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Brain Based Learning: K-12 Teachers' Preferred Methods of Science Instruction

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Brain Based Learning: K-12 Teachers' Preferred Methods of Science Instruction

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by

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ABSTRACT

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The purpose of this quantitative study was to investigate Brain Based Learning (BBL) techniques in teaching science. Participants included 216 K-12, full-time, regular education teachers from 8 Northeast Tennessee school systems who taught at least 1 science class. Specifically this research was guided by 7 research questions on teachers' perceptions and practices in teaching science.

Data were collected by a survey that consisted of 82 statements where teachers rated their level of agreement and was distributed online via Survey Monkey. The first portion of my survey included demographic identifiers, teachers' knowledge of the term BBL, and inquiries regarding science background and training. The remainder of the statements were focused on teachers' perceptions and practices of BBL strategies in teaching science. The final item was open-ended and allowed teachers to share comments related to teaching science. For statements 6-81, participants responded by using a 5-point Likert scale that ranged from 1 (*strongly disagree*) to 5 (*strongly agree*). Quantitative data were analyzed with a series of independent samples *t* tests, one-way analysis of variance tests, and a Pearson correlation coefficient.

The results of the study indicate that teachers' perceptions are positively correlated to their self-reported practices. Females, in general, and elementary teachers tend to practice BBL strategies in teaching science significantly more than other subgroups.

DEDICATION

This work is dedicated to my family. You gave me the encouragement and time needed to see this study to fruition. To my husband Philip, you've never known a time in our relationship when I wasn't working on my doctorate! Your encouragement and belief in me have truly been the wind beneath my wings. To my son Ben, I hope the example I have modeled in terms of hard work and perseverance gives you the belief and encouragement to achieve your own dreams. I love you both with all of my heart.

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CHAPTER 1

INTRODUCTION

With increased demands on educators to improve students' performance on standardized tests, teachers are continuously searching for innovative ways to achieve this goal. Moreover the Common Core State Standards are expected to be fully implemented by 2015-2016. The Tennessee State Department of Education's TN Core (2011) website maintains that the Common Core objective is to "ensure every student graduates high school prepared for college or the workforce" (para. 1). Although the Common Core standards focus mainly on Math and English Language Arts (ELA), science is often incorporated during the ELA block. The standards are more rigorous and more thought provoking than past expectations. Students will be required to think in more open ended, creative, and in-depth ways. The standards are said to be internationally aligned; therefore, it is imperative for students to develop skills that will allow them to compete in a global economy. ACT cutoff scores for science are higher than any other discipline, therefore improving science readiness is crucial (ACT, 2013).

With increased pressures to achieve, Ansari and Coch (2006) acknowledged that it could be beneficial to investigate new avenues of improving education by exploring neuroscience techniques. Neuroscience, or brain research, has received tremendous attention because of the advancements in brain neuroimaging (Bandettini, 2009). Neuroimaging brain scans have deepened our understanding of how the brain functions. By displaying different colors on a computer screen as heightened brain activity occurs, scientists are able to see how the brain learns (Asbury, 2011). Because brain research is still relatively new, very little of the information has been integrated consistently in the mainstream educational setting (Jensen, 2008a).

Teacher effectiveness matters (Darling-Hammond, 2000a). Effective teaching begins with teacher knowledge of the subject area and genuine caring for children. Students who have a positive relationship with the teacher have a sense of belonging in the school environment (Penner & Wallin, 2012). Beyond the aforementioned criteria for effective teaching, understanding how the brain learns could provide teachers with another avenue for reaching their students. Goswami (2004) reported that neuroscience is a relatively new branch of science that examines how the brain functions. In fact, as Wolfe and Brandt (1998) said, brain research is so new that approximately 90% of all neuroscientists who have ever lived are alive today. As teachers increase their knowledge of the dynamics of brain functioning, teaching techniques will transform into meaningful learning experiences (Caine, Caine, McClintic, & Klimek, 2005). In this age of accountability what and how we teach are critical for student achievement (Radin, 2009). "Technologies deriving from the cognitive and brain science" is expected to be the "next frontier" for education (Battro, Fischer, & Lena, 2008, p. 10).

Continuing to teach with the same antiquated techniques will produce the same results. A lesson is considered effective only if students learn the content (Sousa, 2011). Jensen (2008a) suggested that tapping into what is known about neuroscience or brain research could assist educators in developing inroads to improve student success.

Statement of Purpose

The purpose of this study was to examine K-12 regular education teachers' perceptions and practices of BBL strategies in teaching science. Eight districts in East Tennessee were the focus of the study. Teachers' perceptions and practices of BBL in teaching science as it related to teacher gender, grade level taught, and teaching experience were explored. Additionally teachers' perception of BBL strategies compared to their BBL teaching practices in teaching science was also examined.

Research Questions

The following seven research questions guided this study:

RQ1: Is there a significant difference in teachers' perceptions of BBL strategies in the discipline of science among teachers based on years of teaching experience?

RQ2: Is there a significant difference in teachers' self-reported practices of BBL strategies in the discipline of science among teachers based on years of teaching experience?

RQ3: Is there a significant difference in teachers' perceptions of BBL strategies in the discipline of science among elementary, middle, and high school teachers?

RQ4: Is there a significant difference in teachers' self-reported practices of BBL strategies in the discipline of science among elementary, middle, and high school teachers?

RQ5: Is there a significant difference in teachers' perceptions of BBL strategies in the discipline of science between male and female teachers?

RQ6: Is there a significant difference in teachers' self-reported practices of BBL strategies in the discipline of science between male and female teachers?

RQ7: Is there a significant relationship between teachers' perceptions of BBL strategies in the discipline of science and their self-reported classroom practices?

Significance of the Study

Research indicates that nothing is more important in the school setting than teacher quality (e.g., Darling-Hammond, 1999; Hanushek & Rivkin, 2006; Sanders & Rivers, 1996). The foundational requirement for a quality instructor is competence in teaching the subject matter and the ability to display a genuine caring attitude for students. Once those traits are in place, along with established classroom procedures, understanding brain functionality can have a major influence on educational reform. Three common threads were evident throughout the explored research on brain based learning. First and foremost, children need to feel loved and safe in a nurturing learning environment (Ginsburg, 2007). Second, the learning should be relevant to real life situations; relevance provides an ambient environment where meaningful learning can thrive (Jones, 2008). Last, students involved in group interactions flourish more prevalently than students who receive the majority of their instruction dominated by teacher lecture (Knight & Wood, 2005). Brain-compatible lessons are essential for all grade levels and are needed to "round out the conceptual framework" (Radin, 2009, p. 40).

Not surprisingly, research indicated that teachers understand the necessity of engaging the brain during instruction; however, there seems to be disconnect between what was known and what actually transpires in classroom. Pickering and Howard-Jones (2007) reported that there was still too much lecturing when it came to classroom instruction. Recommendations for teacher training in neuroscience as it relates to education were noted by several sources.

Educational pressures to excel are a continuous reality in education. The major factor contributing to student success is the teacher. If the teacher is knowledgeable in the content area, displays a caring attitude for children, provides a safe nurturing environment, and has established classroom procedures, the method of instruction is considered to be the next greatest contributing factor in student success. Brain Based Learning (BBL) strategies are techniques that teachers can implement to promote a positive learning environment for the brain to collect and processes information. Fortunately, more is known about the brain than ever before and that knowledge will continue to augment. Critics caution against the oversimplification of brain research as it relates to education. As our understanding of the brain continues to improve, so should our instructional methods.

This study has provided a foundation for insight into the brain's components and functions. Additionally the study has provided researched suggestions for "brain friendly" classroom techniques. For this study, teachers' perceptions and practices of BBL in teaching science as it related to gender were examined. Furthermore, teachers' perception and practices of BBL in teaching science as it related to years of teaching experience in the classroom were explored. A comparison of grade level taught and teachers' perceptions and practices of BBL strategies in teaching science was also examined. Finally, teachers' perceptions compared to their practices of BBL strategies in teaching science were explored. The results of the study will add to the emerging body of research on BBL regarding the perceptions and practices of K-12 regular education teachers in the discipline of science.

Definition of Terms

For the purpose of this research the following definitions are provided:

Amygdala – An almond shaped structure in the brain that has been "associated with a range of cognitive functions, including emotion, learning, memory, attention and perception" (Baxter & Murray, 2002, abstract para. 1).

Brain Based Learning (BBL) – Instruction that considers how the brain makes connections and processes information (Greenleaf, 2003).

Cortex – "The 'bark' or neuron-packed outer layers of the brain in which conscious thought takes place" (McGeehan, 2001, p. 64).

Functioning Magnetic Resonance Imaging (fMRI) – A noninvasive scan that uses radio waves and magnets to produce images of the brain (Watson, 2008).

Graphic Organizers – Relevance is added to the lesson when key concepts and vocabulary are displayed in pictorial or *graphic* structure by grouping similar concepts together (Hall & Strangman, 2002).

Hippocampus – The hippocampus is the center for learning and is responsible for decision making and emotional control. Learning occurs by transforming experience into memories. (Graham, 2013).

Mirror Neurons – Neurons that are believed to assist in decoding others' behaviors and intentions as well as honing the ability to demonstrate empathy for others. Seeing others' emotions can produce similar feelings in the observer (Sousa, 2011).

Neurogenesis – Our brains' ability to create new neurons (Jensen, 2008c).

Neuromyths – Erroneous or unfounded bridges made between neuroscience and education (OECD Centre for Educational Research and Innovation, 2007).

Neuroscience – The science that allows scientists to observe human brain activity that reflects specific cognitive processes (Luck, 2005).

Positron Emission Tomography (PET) – Scans that use radioactive dye to examine the living human brain and project various color images on a computer screen (Goswami, 2004).

Plasticity – The ability of the brain to change through new experiences throughout life (Craig, 2003).

Primacy Effect – The information shared at the beginning of the lesson and generally the most remembered part of the lesson (Sousa, 2011).

Recency Effect – The last information shared in a lesson and usually the second most remembered information (Sousa, 2011).

Relaxed Alertness – The best way to deliver instruction; it is the ability to provide a challenging lesson in a low threatening environment (Caine & Caine, 1995).

Reverberation – Sounds continuing to stay in a room as the sound waves bounce off hard surfaces such as furniture (American Speech-Language-Hearing Association, 2014).

Limitations and Delimitations

There were three limitations of this study:

1. Teachers elected to participate in the survey. This self-selection may skew collected data limiting the results of the study. The number and type of participants who chose to respond to the survey may have impacted the results of the study.
2. My experience as a science coordinator who favors BBL may produce some bias that could be reflected in the study.
3. Teachers self-reported their perceptions and practices. Self-reporting could result in skewed results.

There were two delimitations of this research that potentially affect the generalizability of the study to other school systems:

1. The participants surveyed were restricted to regular education K-12 teachers who taught at least one science class during the 2013-2014 school year.
2. The participants surveyed were restricted to school systems in Northeast Tennessee.

Organization of the Study

This study is organized into five chapters. Chapter 1 includes the introduction with the statement of purpose, applicable research questions, significance of the study, definition of terms, limitations and delimitations, and the organization of the study. Chapter 2 contains a review of the related literature. Chapter 3 explains the research methodology used in the study. Chapter 4 reports the findings of the data analyses. Chapter 5 has the summary, conclusions, and recommendations for this study.

CHAPTER 2

LITERATURE REVIEW

This literature review is centered on teachers' perceptions and practices of Brain Based Learning (BBL) strategies. The review also is focused on brain functions, history of BBL, the importance of the classroom instructor, direct BBL teaching strategies, indirect BBL teaching strategies, BBL disconnect, and the future of BBL.

Brain Function

A brief review of the brain and some of its components is essential in understanding how our brains function and also in understanding the essence of BBL. The brain weighs about three pounds, is divided into two hemispheres, and is about the size of your two fists placed together. It accounts for approximately 2% of the body's weight, but uses about 25% of the oxygen and 25% of the glucose that the body consumes (D'Arcangelo, 1998). The brain is composed of 78% water with a consistency like soft butter, eggs, or yogurt (Jensen, 2005). The Brain Works Project (Brill, 2014) shared these interesting facts about the brain:

- When awake, the brain produces about 25 watts of power, enough to power a light bulb. (para. 20)
- Although the brain is responsible for our emotions, the brain itself cannot feel pain. (para. 16)

Sylwester (1995) explained that the neuron, located in the cortex, is where the actual learning takes place. It is so small that approximately 30,000 neurons could fit on the head of a pin. Each neuron is composed of a cell body, an axon, and dendrites. Craig (2003) reported that dendrites will branch and the brain's cortex will thicken as a person is exposed to environmental stimulation. The increased surface area allows more information to be transmitted between neurons. Essentially when dendrites grow, learning is occurring.

