.

Implications to general education include the reexamination of existing practices and curricula to include more brain-based strategies. To accomplish this, district leaders would have to provide ongoing professional development for teachers based on the theoretical framework of brain-based learning. In addition, districts would need to provide structure around planning practices to ensure teachers include brain-based strategies in lessons and units. Implications to higher education teacher preparation programs include purposefully integrating brain-based learning with the content that is already part of the existing curricula, ensuring that preservice teachers have at least a basic understanding of the human brain and brain-based learning theory. This would require faculty to seek out information about brain-based learning theory and understand how to translate the research into practice.

The study could impact the teaching practices of elementary teachers and the ecology of an elementary classroom. This study could also impact the content of teacher training programs, including more information and training on the basic structures and functions of the human brain as they relate to brain-based learning theory. Since the human brain is the main organ of learning, it is logical to include instruction on the neurological underpinnings of learning and the implications to lesson design in teacher preparation programs as well as professional development for in-service teachers. Models such as Brain-U (Dubinsky et al., 2013) and Mind, Brain, and Education can serve to inform efforts to include brain-based learning in both general education teacher training and higher education teacher training.

The study also has implications for executive leaders in school districts. School district leaders need to be aware of the current research as well as its application to teaching and learning. Executive leaders should seek out research that could lead to better learning outcomes for all students, such as brain-based learning theory, and then use that research-based theoretical foundation to inform policy, procedures and professional development. It is easy for leaders to get caught up in trends in education that come and go. It is imperative that executive leaders are wary of these trends and find legitimate research to support or rebuff the trends so that they can make informed decisions about how they are to committing resources.

Brain-based learning theory is supported by the research and has been tested over the last 30 years. It has been proven to positively impact student attitudes, motivation and academic achievement. Executive leaders at both school districts and higher education institutions should work to provide teachers with the knowledge and skills necessary to create safe, supportive learning environments that provide challenging, complex learning experiences aligned with the natural learning processes of the human brain.

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Appendix A

Twelve Principles of Brain-Based Learning (Caine & Caine, 1994)

1. The brain is a parallel processor; it can do many things at one time.

2. Learning engages the entire physiology.

3. The search for meaning is innate; it is survival oriented and basic to brain function.

4. The search for meaning occurs through patterning, which is the meaningful organization and categorization of information.

5. Emotions are critical to patterning; what we learn is influenced and organized by our emotion and mind sets.

6. The brain processes parts and wholes simultaneously; both hemispheres are always working together

7. Learning requires both focused attention and peripheral perception; the brain is able to absorb information it is directly aware of and also indirectly aware of.

8. Learning always involves conscious and unconscious processes; we recall an entire experience, not just what we are told.

9. We have at least two types of memory; spatial (instant memory) and rote memory (for facts and skills learned in isolation)

10. We understand and recall facts and skills better when they are embedded in natural, spatial memory.

11. Learning is enhanced by challenge and inhibited by threat.

12. Each brain is unique.

Appendix B

Data Collection Tool: Teacher Interview Protocol

Introduction: Thank you for taking the time to meet with me today. The purpose of this study is to explore what elementary teachers know about brain-based learning, how they apply it either knowingly or unknowingly to lessons, and to what extent that knowledge came from their teacher training program. Therefore, I would like to ask you some questions about your current practice as it relates to brain-based learning theory and strategies. I would also like to explore your practices related to planning for instruction. The second part of the interview will involve a review of a typical lesson plan you use in your classroom.

My study is about brain-based learning strategies and how they are implemented into a typical elementary classroom. It is stated in the information, but I want to emphasize again that what you share with me will remain confidential. To ensure confidentiality, I will assign pseudonyms to participants, focus on overall study themes, and avoid linking any statements to individual names. In addition, when not in use, related interview documents will be secured in a locked file and kept for three years after the successful defense of the dissertation and then destroyed.

I want to be sure to capture all of your responses and also review the interview at a later time. Do I have your permission to record this interview?

Opening Statement: Let me take a moment to review Jensen's seven stages of brain-based planning and the process of brain-based learning with lesson planning as well as the 12 principles of brain-based learning according to Caine and Caine. (I will review Jensen's seven stages of brain-based planning using appendix G, and Caine and Caine's 12 principles of brain-based learning using appendix A.) Tell me about your experience with brain-based learning in your classroom and where you may see some evidence of brain-based learning in your own lesson planning document.