Radin (2009) reported that the brain is unique because it is the only body organ that can "sculpt itself through experience" (p. 45). Therefore, stimulating a child's brain in the early years is vital. Weill Cornell Medical College (2013) conducted a study that indicated children need healthy learning experiences along with a healthy, loving environment. Tierney and Nelson (2009) concluded that lack of a healthy, nurturing environment may cause the brain to "miswire" and lead to abnormal brain development. The first years of brain development build a bridge to later skills. A brain deprived of proper stimulation will result in strong and lasting negative effects.

In the past it was generally accepted that a person could not develop new neurons but only gain new connections between neurons resulting in new learning and memories. Others have argued that the brain could always build new neuron pathways throughout life, which promotes the idea for lifelong learning (Goswami, 2004). Scientists now know that the brain is malleable and, although exponential changes occur more prevalently in the early years, our brains have plasticity, or the ability to change through new experiences, throughout our lives (Craig, 2003). Neurogenesis is the brain's ability to create new neurons (Jensen, 2008c). In contrast to establishing new pathways, the brain also prunes unused areas. Pruning is associated with an individual's experiences; use the area and the connection thickens. However, areas that are not optimized are pruned away. Fortunately not everything endures the pruning process simultaneously. For example seeing and hearing are completed between ages four and six; however, connections that regulate self-control and emotions continue to develop throughout adolescence (Tierney & Nelson, 2009).

Naturally learning cannot take place when the learner is extremely fearful or stressed. Providing an environment where students are not intimidated to participate is considered a powerful force in improving learning (Brendtro & Mitchell, 2012). Encouraging students to learn about their classmates by mentoring and role modeling can help create an accepting school environment (Sterrett, 2012). A little stress can cause a person to act and pay attention; however, high levels of stress have a significant decrease on cognitive abilities (Roberts, 2002). All levels of stress are regulated by the amygdalae. The amygdalae and the hippocampus are located in the brain and are responsible for reasoning and problem solving. The hippocampus is the center for learning and is responsible for decision making and emotional control. It can only function when the amygdalae are not firing. The amygdalae (there are two) are threat sensors. One section of the amygdala processes tone of voice and another processes facial expressions. (Brendtro & Longhurst, 2005).

When a person perceives a threat, there is a "flight, fight, or freeze" response. The firing of the amygdalae is beneficial in extreme cases by causing the body to react quickly; however, prolonged stressful conditions can help explain impaired learning. The amygdalae can be calmed by providing a safe, nurturing environment, team building throughout the year, humor, play, and positive social interaction (Erlauer, 2003). Caine and Caine posited that "relaxed alertness" (1995, Changing the Mental Model, para. 6) is the best way to deliver instruction; it is the ability to provide a challenging lesson in a low threatening environment.

Through the use of Functional Magnetic Resonance Imaging (fMRI), scientists have located a cluster of neurons in our frontal cortex identified as *mirror neurons*. These neurons cause us to mimic behaviors we see in others. For example, everyone has experienced smiling or yawning when observing someone else engaged in a similar activity. Fascinatingly just observing someone engaged in an activity activates the same region of the brain as if the observer were involved in the activity as well. The mirror neurons are believed to assist in decoding others' behaviors and intentions as well as honing the ability to demonstrate empathy for others. Seeing others' happiness can produce similar feelings in the observer (Sousa, 2011). Likewise when teachers display negative attitudes, it can have deleterious effects on the learning environment (Jennings & Greenberg, 2009). Therefore, it is paramount for all school personnel to display warm, caring, empathetic attitudes toward their students. Notably, creating a positive learning environment can now be orchestrated with the knowledge of biological findings regarding brain functioning rather than designing a program with no reasoning for the instruction other than tradition (McGeehan, 2001).

History of Brain Based Learning (BBL)

As Mayhew and Edwards (2007) denoted, a hands-on interactive approach to classroom instruction is not a new concept. In the 1880s John Dewey, a proponent for education reform, advocated learning through a hands-on approach. His philosophy was known as experimentalism or instrumentalism. He was so convinced of the benefits of interactive learning that he and his wife opened an experimental primary school in Chicago in 1894. Later in 1919 he, along with other prominent reformists of the day, cofounded The New School for Social Research, which is still in existence today.

In 1983 Hart (as cited in McGeehan, 2001) was the first to use the term "brain-compatible" when he explained that the educational setting should be adjusted to accommodate for learning rather than teaching as usual without regard to how the brain learns. McGeehan (2001) further noted that Hart's claim received mixed reviews; some people were angered at his insinuation that the educational format of the day was deficient, while others were inspired to change.

More has been learned about the brain in the last 5 years than what was learned in the last century (Roberts, 2002). Since 1979 new knowledge has been gained through the collaborative effort between infant and animal research (Tierney & Nelson, 2009). In the 1990s advances in brain research were so exponential that this period has been denoted as the “Decade of the Brain” (McGeehan, 2001, p. 7). Neuroimaging or Positron Emission Tomography (PET) helped propel brain research. Rather than viewing the brain through an autopsy or examining animal brains, PET scans allow for the examination of the living human brain. PET scans are noninvasive but are mainly intended to examine for brain tumors by using radioactive dye and then examining the computer images for potential compromised areas. Indirectly, the PET scan measures the flow of blood to the brain. It is widely accepted that, depending on the activity, more oxygen-rich blood is transported to corresponding areas in the brain. The colors are then illuminated in various regions of the brain and displayed on a computer screen. Ten years of studying brain scans has allowed scientists to actually see how the brain learns. For example, in contrast to a well-developed brain, when a child has experienced neglect with minimal brain stimulation the difference in the neglected and normal child’s brain scans is quite astonishing (Goswami, 2004). (See Appendix A for a picture that depicts a normal brain and an underdeveloped brain due to lack of stimulation.)

Functional Magnetic Resonance Imaging (fMRI) is quickly replacing PET scans as a way to examine brain activity. PET scans rely on radioactive dye to illuminate regions of the brain, whereas fMRI is noninvasive and uses radio waves and magnets to produce images. Rather than focusing on the brain’s structure, the fMRI focuses on the how the brain functions. Simplistically, the fMRI is a medical procedure where a person’s upper body is placed inside a tube with a ring of magnets encircling the head. When the machine is activated, the magnets revolve at a high speed, "creating a magnetic field that is 500,000 times stronger than the Earth's magnetic field" (Watson, 2008, para. 2). Oxygen travels in the blood's hemoglobin that is rich in iron. As blood migrates to the activated areas of the brain, the huge ring of magnets is attracted to the hemoglobin and is able to pinpoint the region responsible for the activity within one millimeter; that is about the thickness of a dime. The images are then displayed in a colorful array on a computer screen and allow scientists to ascertain how the brain functions (Sousa, 2011). As neuroscientists continue to explore these and other techniques, knowledge of the brain will only improve with time.

The Instructor Matters

Albert Einstein proclaimed, "It is the supreme art of the teacher to awaken joy in creative expression and knowledge" (Einstein, 2007, p. 21). According to Hoy and Miskel (2005) of all the influences that affect student achievement within the school, the single most important factor is the quality of the teacher.

Hattie (2003) reported on a study conducted to determine the greatest factors influencing student performance. It was hoped that once the identifying factors were recognized, greater efforts could be imposed to strengthen the areas that created the greatest impact. Factors within the school setting such as the principal, teaching strategies, and the school climate all affect the student to some extent. Understandably, the students' ability and background, which lies outside the scope of the school's influence, rated at a 50% variance; however, the next largest factor was the teachers' influence, which accounted for 30% of the variances. "It is what teachers know, do, and care about which is very powerful in the learning equation" (Hattie, 2003, p. 2).

To illustrate the importance of school wide implementation of BBL, Caine and Caine (1995) reported on the following scenario: Dry Creek Elementary School in Rio Linda, California, was considered a dysfunctional school where the students scored poorly on standardized tests. The school was known for high student turnover with most students coming from low-socioeconomic homes. The school's personnel decided to make a change. A 3-year study was initiated to explore and implement procedures to improve instruction. They had limited resources to invest in the project; therefore, their main focus was to change the climate of the school by implementing cost-effective brain-based learning techniques throughout the school. The idea of BBL involved a shift from memorizing to making learning relevant and meaningful to the students through thematic instruction and cooperative learning. The students took an active role in evaluating the learning progress and behavior. Initially, the teachers were not forced to participate. Regardless, the majority of the teachers were onboard for the task or so they thought. Actual implementation was difficult because most of the participants wanted an instant fix. It was determined that many of the teachers lacked academic knowledge. Three major changes took place within the school. Primarily, the school focused on creating a nonthreatening but challenging environment for teachers who were given the opportunity to explore new instructional ideas. Second, it was decided that everyone should participate. All adults including the janitor and cafeteria workers were encouraged to participate in the program because everyone was considered important when impacting the life of a child. Finally, each staff person was immersed in learning communities where theories of instruction and brain based learning (BBL) strategies were translated into actual classroom practices. It was not always easy, but after 2 months the faculty became more caring and supportive of the students and of each other. After 1 year, California's educational department honored the school by recognizing it as a "distinguished" school. A gradual improvement in academic performance continued throughout the 3-year research period. Most notably were the academic improvements for the special education students.

There seems to be some discrepancy regarding which gender is most likely to teach using BBL strategies. In one case 43 school principals were surveyed; nearly all of them indicated that they thought males, rather than females, would be more likely to use interactive learning activities (Wilkins & Gamble, 2013). Contradictorily Starbuck's (2003) empirical research indicated that females were the ones who were more likely to conduct group activities.

Teacher experience matters in terms of planning. It was found that experienced teachers were able to apply more strategy alternatives to the instruction. Experienced teachers were able to meet individual needs more readily than inexperienced teachers who focused more on whole group instruction. Furthermore classroom management and the ability to vary psychomotor activities were elevated skills for the experienced teacher (Housner & Griffey, 1985). "How [educators] teach is just as important as what [they] teach" (Glasgow City Council, 2009, p. 8).

Teachers must consider students' attention spans when planning. Tate's (2007) stated rule of thumb for calculating a person's attention span is to expect 1 minute of focus time for each year of life. For example, 8-year-olds can generally sit for 8 minutes before attention span starts to wane. After that time, they need a change in activity. This formula holds true until around 20 minutes; after 20 minutes, even adults need a change in activities. The change can be subtle such as talking to a shoulder partner or more pronounced like having the students stand and add movement to a concept or switching activities all together.

Lecturing nonstop for an entire class period is detrimental to learning. Even if the class is well-behaved, students can only endure approximately 4 to 8 minutes of uninterrupted lecture before their minds start to wander and drift to other things (Perry, 2000). Sousa (2011) indicated that frequent transitions add primacy and recency to the lessons. Primacy is the information that is shared at the beginning of the lesson. Recency is the last information that is shared in a lesson. This phenomenon is not new; Ebbinghaus (as cited by Sousa, 2011) studied the primacy and recency effect as early at 1880. Sousa further proclaimed, “During a learning episode, we remember best that which comes first, second best that which comes last, and least that which comes just past the middle” (2011, p. 95). Therefore, the teacher needs to begin the class by sharing new information while the attention span is at its highest. It is not the time to read the bulletin or review homework. Teachers need to be mindful of the primacy and recency effect when planning their lessons. By transitioning to various activities throughout the lesson, more opportunities for primacy and recency exist (Glasgow City Council, 2009).

Billington, Hoelscher, Haroldson, Roehrig, and Dubinsky (2013) posited that one way to perpetuate the knowledge of BBL is for preservice teachers to learn the concept while still in college and for teachers who are already in the classroom to attend summer workshops. (Dubinsky, 2010) described one such workshop that was offered to teachers in Minnesota. The workshop was entitled BrainU and lasted for 2 weeks. It was a beginners’ neuroscience course designed with teachers in mind. Less than 20% of the workshop involved lecture; the remainder of the workshop allowed teachers to participate in inquiry-based experiments and observations that were combined with information about neuroscience. The teachers learned in a manner that they would be expected to deliver a lesson. When the participating teachers were later observed, it was determined that the teachers were using the learned brain activities. Students were more engaged, the cognitive interaction between the teachers and students had improved, and students reported enjoying science more. Even at the end of the school year, students were able to recall facts from the lesson on the brain.