Main Questions:

Teacher Interview Question 1: Describe what you know or think you know about brain-based learning?
Follow-up question: Can you describe the physical set up of your classroom? What would I see if I came to visit?

Teacher Interview Question 2: Based on the information that we just reviewed, what strategies or practices are you currently using in your classroom that you would consider to be brain-based?
Probing question: Can you describe them?
Probing question: How did you come to use those particular strategies in your lessons?

Teacher Interview Question 3: Is there a district lesson planning framework or document that you currently use when planning for instruction?
Probing question: Why do you use that process or framework?
Probing question: What do you see as the advantages and disadvantages to the framework?

Teacher Interview Question 4: Describe the ways you provide exposure to new learning concepts and skills for students?
Probing question: Describe experiences you have had using strategies such as brainstorming, KWL charts, mind mapping or other strategies that help prime students' minds for new learning.

Teacher Interview Question 5: Describe strategies that you use to create curiosity and excitement as you prepare students for a new unit or lesson?
Probing question: Describe a lesson that asked students to make a personal connection to a new topic of learning?
Probing question: Describe how you create novelty and hook students or engage their emotions.

Teacher Interview Question 6: How do you currently provide learning experiences that engage students in the topic or content?
Probing question: What kinds of activities seem to engage students the most?
Probing question: In the lesson you brought, tell me about an example that would get students engaged.

Teacher Interview Question 7: In what ways do you check for student understanding and confidence with new concepts?
Probing question: Which strategies appear to get the best response from students?
Probing question: How much time do you typically provide students to reflect, journal, review, or discuss their learning?

Teacher Interview Question 8: Now that you are a little more familiar with brain-based learning, what concepts were covered during your undergraduate or graduate program?
Follow-up question: Can you describe the content and spirit of the classes you took regarding brain-based learning?

Closing statement: Our interview is ending. Is there anything else that you would like to discuss with regards to brain-based learning theory and how you are implementing it in your classroom? Thank you for taking the time to meet with me today.

Appendix C

Data Collection Tools: Higher Education Faculty Interview Protocol

Introduction: Thank you for taking the time to meet with me today. The purpose of this study is to explore what elementary teachers know about brain-based learning, how they apply it either knowingly or unknowingly to lessons, and to what extent that knowledge came from their undergraduate teacher training. Therefore, I would like to ask you some questions about your current teacher training program as it relates to brain-based learning theory and strategies. I am interested in gaining a better understanding of how much brain-based learning theory is part of teacher training programs and so, would like to ask you some questions that will help me understand the current design of your program.

My study is about brain-based learning strategies and how they are implemented into a typical elementary classroom. It is stated in that information, but I want to emphasize again that what you share with me will remain confidential. To ensure confidentiality, I will assign pseudonyms to participants, focus on overall study themes, and avoid linking any statements to individual names. In addition, when not in use, related interview documents will be secured in a locked file for three years after the completion of the current research.

I want to be sure to capture all of your responses and also review the interview at a later time. Do I have your permission to record this interview?

Opening Statement: I want to take a moment to review Caine and Caine's 12 principles of brain-based learning (Appendix A) and Jensen's seven stages for planning (Appendix G). Can you describe the current requirements and curriculum of your undergraduate teacher training program?

Higher Education Faculty (HEF) Interview Question 1: Can you tell me about any courses that include brain-based learning theory integrated into the curriculum?
Follow up: Can you give me an example of a class you believe teaches methods that are aligned with current neuroscience research or brain-based learning theory?

HEF Interview Question 2: In what ways is brain-based learning theory incorporated into the existing curriculum?
Probing question: How could the existing curriculum allow for the inclusion of brain-based learning theory and strategies without adding credit hours?

HEF Interview Question 3: How is brain-based learning being incorporated into methods classes, field experiences and student teaching experiences?

Probing question: How are students encouraged to integrate brain-based learning strategies when planning for instruction during student teaching placements?

HEF Interview Question 4: If brain-based learning theory was a more integral part of the existing teacher preparation program curriculum, what would that look like?
Probing question: Where do you see that fitting into the current program?

HEF Interview Question 5: What potential benefits do you see to increasing the amount of brain-based learning theory students learn and incorporate into their practice?
Probing question: What are potential barriers to increasing brain-based learning theory into the existing courses?

Closing statement: As our interview draws to a close, can you think of anything else you would like to discuss with regards to brain-based learning that may be relevant to my study?