Jensen (2008a) postulated that teachers attempt to change brains every day they enter a classroom. Jensen (2008a) further analogized that when people have car trouble they go to a mechanic who understands the workings of a car but probably would not go to a teacher to learn more about the brain, although each year, parents entrust their children to educators and fully expect them to develop their children's brains. Sousa (2011) indicated that educators would surely be more successful with their charges if they understood how the brain functions.

Direct Brain Based Learning Activities

BBL is not a canned program that will cure all educational woes (Craig, 2003; Sousa, 2011). While everyone is different, research has identified some strategies to improve learning for the majority of people. For example, the following are some direct strategies that can be found in brain compatible classrooms: music, graphic organizers, group work, memorable learning experiences, storytelling, involved body movement, students interacting with one another, challenging lessons, and specific and timely teacher feedback (Politano & Paquin, 2000). This list is certainly not exhaustible, nor is it necessary to implement all of these strategies at one time.

When planning a lesson, teachers must assure that the lesson has relevance (Jones 2008). Lesson relevance is the biggest indicator of student success and is achieved by making the lesson meaningful to the students' lives. The National Science Education Standards recommend that children be taught by inquiry-based lessons that also provide "meaningful, student-centered knowledge building [and] real-world settings when interactive teaching methods are used" (Foy, Feldman, Lin, Mahoney, & Sjoblom, 2006, p. 128). According to Caine and Caine (1990) when facts are learned in isolation without making a connection to former information, the brain resists and more repetition and memorization will be required. Craig indicated that, "The brain is designed to perceive and generate patterns [and] resists having meaningless patterns imposed upon it" (2003, p. 4).

Roberts (2002) recommended that teachers impose the "60/40 rule" when planning their lessons, whereby 60% of the instruction should involve material with which the students have had experiences and the other 40% should involve novel activities to create that element of surprise (Roberts, 2002, p. 283). In addition to novelty, the brain enjoys a challenge. Our brains enjoy the challenge of problem-solving activities (Brendtro & Longhurst, 2005). Therefore, each lesson should involve familiar, accurate content as well as new and delectably challenging material. Wolfe credited Madeline Hunter with saying, "Practice doesn't make perfect; it makes permanent" (1998, para. 4).

As Tate (2003) pointed out, not many jobs are completed by a sole entity. Humans are social beings and students need to be talking to one another in planned, organized groups. DeHaan (2005) reported that a survey was conducted among 123 research universities nationwide to determine what percentage of the student body was engaged in interactive instruction for introductory science classes. Disappointingly the majority of the instruction was lecture based while only a small percentage of the students (about 20% of the campuses) were involved in active science. Davis (2009) reported that regardless of the discipline, students learn better and remember information longer when they are working in small groups as opposed to receiving information through other instructional techniques. Working in groups allows the students to be engaged in the learning and increases oxygen levels as they are communicating with one another. As Tate (2002) said in one of her workshops, "The one doing the talking is the one doing the learning."

Merrell (2004) noted that the importance of music in the classroom cannot be denied in creating a productive classroom environment. Mannes's (2011) research indicated that a faster or slower tempo of music directly coincided with heart rate regardless of the genre. All cultures throughout history have incorporated music as a part of their society. In fact David Levitin (as cited by Landau, 2012), a psychologist who studies the neuroscience of music, indicated that areas of the brain that respond to language developed after areas that respond to music. Evidently Plato (as cited in Joseph, 2002) understood the power of music as is illustrated in his comment, "I would teach children music, physics, and philosophy; but most importantly music, for the patterns in music and all the arts are keys of learning" (para. 14). As Mannes further indicated, "Music's connection with heart rate, breath, and movement… means that it can *affect* these bodily functions" (2011, p. 21). Because music is such a powerful force and an integral part of our biological tapestry, it should not be overlooked when creating a brain compatible classroom (Jensen, 2000). Class content set to upbeat tunes escalates the potential for information to be implanted into long-term memory. Additionally, music can be played softly in the background as children are engaged in class assignments (Brewer, 1995).

Jensen (2000) said that, along with music, movement can be added to deepen understanding. Helgeson (2011) contended that when movement is added to lessons, classroom disruptions decrease and student participation increases. Adding movement while learning content allows information to be transferred to one of the strongest memory centers in the brain – the procedural memory center. Remembering how to ride a bike or drive a car is an example of procedural memory. Having the students implement movements to strengthen a concept will help ensure the information is remembered long after the test has passed (Tate, 2003). Teachers should use students' energy rather than fighting against it (Given, 2002).

Another component of BBL that perpetuates relevance of the content is the use of graphic organizers. Graphic organizers are known by a variety of names including mind maps, concept maps, and story maps. They are brain friendly approaches to arranging information. Graphic organizers come in a plethora of designs and can be used in an array of topic areas. Relevance is added to the lesson when key concepts and vocabulary are displayed in pictorial or graphic structure by grouping similar concepts together (Hall & Strangman, 2002). Graphic organizers are considered a roadmap for learning (Dye, 2000). According to Moore and Readence (1984) research appeared inconclusive as to whether teacher-made or student constructed organizers are better. Further research indicated that creating the organizer after the content and vocabulary had been discussed significantly expedited the learning process. Examples of graphic organizers can be found in Appendix B.

Saleh (2012) reported on a study that involved 100 high school physics students. Fifty of the students were taught Newton's Laws in interactive, brain compatible ways; the other 50 were taught in the traditional lecture manner. Not surprisingly it was found that students taught through brain research methods possessed better knowledge regarding Newton's Laws and when tested their retention was significantly better than the control (lecture) group. Mainly the approach provided to the experimental group was to eliminate fears and maintain challenging activities. The students were immersed in the learning experience through engaging in real life activities. The conclusion is that, "Learning experiences *do* help the brain grow, emotional safety *does* influence learning, and making lessons relevant can help information to stick" (Saleh, 2012, p. 109).

To further improve performance, constructive feedback should be given. Feedback has been shown to improve motivation, which, in turn, improves learning. Effective feedback should be timely, specific, and presented in a positive manner (Brookhart, 2008).

Indirect Brain Based Learning Strategies

After making the child feel appreciated and safe, establishing classroom routines and structure were seen as vital components in highly successful schools (Robinson, Lloyd, & Rowe, 2008). According to Jensen (2008c) the next most important element was to improve learning stems from the physical classroom environment. Taylor and Enggass (2009) appropriately referred to the classroom environment as "the silent curriculum." As Dyck (2002) contended the aesthetics of the environment surrounding the learner can set the stage for learning. Graetz (2006) highlighted the importance of aesthetically pleasing classrooms in creating positive emotions toward learning; these well-appointed classrooms can assist in creating a pleasant learning atmosphere that contributes to a nurturing environment. The top five indirect factors indicated by Jensen (2008c) were "lighting, acoustics, temperature, seating flexibility, and crowding" (p. 17). The Reggio Emilia Approach, named for a town in Italy, emphasizes the teacher and student as cocollaborators for instruction and the classroom environment as "the third teacher" (Gandini, 1998, p. 177).

An empirical study was conducted in the UK (Barrett, 2013) and was the first of its kind to study the impact of the physical environment on students' learning. Seven schools and 751 students were involved in the study. The conclusions indicated that if all other factors are equal concerning student ability, students in the best physical environment compared to those in the poorest environments made the equivalent of a year's additional growth in reading, writing, and math. Gee (2006) concluded that when students' physical and physiological needs are not being met they are going to be distracted and uncomfortable in their learning environment.

Often, because of logistics or school policy, teachers cannot alter the lighting in their classroom; however, because fluorescent lighting can cause agitation for some people, teachers should opt for natural lighting or use indirect lighting, such as lamps, whenever possible (Pairman & Terreni, 2001.) Johnson (2013) noted that when students are in poorly lit rooms with no control of the lighting, academic performance will be affected.

Acoustics is another area to consider. Students have difficulty paying attention when they must strain to hear the material presented. Acoustical issues can include such things as excessive noise, echoing, and reverberation. Until the mid-nineties no one seemed to be fully aware of the severity poor acoustics could have on the learning environment (Berg, Blair, & Benson, 1996.) The classroom has a constant flow of information being shared through speaking and listening; therefore, it is vital for educators to be aware of the role acoustics plays in the learning process. The noise factor is especially detrimental for children age 15 and under who are still developing speech patterns (Nelson, Soli, & Seltz, 2002).

The temperature of the room can also affect instruction. An empirical study transpired in a high school in Oregon. Students were divided into three groups and the same test was administered to each group. The room temperatures were set at 61°, 81°, and 72°, respectively. At 61°, the average test score was 76%. The room set at 81° had an average test score of 72%. At 72°, the average test score was 90% (Hadfield, n.d.). Dunn (1990) indicated that when the body is too hot or too cold, the brain constantly sends a message to the body to "do something" to correct the situation. Obviously this constant distraction makes it difficult for students to concentrate on the intended lesson. The optimal room temperature, as reported by Hadfield (n.d.), is approximately 72°.

Seating flexibility also affects the learning environment. Ridling (1994) examined three types of seating arrangements: rows, clusters, and u-shaped. The cluster or u-shaped seating arrangement both showed an increase in student interaction and collaboration when compared to the seating that was arranged in straight rows. An empirical study was conducted at the college level to examine the effect that flexible seating would have on student scores at the end of the term. Two classes were taught the same curriculum, by the same instructor, and using the same material. The independent variable, other than the time of day, was the seating arrangement; one class was set up in traditional rows while the other class used the U-shaped format. All instruction was consistent between the two classes; students in the flexible seating arrangement achieved higher scores (Neill & Etheridge, 2008). When possible, the classroom seating should be flexible so it can be altered according to the learning objective.

Allen and Hessick (2011) said that plants are inexpensive aesthetic contributors that improve the classroom environment. Han (2009) reported the findings of a study that involved 76 eighth grade students. In this empirical study, six plants were added to one classroom while none were added to the other. Students were surveyed once every 2 weeks. Although the researcher noted that other influential factors could be contributors, the group with the plants indicated significantly increased positive feelings of comfort and friendliness. They also had fewer absences and fewer behavior issues. NASA (2007) reported on environmental research that found plants are natural air purifiers that can reduce the level of airborne toxins. It was also noted that plants can have a positive psychological effect on people and those who are around plants have been shown to recover more quickly from illnesses. As Allen and Hessick (2011) concluded, with all the benefits that plants provide at such a low cost, it would certainly be advantageous to add plants to the classroom environment.

Callaghan (2013) noted that classroom aesthetics are not to be confused with mere decorations, because as previously noted the impact on learning can be quite substantial. The teacher may not be able to change all of the aforementioned factors; however, making indirect instructional changes when possible will work to the teachers' advantage during instruction.

Brain Based Learning Disconnect

According to Shore (2012) the old adage of "sit down and be quiet" is the total opposite of what should be occurring if increased learning is the objective. It is the least effective teaching practice, but unfortunately, the most used technique. Teachers need to encourage movement, learning games, role play, and other strategies that involve the student talking and moving. Chickering and Gamson (1987) found that lecture alone resulted in a 5% retention rate. When audiovisuals and discussion groups were included, the retention rate jumped to 50%. When the student had to immediately teach the information to another student, the retention rate leaped to 90%. Although dated by research standards, Chickering and Gamson offered timeless advice related to learning.

> Learning is not a spectator sport. Students do not learn much just by sitting in classes listening to teachers, memorizing prepackaged assignments, and spitting out answers. They must talk about what they are learning, write about it, relate it to past experiences, and apply it to their daily lives. They must make what they learn part of themselves. (p. 4)

Tinto and Pusser (2006) reported that research continuously reinforces the benefits of an interactive classroom, but there is still disconnect between what is known to be successful and what actually occurs in the classroom. There appears to be a contradiction between research, theory, and application. Tosun (2000) posited that the main culprits affecting science instruction appear to be time constraints, lack of pedagogical content knowledge, lack of interest by the instructor, and lack of materials. When it comes to teaching science, elementary teachers tend to attenuate it. Appleton (2013) further construed that when science is taught in the elementary grades, teachers generally tend to incorporate a science theme in their language arts classes rather than teaching science as a separate entity. Garcia (2003) conducted an empirical study and found that 30% of the teachers at one elementary school selected "lack of time" as the biggest barrier for not teaching science with an interactive approach. Allen (2006) reported three main reasons for teachers to avoid teaching science, "They don't like science, they don't feel confident in their knowledge of science, and they don't know how to teach science effectively" (p. 1).

Radin (2009) conducted a study with six exemplary teachers and 10 brain experts in an attempt to understand why the teachers were successful. The teachers completed a survey indicating their preferred instructional methods and the results were examined by the brain theorist. In each case the teacher was using brain-compatible techniques; however, they were unable to verbalize why these techniques were successful. The experts concluded that teachers are professionals and should be able to articulate why a practice is used rather than "functioning intuitively" by trial and error. Radin recommended that teachers base their teaching on scientific knowledge of how the brain learns.

The power of an interactive classroom cannot be overemphasized, as illustrated by the following study reported in *Science* (Mervis, 2011). Carl Wieman was a corecipient of the Nobel Prize in physics in 2001 and conducted a study at the college level comparing standard lecture to an interactive delivery approach. A postdoc student and a graduate student were trained to teach an introductory portion of a physics class by incorporating an educational approach known as "deliberate practice." This technique allowed students to be actively engaged in the learning process by tackling problem-solving scenarios. Meanwhile another group received the introductory instruction from a tenured professor through standard lecture. The experiment lasted for three 1-hour sessions and was concluded after a week with both groups taking a 12-question exam. The interactive classroom scored twice as high as the group that received the content through the standard lecture format. Furthermore, attendance and attention span were elevated in the interactive class leading Wieman (2005) to gain support for the following conclusion,

> The teaching style of a class is more important than who the instructor is. That is, a teaching assistant or graduate student using interactive teaching methods can deliver a more effective lecture on a topic than a tenured professor who uses traditional methods and is an expert in the field. (para. 1)

McMurrer (2008) examined a study conducted in 2006 to determine the amount of time allocated for science and social studies instruction since the introduction of No Child Left Behind (NCLB) in 2002, which strongly emphasized that more time should be spent teaching math and English Language Arts (ELA). Of those school systems that increased their ELA and math instruction time the following results were noted,

> 72% indicated that they reduced time by a total of at least 75 minutes per week for one or more of these other subjects. For example, more than half (53%) of these districts cut instructional time by at least 75 minutes per week in social studies, and the same percentage (53%) cut time by at least 75 minutes per week in science. (McMurrer, 2008, para. 5)

Goffe and Kauper (2012) surveyed 275 college instructors to ascertain the reason lecture is prevalent as a teaching method. The professors were more or less evenly distributed among three groups: 1) One group reported that students learned best by lecture; 2) The second group did not report that lecture was the best option, but it was cost effective; and 3) The third group reported that lecture was not effective and actively sought alternative teaching methods. It was noted that, of the respondents, the average instructor spent “70% of class time lecturing, 20% leading class discussion, and 10% using other learning activities” (Goffe & Kauper, 2012, p. 1).

These findings are consistent with earlier studies conducted by Watts and Schaur (2011) where they found that 83% of the professors devoted their instructional time to lecture.

VanDijk and Jochems (2002) reported on one college study where teachers and students both received surveys regarding instructional methods. When teachers described themselves as being concerned with what they do and how they deliver information, the students described their own learning as “superficial.” Likewise, when the instructors described their teaching style as student oriented, the students reported “significantly deeper approaches to learning” (VanDijk & Jochems, 2002, p. 276).

Although evidence strongly supported the augmentation of activities into the educational setting, standard lecture without student interaction still dominates as the preferred delivery method. Physics instructors Henderson and Dancy (2011) presented a survey question to their fellow faculty members inquiring as to why research based activities were not used in the classroom. The reasons included, “1) expectations of content coverage; 2) lack of instructor time; 3) departmental norms; 4) student resistance; 5) class size and room layout; and 6) time structure” (Henderson & Dancy, 2011, p. 3). Ironically, the pressures of time constraints to cover course content should advocate for less lecture rather than more. Even as early as 1972, Bligh was aware of the perils of lecture. In fact, after 21 investigatory studies, Bligh (1972) concluded that not even one study held lecturing superior to other teaching methods. Lecture has repeatedly been identified as an extremely weak approach to instruction; however, it is overwhelmingly used because it takes less time and money to administer than creating an active learning environment.

Another disconnect creating havoc between neuroscience and the implementation of BBL in the classroom results from teachers receiving misinformation regarding the brain. As scientists constantly learn new facts about the brain, erroneous information must be purged from what was formerly considered factual. Unfortunately, it is particularly difficult to change longstanding accepted ideas. The following is a list of common "neuromyths" as noted by Wolfe (2010) that many people cling to as facts.

- We only use 10% of our brain.
- Listening to Mozart will make you smarter.
- Some people are more "right brained," and others are more "left brained."
- Everything important is learned by age three.
- You can't change your brain.
- The brain remembers everything it has ever experienced; forgetting is an absence of recall ability.
- Gender differences outweigh individual differences when it comes to learning abilities.
- There are brain differences by race.
- Drinking plenty of water is important for brain functions. (Wolfe, 2010, p. 10)

Information about the brain is certainly changing; however, if educators wait until all the facts are revealed, opportunities to influence the classroom in a positive way will be lost. As promising as the potential for brain research is to the educational realm, Willis (2008) cautioned about oversimplification of the idea that brain research activities will fix all of the educational woes. With brain research being a relatively new branch of science, Willis encouraged educators to stay up-to-date on the latest neuroscientific research and not just buy the next book on brain research from someone who may just want to make a "quick buck" on the newest hype. With careful consideration, brain based learning can be beneficial and will become mainstream within the next decade.

Bridging the gap between neuroscientists and teachers is a constant struggle. In 2007 a study by Pickering and Howard-Jones was conducted in the UK where 200 educators attended a workshop on brain research. One hundred of the educators were required to attend the training while the other 100 volunteered to attend. The majority of the responses (189) were in questionnaire format; 11 responses were gathered in an interview process. Regardless of the group, results indicated that teachers rated the role of brain studies important in the educational realm. They considered brain knowledge important for "*how* they taught but not *what* they taught." It was further noted that teachers are enthusiastic to know about brain research, but there appeared to be disconnect in dissemination of information between researchers and teachers. Neuroscientists had a difficult time transmitting information in terms that the layperson could understand and teachers did not want to be "told what works" by researchers who had not been in the classroom (Pickering & Howard-Jones, 2007, p. 109).

Friedman (1999) indicated that boys are generally more motivated and have more of a positive attitude toward science. As girls continue through school, they lose their interest in science due to lower teacher expectations and gender biased instruction. In a viscous cycle, most elementary teachers are female and have a weak background in science. To break this cycle teachers need to first be comfortable with teaching science content. Providing instructors with opportunities to interact with other more knowledgeable educators for collaboration and support was shown to improve teachers' pedagogical content knowledge (Friedman, 1999).

Rato, Abreu, and Castro-Caldas (2011) conducted a survey of teachers in Portugal. The results indicated that the teachers are interested in how the brain functions but have difficulty integrating neuroscientific knowledge into their classrooms. The authors suggested that the introduction of neuroscience be part of preservice teacher training in order to build a better understanding of applicable knowledge between researchers and educators. Dubinsky (2010) encouraged educators to attend workshops and seminars where dialog between the presenter and teacher is encouraged. A large audience presentation is beneficial for spreading information to a vast number but does not provide an opportunity for teacher interactions with the actual BBL activities. In order to effectively instruct students in BBL, teachers should experience neuroscience by partaking in small group discussions, hands-on experiments, and inquiry-based activities. The educator does not need to know the intricate workings of the brain at the cellular level. Instead, the teacher needs to be aware of activities that can create a nurturing environment for continual brain development.

Future of BBL

While BBL is a promising avenue for educators to reach their students, there are critics who frown upon the use of BBL in the classroom. Wolfe (2009) wrote that educators have a strong interest in the brain because understanding how the mind learns would result in more effective instruction. However Willingham (2006) contended that educators do not have enough knowledge of neuroscience to adequately implement BBL activities into the classroom and that educators cannot distinguish between fact and hype. Willingham contended that it will be years before brain research will have any true relevance to the classroom setting. Fischer et al. (2007) posited that rather than delaying implementation of BBL techniques in the classroom until further scientific research is substantiated, practical classroom endeavors incorporating BBL activities should be encouraged to assist in advancing the research. Sousa (2011) reported that in order to better bridge the gap between neuroscience and education, a new discipline identified as educational neuroscience had been established. The goal is to influence educational practices for educators by basing their instruction on solid scientific research from the fields of neuroscience, education, and psychology.

Although there are naysayers, BBL is indeed a thriving discipline (Hook & Farah, 2013). In 2002 Harvard University began offering master’s and doctoral degrees in the area of brain learning. The program is called “Mind, Brain, and Education” (MBE); the impetus for the program was students' interest in the new developments of brain information with the regards to learning and education. Harvard's MBE program served as a model for other universities interested in beginning a similar program (Anderson, 2007; Jensen, 2008b).

Johns Hopkins University has hosted Neuro Education Initiative (NEI) Institutes since 2008 (Labriole, 2010). The purpose is to understand how brain research can better relate to student learning. Additionally, as of 2012 Johns Hopkins School of Education (2013) began offering a 15-credit graduate Mind, Brain Teaching Certificate designed for,

> PK-16 teachers, administrators, and student support personnel who seek to explore how research in the cognitive and neurosciences has the potential to inform the field of education. The certificate builds upon basic and applied research from the fields of cognitive science, psychology and brain science, neurology, neuroscience, and education. It will provide educators with knowledge of cognitive development and how emerging research in the brain sciences can inform educational practices and policies. (para. 1)

As Collins and Prabhakar reported in 2013, President Obama announced an extraordinary new program entitled the "BRAIN Initiative," which stands for Brain Research through Advanced Innovative Neurotechnologies Initiative. The expected outcome of the program should change our understanding of the human brain. The intent of the project is to uncover the complexities of the brain in order to treat brain medical issues as well as understand how the brain learns and functions. This undertaking is being hailed as the "Grand Challenge of the 21st Century" akin to mapping the human genome (Collins & Prabhakar, 2013, para. 4). According to Collins and Prabhakar (2013) the project is receiving "approximately $100 million in funding for research supported by the National Institutes of Health (NIH), the Defense Advanced Research Projects Agency (DARPA), and the National Science Foundation (NSF) in the President's Fiscal Year 2014 budget" (Collins & Prabhakar, 2013, para. 9). The project is expected to be ongoing and funded through foundations and private research institutions. Many great minds from various disciplines including medicine, nanoscience, engineering, and technology will join forces to begin laying the foundation for a greater understanding of the brain. Burton (2009) said that BBL is here to stay and will only be stronger in time as educators learn how to accommodate students' knowledge in the ways that the brain learns naturally.

Summary

Research supporting the implementation of Brain Based Learning into the curriculum is a fairly new approach that has gained steam over the last 10 years through advancements in brain scanning technologies. Within the educational setting, teacher quality is the greatest factor influencing student achievement (Hattie, 2003). The instructor should be competent in teaching the subject matter and have the ability to display a genuine caring attitude for children (Darling-Hammond, 2000b), and the instructor should establish stability by generating and adhering to predictable class procedures along with creating a classroom environment that is physically conducive to learning. Teachers understanding the functionality of the brain can have a major impact on educational reform. Most importantly, children need to feel loved and safe in a nurturing learning environment. Learning should be relevant to real life situations and the teacher should limit teacher lecture and opt for more student-to-student interactions. Brain compatible lessons are essential for all grade ranges and are needed to "round out the conceptual framework" (Radin, 2009, p. 40).

As knowledge regarding the brain continues to increase, teachers should be aware of new advancements in order to improve their instructional delivery methods (Sylwester, 1995). Teachers' knowledge and implementation of direct and indirect teaching methods will improve classroom performance. Preservice teachers and established teachers should understand how the brain functions, whether through college coursework or by attending neuroscience instruction designed with the teacher in mind. After all, the teacher's goal is to change brains daily (Zull, 2002). As Jensen (2008b) summed it up, “schools work to the degree that the brains in the schools are working well.” Although the focus of this literature review was to provide support for the use of BBL in science classes, these strategies are applicable to all disciplines.

CHAPTER 3

RESEARCH METHOD

This research was an evaluation of the perceptions and practices of teachers with regards to Brain Based Learning (BBL) strategies in teaching science. The purpose of the study was to determine teachers' perceptions and practices of BBL strategies in teaching science in eight districts in Northeast Tennessee. More specifically, full-time, regular education, K-12 teachers' perceptions of BBL, along with their implementation of BBL strategies were examined. In order to effectively investigate the problem, a nonexperimental quantitative study was used.