Appendix D

Introduction Email and Study Information (Teacher)

Date,

Dear (insert teacher's name),

My name is Gina DiTullio. I am an assistant principal at a local school for students with special needs. In addition, I am a doctoral candidate in the Executive Leadership Program at St. John Fisher College. I am conducting a research study as a requirement of my Ed.D. degree in Executive Leadership. I would like to invite you to participate in the study and allow me to interview you.

The topic of my study is an examination of planning and implementing brain-based learning strategies in the elementary classroom, and how teachers learned about those strategies. I plan to interview current elementary teachers in public elementary schools in the Western County area of New York State. I am interested in learning about what strategies you might use when planning and implementing instruction, and the lesson planning process that you are using in the classroom.

The interview will take place at a place in a mutually convenient location and time, and will take approximately 45 - 60 minutes. The interviews will be audio-recorded. There is no preparation required for the interview. Your participation or non-participation in this research study will not impact your evaluation or reputation in any way.

If you participate and become uncomfortable answering the questions, you can choose not to answer. Participation in this study is voluntary and you may withdraw your participation at any time. Pseudonyms will be assigned to all participants. The participant's name and identifying information will remain confidential and will not appear in transcripts, analysis, or the final study. Written transcripts will be stored in an office in a locked cabinet accessible only to the researcher for a period of three years after the successful defense of the dissertation and then shredded. When not in use, the audio and electronic files of the data, as well as interview transcriptions, will be secured on a password protected hard drive in and office and will be placed in the same cabinet with access only to the researcher for a period of three years after the successful defense of the dissertation and then destroyed.

In appreciation of your willingness to meet with me for the interview and your time, you will receive a small Amazon gift card at the completion of the interview.
Thank you for your consideration. If you would like to participate, please contact me to schedule an interview by email at gd02178@sjfc.edu or by phone at (585) xxx-xxxx.

Also, you may contact me with any questions or concerns you may have.
Participant information will be kept confidential by assigning pseudonyms to participants and securing all interview materials and recordings on a password protected hard drive and locked cabinet. This information will be reviewed again at the time of the interview and you will be asked to sign the Informed Consent Form prior to participation.

Sincerely,

Gina DiTullio
Education Doctoral Candidate, Executive Leadership
St. John Fisher College, Rochester, NY

Appendix E

Introduction Email and Study Information (Higher Education Professional)

Date,

Dear (insert professor's name),

My name is Gina DiTullio. I am an assistant principal at a local school for students with special needs. In addition, I am a doctoral candidate in the Executive Leadership Program at St. John Fisher College. I am conducting a research study as a requirement of my Ed.D. degree in Executive Leadership. I would like to invite you to participate in the study and allow me to interview you.

The topic of my study is an examination of planning and implementing brain-based learning strategies in the elementary classroom. I plan to interview current elementary teachers in the Western County area of New York State. In addition, I plan to interview education faculty that are affiliated with undergraduate teacher training programs. I am interested in learning about your knowledge of brain-based learning theory and to what extent brain-based theory is part of the teacher training programs.

The interview will take place at a place in a mutually convenient location and time, and will take approximately 45 - 60 minutes. The interviews will be audio-recorded. There is no preparation required for the interview. Your participation or non-participation in this research study will not impact you in any way.

If you participate and become uncomfortable answering the questions, you can choose not to answer. Participation in this study is voluntary and you may withdraw your participation at any time. Participant information will be kept confidential. Pseudonyms will be assigned to all participants. The participant's name and identifying information will remain confidential and will not appear in transcripts, analysis, or the final study. Written transcripts will be stored in an office in a locked cabinet accessible only to the researcher for a period of three years after the successful defense of the dissertation and then shredded. When not in use, the audio and electronic files of the data, as well as interview transcriptions, will be secured on a password protected hard drive in and office and will be placed in the same cabinet with access only to the researcher for a period of three years after the successful defense of the dissertation and then destroyed.

In appreciation of your willingness to meet with me for the interview and your time, you will receive a small Amazon gift card at the completion of the interview.
Thank you for your consideration. If you would like to participate, please contact me to schedule an interview by email at gd02178@sjfc.edu or by phone at (585) xxx-xxxx.

Also, you may contact me with any questions or concerns you may have.
This information will be reviewed again at the time of the interview and you will be asked to sign the Informed Consent Form prior to participation.