Research design describes the procedures that are used in a study. These procedures include identifying a plan to produce data that are used to answer the research questions (McMillan & Schumacher, 2006). Creswell (2009) described quantitative research as a method for testing objective theories through an examination of the relationships among variables. For the purpose of this study the quantitative research design was further refined to the subclassification of nonexperimental research. According to McMillan and Schumacher (2010) a "nonexperimental research design describes phenomena and examines relationships between different phenomena without any direct manipulation of conditions that are experienced" (p. 22). This nonexperimental study used a survey to evaluate the perceptions of teachers in eight school districts in Northeast Tennessee regarding BBL and the preferred method of science instruction.

Research Questions and Null Hypotheses

This nonexperimental quantitative study was guided by the following seven research questions and corresponding null hypotheses.

RQ1: Is there a significant difference in teachers' perceptions of BBL strategies in the discipline of science among teachers based on years of teaching experience?

Ho1: There is no significant difference in teachers' perceptions of BBL strategies in the discipline of science among teachers based on years of teaching experience.

RQ2: Is there a significant difference in teachers' self-reported practices of BBL strategies in the discipline of science among teachers based on years of teaching experience?

Ho2: There is no significant difference in teachers' self-reported practices of BBL strategies in the discipline of science among teachers based on years of teaching experience.

RQ3: Is there a significant difference in teachers' perceptions of BBL strategies in the discipline of science among elementary, middle, and high school teachers?

Ho3: There is no significant difference in teachers' perceptions of BBL strategies in the discipline of science among elementary, middle, and high school teachers.

RQ4: Is there a significant difference in teachers' self-reported practices of BBL strategies in the discipline of science among elementary, middle, and high school teachers?

Ho4: There is no significant difference in teachers' self-reported practices of BBL strategies in the discipline of science among elementary, middle, and high school teachers.

RQ5: Is there a significant difference in teachers' perceptions of BBL strategies in the discipline of science between male and female teachers?

Ho5: There is no significant difference in teachers' perceptions of BBL strategies in the discipline of science between male and female teachers.

RQ6: Is there a significant difference in teachers' self-reported practices of BBL strategies in the discipline of science between male and female teachers?

Ho6: There is no significant difference in teachers' self-reported practices of BBL strategies in the discipline of science between male and female teachers.

RQ7: Is there a significant relationship between teachers' perceptions of BBL strategies in the discipline of science and their self-reported classroom practices?

Ho7: There is no significant relationship between teachers' perceptions of BBL strategies in the discipline of science and their self-reported classroom practices.

Instrumentation

Quantitative data were collected by means of a survey. With permission, many of the items used in my survey were obtained from Wachob's (2012) Brain-Based Learning Survey Questionnaire (BBLSQ). Wachob conducted a similar study on BBL although some of his questions related to Brain Gym, a specific BBL program. My inquiries were more general in regards to BBL strategies and did not include a specific BBL program. Furthermore my survey was focused only on the discipline of science rather than the general curriculum; therefore, my survey is a modified version of Wachob's (see Appendix C).

The first part of the survey included four demographic identifiers: gender, number of years taught, time in the profession, and grade span taught. The fifth item identified teachers' knowledge of BBL. Statements 6-10 referred to the teacher's science background and training. Statements 11 – 43 addressed teachers' perceptions, while statements 44-81 addressed teachers' self-reported practices. The last item (#82) was open-ended and allowed teachers to voluntarily share comments related to teaching science. For statements 6-81, participants responded by using a 5-point Likert scale that ranged from 1 (*strongly disagree*) to 5 (*strongly agree*). Some of the items were reverse scaled to avoid a bias known as acquiescence response, or agreement with a statement regardless of the question (Knowles & Condon, 1999). The sections of the BBLSQ were divided into three categories: (1) Teachers' demographics, background, and training; (2) Teachers' perceptions about BBL in teaching science; and (3) teachers' BBL practices in teaching science. The last item on the survey included an open-ended opportunity for participants to share any other thoughts they may have had regarding BBL or teaching methods for science.

According to McMillan and Schumacher (2006), "Validity is a judgment of the appropriateness of a measure for specific inferences, decisions, consequences, and use of the result from the scores that are generated" (p. 130). Validity was enhanced by administering a pilot instrument to a group of 10 purposefully selected K-12 regular education teachers who were teaching science in some capacity. The group made suggestions for modifications to the instrument that included formatting changes, eliminating and adding certain questions, and clarifying confusing terms. Cronbach's alpha reliability coefficient for the perceptions portion of the survey was .80, and the practices portion was .87.

Sample

Participants in this study included kindergarten through high school regular education teachers who taught a minimum of one science class and were employed full-time in one of eight Northeast Tennessee school systems. The participants were selected because it was a convenient sample for my location. Concerning sampling and random samples Hultsch, MacDonald, Hunter, Maitland, and Dixon (2002) explained, "Relatively small structured samples of convenience may, in some cases, yield results that look remarkably similar to those obtained with much larger samples selected using random sampling strategies" (p. 358).

Of the 216 study participants, the majority was female, taught elementary school, and had 11+ years of experience teaching. There were 35 (16.2%) male teachers and 181 (83.8%) female teachers. The number of teachers who taught for 1-5 years was 44 (20.4%), 6-10 years was 49

(22.7%), and 11+ years was 123 (56.9%). The grade ranges taught were 142 in elementary (65.74%), 36 in middle grades 6-8 (16.7%), and 38 in high school grades 9-12 (17.59%).

Data Collection

Permission to conduct research was obtained from my dissertation committee, the Director of Schools of each participating school district (Appendix D), and the university Institutional Review Board (IRB) (Appendix E). The survey instrument (Appendix C) was distributed to the participants via Survey Monkey, an Internet based survey service. Participants came from a distribution list that included all full-time, regular education kindergarten through 12th grade teachers who taught science in some capacity in the eight school districts of Elizabethton City Schools, Greene County Schools, Greeneville City School, Hamblen County Schools, Johnson County Schools, Sullivan County Schools, Unicoi County Schools, and Washington County Schools in Northeast Tennessee. All potential members of these districts were contacted (Appendix F) through an email invitation to participate in the study with a link to the survey site provided along with a statement regarding confidentiality. Participants were informed that the survey would permit them to skip a statement if it made them uncomfortable. Confidentiality was ensured because no personal identifiable information was collected as part of the online survey instrument.

Data Analysis

Data from this research were analyzed through a nonexperimental quantitative methodology. To find the statistical calculations of this study, data were obtained through the survey instrument. The Statistical Package for Social Sciences (SPSS) Version 20.0 data analysis software was used for all data analysis procedures in this study. Each research question had a corresponding null hypothesis. Null hypotheses Ho1, Ho2, Ho3, and Ho4 were tested by using the Analysis of Variance (ANOVA) procedure. Null hypotheses Ho5 and Ho6 were tested by using a series of independent samples *t*-tests. Null hypothesis Ho7 was tested by using a Pearson correlation. The means of perceptions and practices were obtained with the mid-point of the scale (3.0) representing neutrality as the test value. All data were analyzed at the .05 level of significance.

Summary

Chapter 3 reports the methodology and procedures for conducting the study. After an introduction, a description of the research design, selection of the data sources, data collection procedures, research questions and corresponding null hypotheses, the consequent data analysis procedures were delineated.

CHAPTER 4

FINDINGS

The purpose of this study was to examine K-12 regular education teachers' perceptions and practices of Brain Based Learning (BBL) strategies in teaching science. Participants in the study included K-12, full-time, regular education teachers from eight Northeast Tennessee school systems who taught a minimum of one science class. In this chapter data are presented and analyzed to address seven research questions and test seven corresponding null hypotheses. Data were analyzed from an online survey. The first portion of my survey included demographic identifiers, teachers' knowledge of the term BBL, and statements regarding the respondent's science background and training. The remainder of the items focused on teachers' perceptions and practices of BBL strategies in teaching science. The final item was open-ended and allowed teachers to voluntarily share comments related to teaching science. For statements 6-81, participants responded by using a 5-point Likert scale that ranged from 1 (*strongly disagree*) to 5 (*strongly agree*). The means of perceptions and practices were obtained with the mid-point of the scale, neither agree nor disagree (3), as the test value. Quantitative data were analyzed with a series of independent samples *t* tests, one-way analysis of variance tests, and a Pearson correlation coefficient. Data were retrieved following the execution of a survey (Appendix C) through an online survey format. The survey was distributed once with two follow-up reminders for the 216 participants.

Research Question 1

RQ1: Is there significant difference in teachers' perceptions of BBL strategies in the discipline of science among teachers based on years of teaching experience?

Ho1: There is no significant difference in teachers' perceptions of BBL strategies in the discipline of science among teachers based on years of teaching experience.

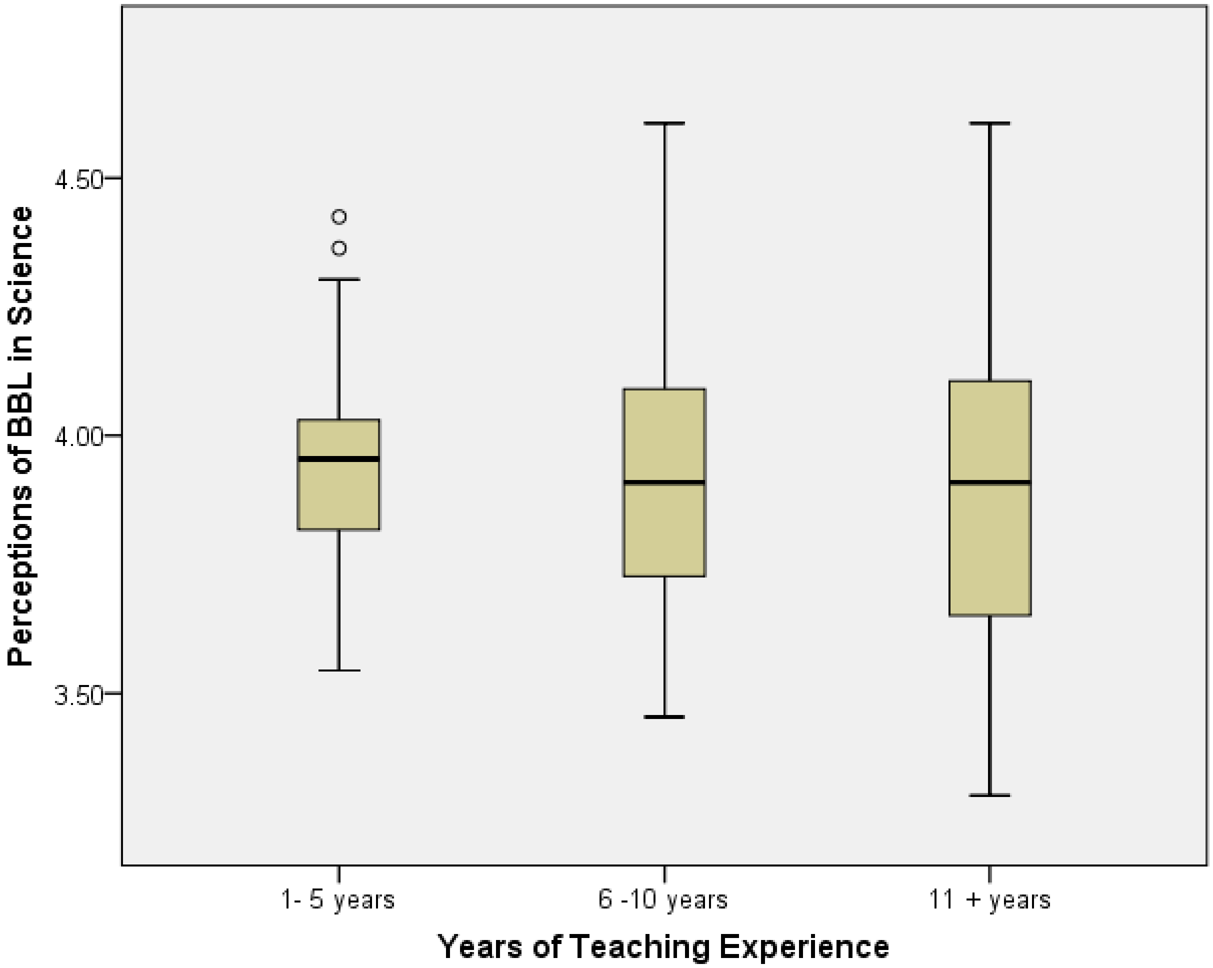
A one-way analysis of variance was conducted to determine whether or not there were significant differences in teachers' perceptions of BBL strategies in teaching science among teachers with varying levels of teaching experience. The dependent variable was perceptions of BBL strategies in teaching science. The independent variable (years of teaching experience) had three levels: 1 to 5 years of experience, 6 to 10 years, and 11 or more years.

The ANOVA was not significant, $F(2, 213) = .28$, $p = .760$, $n = 216$. Therefore, the null hypothesis was retained. The effect size as measured by η^2 was small (< .01). That is, less than 1% of the variance in the perceptions of BBL strategies was accounted for by teachers' years of teaching experience. Table 1 shows that the perception means for the three levels of teaching experience were very similar. Figure 1 shows the boxplot for perceptions of BBL strategies in science by teachers' level of teaching experience.

Table 1

Teachers' Perceptions of BBL Strategies in Science by Years of Teaching Experience

Years of Teaching Experience	*n*	*M*	*SD*
1 - 5 years	44	3.9449	.20701
6 - 10 years	49	3.9301	.28226
11+ years	123	3.9097	.31015
Total	216	3.9215	.28487



o = an observation between 1.5 times to 3.0 times the interquartile range

Figure 1. Teachers' perceptions of BBL in science by years of teaching experience.

Research Question 2

RQ2: Is there a significant difference in teachers' self-reported practices of BBL strategies in the discipline of science among teachers based on years of teaching experience?

Ho2: There is no significant difference in teachers' self-reported practices of BBL strategies in the discipline of science among teachers based on years of teaching experience.

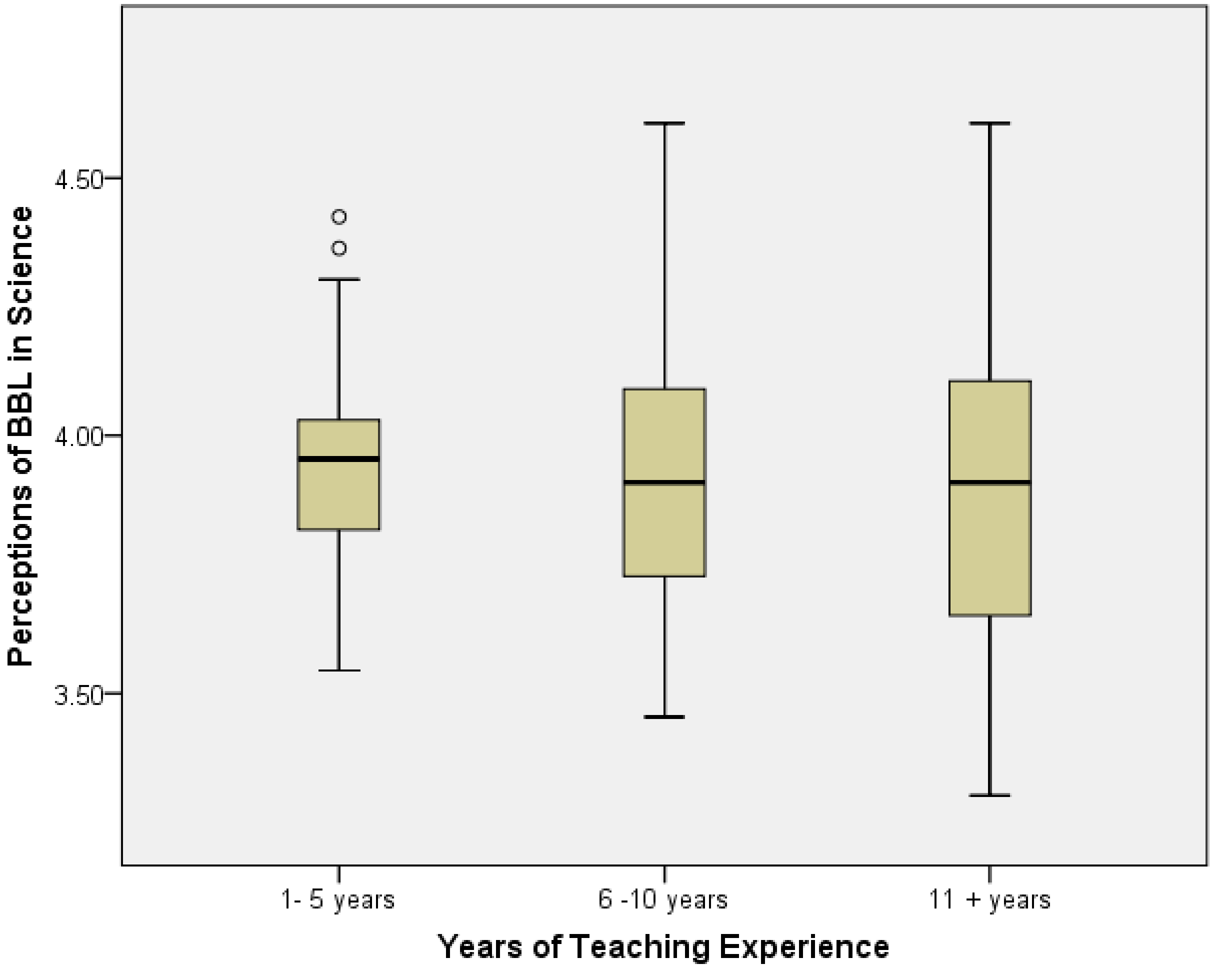
A one-way analysis of variance was conducted to determine whether or not there were significant differences in teachers' practices of BBL strategies in teaching science among teachers with varying levels of teaching experience. The dependent variable was practices of BBL strategies in teaching science. The independent variable (years of teaching experience) had three levels: 1 to 5 years of experience, 6 to 10 years, and 11 or more years.

The ANOVA was not significant, $F(2, 213) = .14$, $p = .867$, $n = 216$. Therefore, the null hypothesis was retained. The effect size as measured by η^2 was small (< .01). That is, less than 1% of the variance in the practices of BBL strategies was accounted for by teachers' years of teaching experience. Table 2 shows the practice means for the three levels of teaching experience were very similar. Figure 2 shows the boxplot for practices of BBL strategies in science by teachers' level of teaching experience.

Table 2

Teachers' Practices of BBL Strategies in Science by Years of Teaching Experience

Years of Teaching Experience	*n*	*M*	*SD*
1 - 5 years	44	3.7891	.28578
6 - 10 years	49	3.7696	.34133
11 + years	123	3.7575	.33731
Total	216	3.7667	.33731



o = an observation between 1.5 times to 3.0 times the interquartile range

Figure 2. Teachers' practices of BBL in science by years of teaching experience.

Research Question 3

RQ3: Is there a significant difference in teachers' perceptions of BBL strategies in the discipline of science among elementary, middle, and high school teachers?

Ho3: There is no significant difference in teachers' perceptions of BBL strategies in the discipline of science among elementary, middle, and high school teachers.

A one-way analysis of variance was conducted to determine whether or not there were significant differences in teachers' perceptions of BBL strategies in teaching science among teachers of varying grade levels. The dependent variable was perceptions of BBL strategies in teaching science. The independent variable (grade level taught) had three levels: Elementary School grades 1-5, Middle School grades 6-8, and High School grades 9-12.

The ANOVA was not significant, $F(2, 213) = 1.49$, $p = .227$, $n = 216$. Therefore, the null hypothesis was retained. The effect size as measured by η^2 was small (< .01). That is, less than 1% of the variance in the perceptions of BBL strategies was accounted for by teachers' grade level taught. Table 3 shows that the perception means for the three grade levels taught were very similar. Figure 3 shows the boxplot for perceptions of BBL strategies in science by teachers' grade level taught.

Table 3

Teachers' Perceptions of BBL Strategies in Science by Grade Level Taught

Grade Level Taught	*n*	*M*	*SD*
Elementary (K – 5)	142	3.9359	.29396
Middle (6 – 8)	36	3.8468	.26337
High School (9 – 12)	38	3.9386	.26479
Total	216	3.9215	.28487

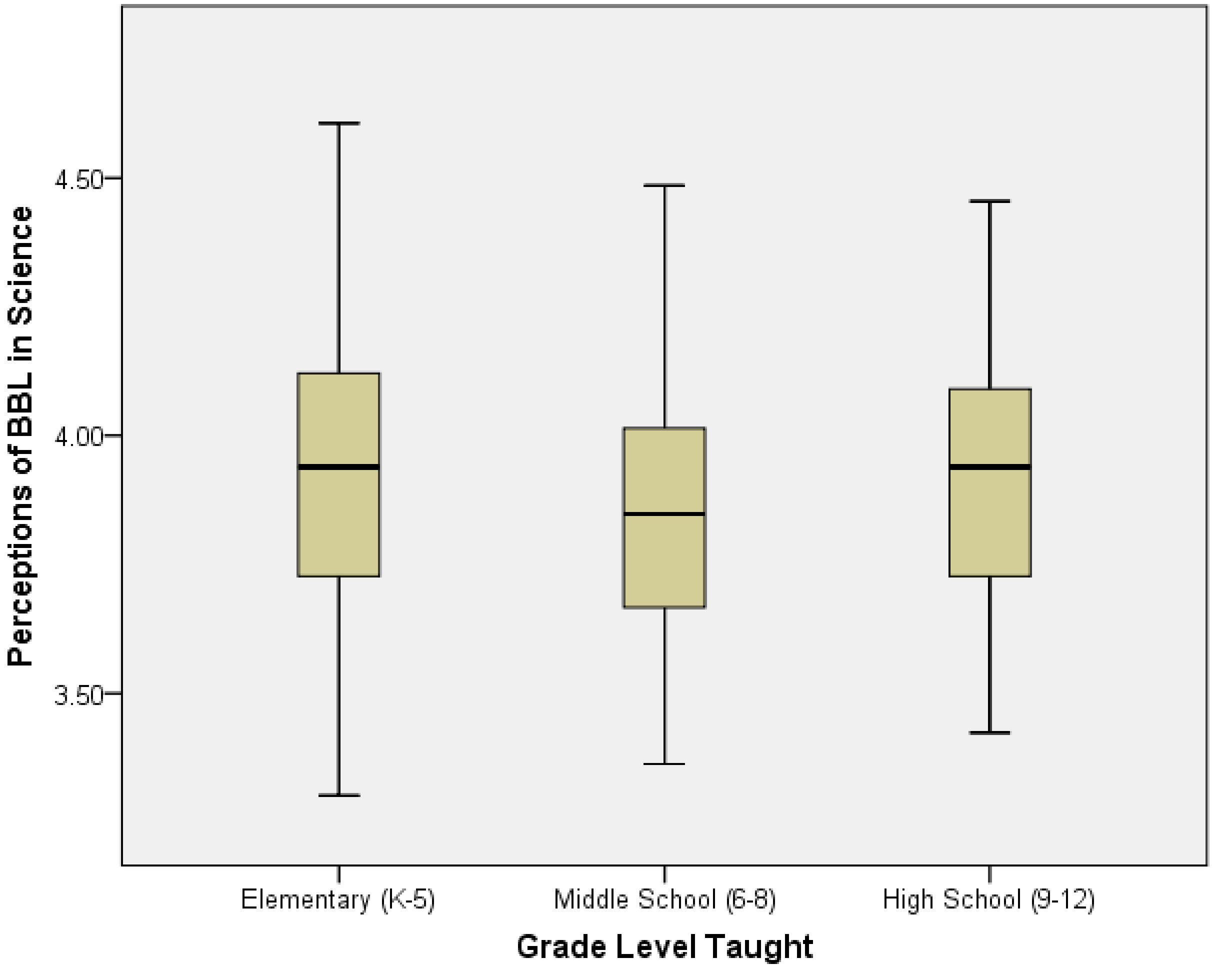


Figure 3. Teachers' perceptions of BBL in science by grade level taught.

<u>Research Question 4</u>

RQ4: Is there a significant difference in teachers' self-reported practices of BBL strategies in the discipline of science among elementary, middle, and high school teachers?

Ho4: There is no significant difference in teachers' self-reported practices of BBL strategies in the discipline of science among elementary, middle, and high school teachers.

A one-way analysis of variance was conducted to determine whether or not there were significant differences in teachers' practices of BBL strategies in teaching science among teachers of varying grade levels. The dependent variable was practices of BBL strategies in teaching science. The independent variable (grade levels taught) had three levels: Elementary School grades 1-5, Middle School grades 6-8, and High School grades 9-12.