Sincerely,

Gina DiTullio
Education Doctoral Candidate, Executive Leadership
St. John Fisher College, Rochester, NY

Appendix F

St. John Fisher College
INFORMED CONSENT FORM

Title of Study: An Examination of Planning and Implementing Brain-Based Strategies in the Elementary Classroom

Name(s) of researcher: Gina DiTullio (585-xxx-xxxx)

Faculty Supervisor: Dr. Marie Cianca (585-xxx-xxxx)

Purpose of Study: The purpose of this study is to learn the extent to which brain-based learning theory and strategies are known and implemented in the planning and teaching practices of elementary teachers. The study also aims to explore to what extent teachers learn about brain-based strategies in undergraduate teacher preparation programs.

Place of study: Various. The in-person interviews with teachers and higher education faculty will be kept within a 50-mile radius of the schools and institutions, at locations chosen by participants. Interviews will take place in person.

Length of participation: One interview lasting no more than 60 minutes.

Risks and benefits: The expected risks and benefits of this study are explained below.

Minimal risk exists, as the probability of and magnitude of harm or discomfort anticipated in the research are not greater in and of themselves than those ordinarily encountered in daily life or during routine tests. Participants will be audio-recorded during interviews. There are no additional anticipated emotional or physical risks associated with participating in this study. Participation or non-participation in this research study will not impact volunteers in any way. By participating in this study, participants will contribute to study results, which will add to the current body of research on the implementation of brain-based learning strategies in elementary classrooms.

Method for protecting confidentiality/privacy: All consent is voluntary. Pseudonyms will be assigned to all participants. Participants name and identifying information will remain confidential and will not appear in transcripts, analysis, or the final study. Written transcripts will be stored in an office in a locked cabinet accessible only to the researcher for a period of three years after the successful defense of the dissertation and then shredded. When not in use, the audio and electronic files of the data, as well as interview transcriptions, will be secured on a password protected hard drive in and office and will be placed in the same cabinet with access only to the researcher for a period of three years after the successful defense of the dissertation and then destroyed.

Your rights: As a research participant, you have the right to:

1. Have the purpose of the study, and the expected risks and benefits fully explained to you before you choose to participate.
2. Withdraw from participation at any time without penalty.
3. Refuse to answer a particular question without penalty.
4. Be informed of appropriate alternative procedures or courses of treatment, if any, that may be advantageous to you.
5. Be informed of the results of the study.

I have read the above, received a copy of this form, and I agree to participate in the above-named study.

___________________________ ___________________________ ___________

Print Name (Participant) Signature Date

___________________________ ___________________________ ___________

Print Name (Investigator) Signature Date

If you have any further questions regarding this study, please contact the researcher above. If you experience emotional or physical discomfort due to participation in this study, please contact your health care provider or local crisis provider.

The Institutional Review Board (IRB) of St. John Fisher College has reviewed this project. For any concerns regarding this study and/or if you experience any physical or emotional discomfort, you can contact Jill Rathbun by phone at 585-385-8012 or by email at irb@sjfc.edu

Appendix G

Handout to be used during interview protocol

The Seven Stages of Brain-Based Planning (Jensen, 2008a)

Stage	Description	Examples
Stage 1: Pre-exposure	Provides the brain with an overview of the new learning and helps the brain develop better conceptual maps	1. Post an overview of the new topic 2. Figure out what students already know about the topic and begin lesson planning there 3. Build strong, positive rapport with learners
Stage 2: Preparation	Create curiosity or excitement. Similar to the "anticipatory set" but goes a bit further in preparing the learners.	1. Create a real-world grounding experience 2. Create personal connections to the topic for each learner 3. Provide something concrete or experiential to build from
Stage 3: Initiation and Acquisition	Provides immersion; allows learners to be momentarily overwhelmed with new information and creates a desire to make sense of it	1. Provide concrete learning experiences 2. Provide choice and opportunity for students to explore 3. Offer group or team projects that encourage creativity

Stage 4: Elaboration	Processing stage; requires genuine thinking and urges students to make intellectual sense of new learning	1. Provide an open-ended debriefing 2. Have learners design an evaluation rubric 3. Have students do the teaching
Stage 5: Incubation and Memory Encoding	Downtime and review time	1. Provide time for unguided reflection 2. Have learners take a walk and discuss the topic 3. Ask learners to discuss new learning with peers or family members
Stage 6: Verification and Confidence Check	Learners confirm their learning for themselves as well as the teacher	1. Have learners present their new learning to others 2. Ask students to interview and evaluate each other 3. Quiz students, or have them quiz each other
Stage 7: Celebration and Integration	Engage emotions; make it fun and instill the love of learning	1. Provide class sharing time 2. Facilitate class-designed celebration 3. Incorporate the new learning into future lessons