The ANOVA was significant, $F(2, 213) = 9.00$, $p < .001$, $n = 216$. Therefore, the null hypothesis was rejected. The effect size as measured by η^2 was medium (.08). That is, 8% of the variance in the practices of BBL strategies was accounted for by teachers' grade level taught. Follow-up tests were conducted to evaluate pairwise differences among the means. The Tukey post hoc test showed there were significant differences in classroom BBL practices means between elementary school teachers and middle school teachers ($p = .017$) and between elementary school teachers and high school teachers ($p = .001$). In each case elementary teachers had the higher mean. There was no significant difference in the practice means between middle school and high school teachers ($p = .769$). Table 4 shows that the practice means and standard deviations for BBL strategies in science by teachers' grade level taught with 95% confidence intervals for the pairwise differences in means. Figure 4 shows the boxplot for practices of BBL strategies in science by teachers' grade level taught.

Table 4

Teachers' Practices of BBL Strategies in Science by Grade Level Taught with 95% Confidence Intervals for the Pairwise Differences

Grade Range	*n*	*M*	*SD*	Elementary	Middle
Elementary (K – 5)	142	3.83	.33		
Middle (6 – 8)	36	3.67	.33	.03 to .31*	
High School (9 – 12)	38	3.61	.29	.08 to .36*	-.13 to .23

*****The pairwise difference in means was significant at the .05 level.

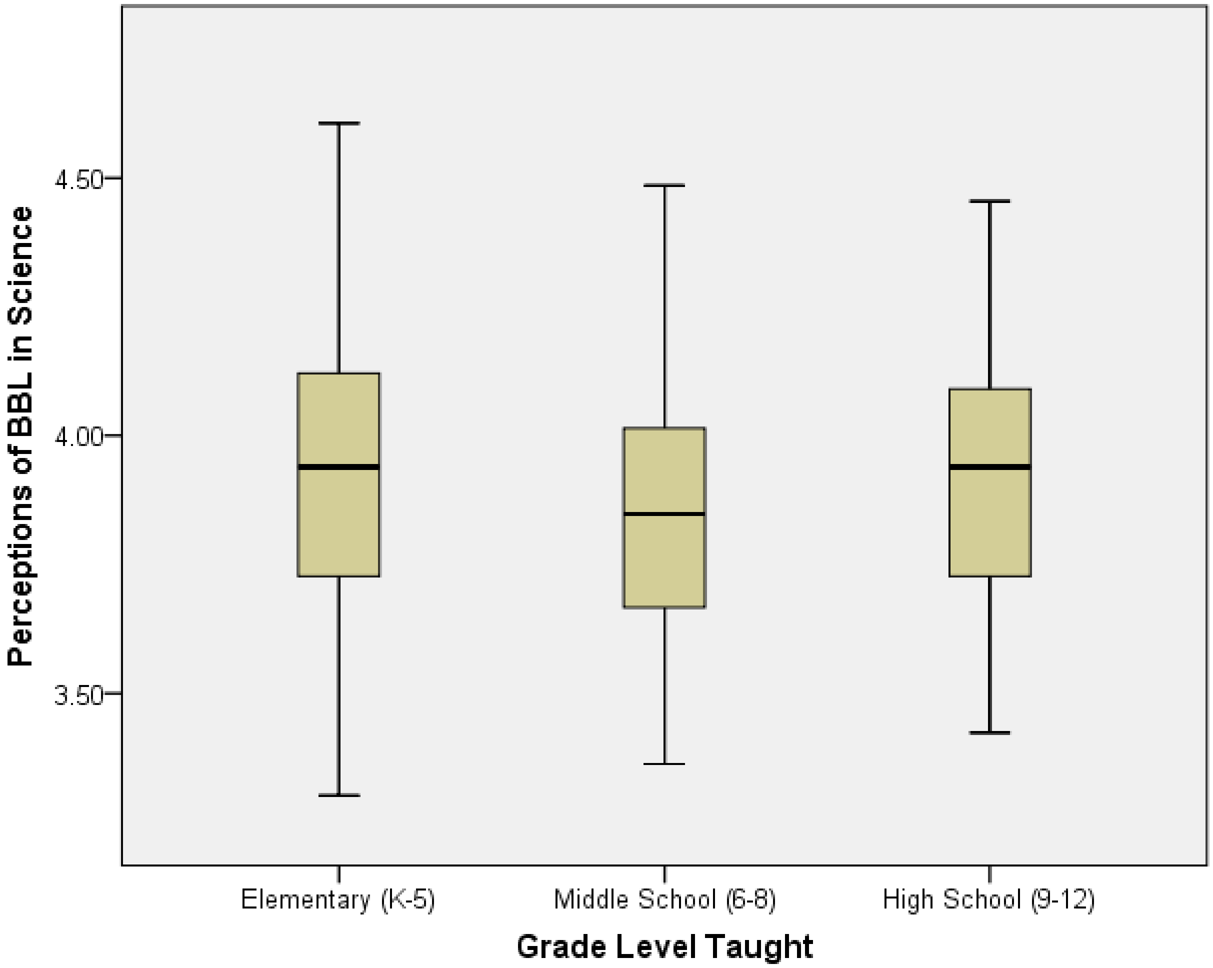


Figure 4. Teachers' practices of BBL in science by grade level taught.

<u>Research Question 5</u>

RQ5: Is there a significant difference in teachers' perceptions of BBL strategies in the discipline of science between male and female teachers?

Ho5: There is no significant difference in teachers' perceptions of BBL strategies in the discipline of science between male and female teachers.

An independent samples *t*-test was conducted to determine whether or not there were significant differences in teachers' perceptions of BBL strategies in teaching science based on gender. The dependent variable was teachers' perceptions in BBL strategies in teaching science. The independent variable was gender.

The *t*-test was significant, $t(214) = 2.43$, $p = .016$, $n = 216$. Therefore, the null hypothesis was rejected. The mean perceptions of BBL in science for females ($M = 3.94$, $SD = .29$) was significant and was slightly higher (0.12) than the mean for male teachers ($M = 3.82$, $SD = .25$). The effect size as measured by η^2 was small (.03). That is, 3% of the variance in the perceptions of BBL strategies was accounted for by gender. Figure 5 shows the boxplot for perceptions of BBL strategies in science by teachers' gender.

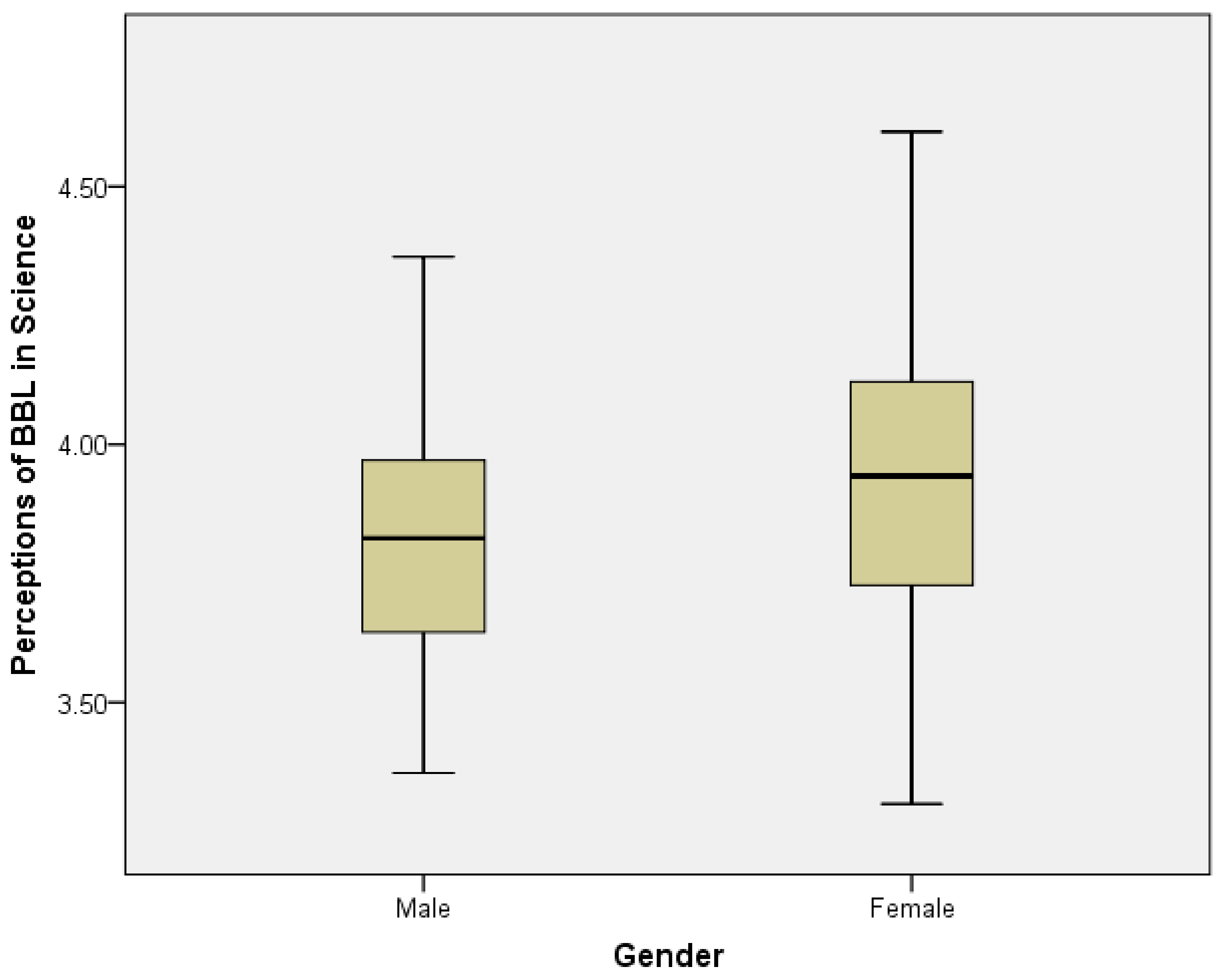


Figure 5. Teachers' perceptions of BBL in science by gender.

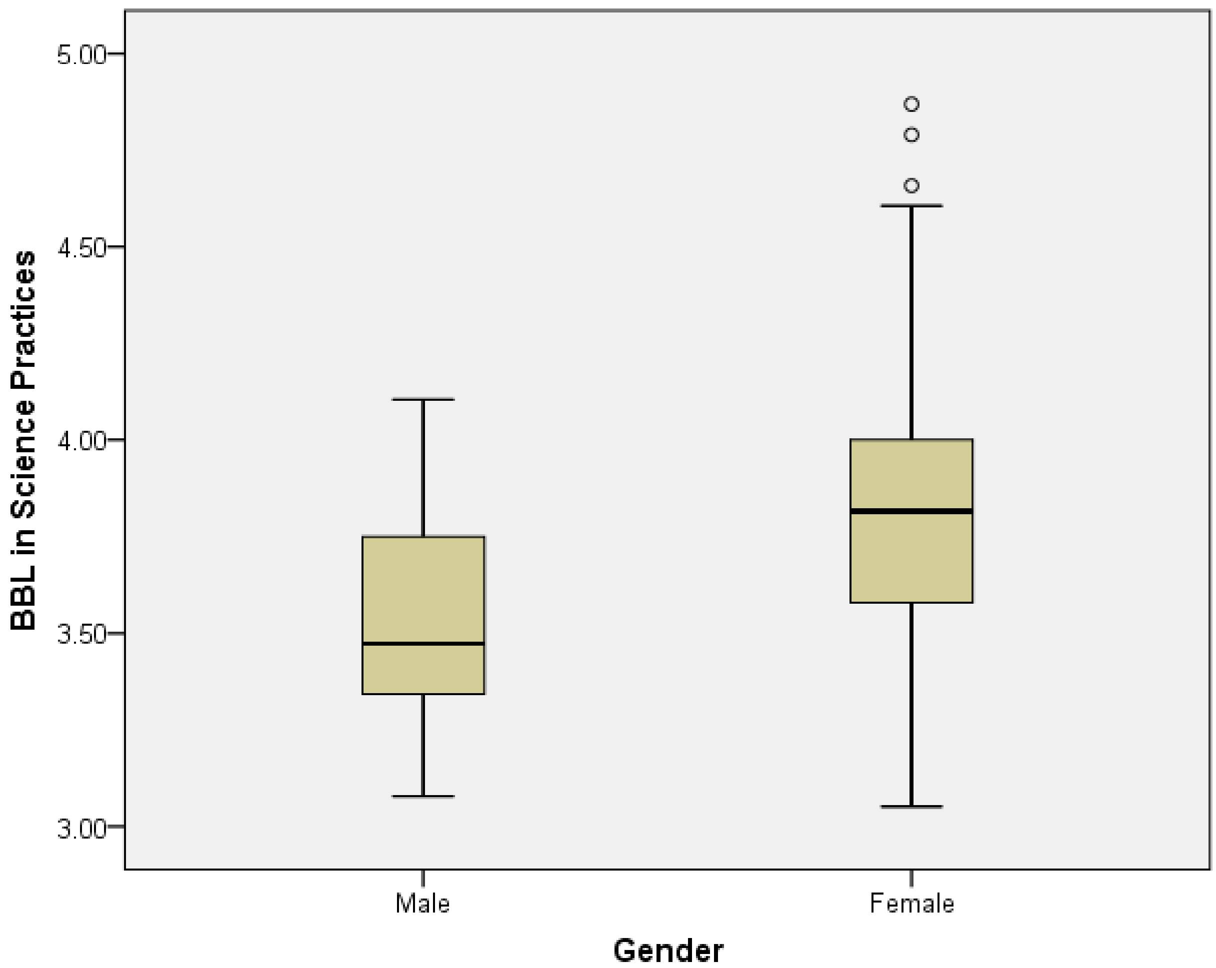
Research Question 6

RQ6: Is there a significant difference in teachers' self-reported practices of BBL strategies in the discipline of science between male and female teachers?

Ho6: There is no significant difference in teachers' self-reported practices of BBL strategies in the discipline of science between male and female teachers.

An independent samples *t*-test was conducted to determine whether or not there were significant differences in teachers' practices of BBL strategies in teaching science based on gender. The dependent variable was teachers' practices of BBL strategies in teaching science. The independent variable was gender.

The *t*-test was significant, $t(214) = 4.51$, $p < .001$, $n = 216$. Therefore, the null hypothesis was rejected. The mean practices of BBL in science for females ($M = 3.81$, $SD = .33$) was significant and was higher (0.27) than the mean for male teachers ($M = 3.54$, $SD = .28$). The effect size as measured by η^2 was medium (.09). That is, 9% of the variance in the practices of BBL strategies was accounted for by gender. Figure 6 shows the boxplot for practices of BBL strategies in science by gender.



o = an observation between 1.5 times to 3.0 times the interquartile range

Figure 6. Teachers' practices of BBL in science by gender.

Research Question 7

RQ7: Is there a significant relationship between teachers' perceptions of BBL strategies in the discipline of science and their self-reported classroom practices?

Ho7: There is no significant relationship between teachers' perceptions of BBL strategies in the discipline of science and their self-reported classroom practices.

A Pearson correlation coefficient was computed to assess the relationship between teachers' perceptions of BBL strategies in science and their self-reported classroom practices.

The correlation was statistically significant. There was a strong, positive correlation between the two variables, $r(214) = .68$, $p < .001$, $n = 216$. Therefore, the null hypothesis was rejected. The coefficient of determination, r^2, indicated that 46% of the variance in teachers' self-reported practices in BBL strategies was shared with teachers' perceptions of BBL strategies in teaching science. Figure 7 shows a scatterplot summary of the results. Overall, there was a strong positive correlation between teachers' perceptions and self-reported practices in BBL strategies in teaching science.

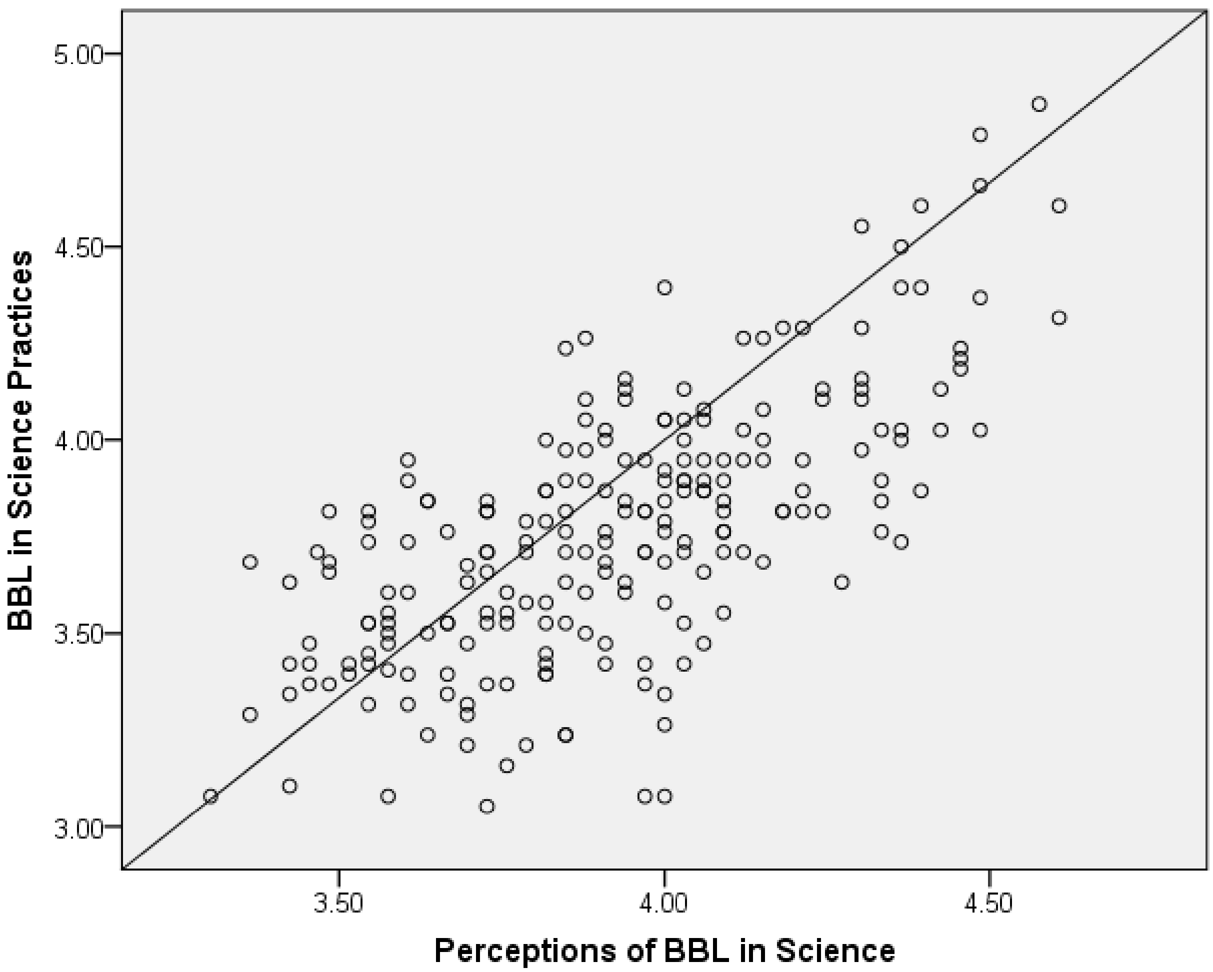


Figure 7. Teachers' perceptions and self-reported practices in BBL strategies in teaching science.

Open-Ended Item

In addition to the 81 items on the survey, participants were given an opportunity to share anything they would like regarding teaching science. Twenty-seven participants responded to the final item: Feel free to add anything you would like regarding the teaching of science. Overwhelmingly, the teachers indicated the need for more materials and time for science instruction as highlighted by some of the statements here:

"I would welcome opportunities to incorporate more hands-on learning in my science classes. Time is a factor, so ideas for quick, easy-to-set up activities would be more feasible."

"I would like to have more experiments in my science class but time limits and lack of equipment hinders this [from] happening often."

"I would LOVE to have longer class periods to utilize these BBL practices!"

"I wish I had more science hands-on supplies to do more labs."

"I NEED MORE RESOURCES FOR HANDS-ON ACTIVITIES!!"

"It can be difficult to prepare lesson plans without the necessary science materials."

"Labs and hands-on activities are limited by lack of materials and lack of space."

"Too much emphasis on high stakes testing. No time and especially no resources and materials for science labs classroom. Too crowded for effective group work."

"I am a 4th grade teacher. I teach math, science, and social studies. It is extremely difficult to find time to do science the way I like. It usually takes me days, even weeks to complete one lesson."

"Science and social studies is not part of K-2 curriculum. It is up to the teacher to incorporate it with whatever resources they can find."

"I rarely have time to teach science, unless it is integrated into our reading series. Sad, but true."

"With the focus on language arts and math, due to standardized testing, science and social studies often take a back seat."

"The materials I use for labs are purchased with my own money. There is not a fund for consumables used in my science class."

Chapter Summary

This chapter presented the data obtained from 216 participants from eight Northeast Tennessee School districts. The first portion of my survey included demographic identifiers, teachers' knowledge of the term BBL, and inquiries regarding science background and training. The remainder of the items focused on teachers' perception and practices of BBL strategies in teaching science. The final statement was open-ended and allowed teachers to voluntarily share comments related to teaching science.

There were seven research questions and seven corresponding null hypotheses. All data were collected through an online survey. RQ1 results indicated that there was no significant difference in teachers' perceptions of BBL strategies in teaching science among teachers with varying levels of teaching experience. RQ2 results indicated that there was no significant difference in teachers' self-reported practices of BBL strategies in teaching science among teachers with varying levels of teaching experience. RQ3 results indicated that there was no significant difference in teachers' perceptions of BBL strategies in teaching science among elementary, middle, and high school teachers. RQ4 results indicated that was a significant difference in teachers' self-reported practices of BBL strategies in teaching science among elementary, middle, and high school teachers, with elementary teachers incorporating more of the strategies. RQ5 results indicated that there was a significant difference in teachers' perceptions of BBL strategies in teaching science between male and female teachers, with females having a better perception of it. Generally, females have significantly more positive perceptions of BBL strategies than do males. RQ6 results indicated that there was a significant difference in teachers' self-reported practices of BBL strategies in teaching science between male and female teachers. Overall, female teachers' reported that they used significantly more

BBL strategies in teaching science than males. RQ7 results indicated that there is a strong correlation between teachers' perceptions and self-reported practices of BBL in teaching science. The open-ended question indicated that teachers desire more time and materials for the teaching of science.

CHAPTER 5

SUMMARY, CONCLUSTIONS, AND RECOMMENTATIONS

Introduction

This chapter contains the findings, conclusions, and recommendations for readers who may use the results as a resource when reviewing and revising Brain Based Learning programs. The purpose of this quantitative study was to investigate Brain Based Learning (BBL) techniques in teaching science. Participants in the study included K-12, full-time, regular education teachers from eight Northeast Tennessee school systems who taught at least one science class during the 2013-2014 school year. Specifically this research was guided by seven research questions on teachers' perceptions and practices in teaching science. The study was conducted using data from 216 respondents collected through an online survey.

Summary of Findings

The survey in this study began with inquiries to obtain descriptive analysis of teachers' knowledge of BBL and their background and training regarding teaching science. The statistical analysis shown in the results was based on seven research questions. In Chapter 3 each research question had one corresponding null hypothesis. The null hypotheses for questions RQ1 through RQ4 were analyzed using a series of one-way analysis of variance. The null hypotheses for questions RQ5 and RQ6 were analyzed using independent samples *t*-tests. The null hypothesis for RQ7 was analyzed using a Pearson correlation coefficient. There were 216 K-12 regular education teacher participants in the study. The level of significance used in the test was .05.

Analysis of survey items 5-10 regarding teachers' knowledge of BBL, science background, and training revealed this information. The term BBL was considered a new term to

18 (8.3%) participants; 75 (34.7%) participants had heard of BBL but were not sure what all was included in the concept; 32 (14.8%) claimed to understand BBL but rarely incorporated it into the classroom, and 91 (42.1%) stated that they understood BBL and regularly incorporated it into the classroom. When asked if there was a teacher who served as inspiration, 62% agreed (4) or strongly agreed (5) to have had at least one teacher in K-12 who inspired them in teaching science. Regarding whether preservice classes in college had prepared the teachers to teach science interactively, only 31.5% agreed (4) or strongly agreed (5) to being prepared. When asked if the participant had attended a workshop to learn how the brain learns, 65% agreed (4) that they had attended. When asked if they would like to attend a workshop on interactive science instruction, 82% agreed (4) or strongly agreed (5) that they would like to attend such a workshop. As far as future training on how the brain learns, 62% agreed (4) or strongly agreed (5) that they need more training.

1. Results for RQ1 indicated that there was no significant difference in teachers' perceptions of BBL strategies in teaching science among teachers based on years of teaching experience.
2. Results for RQ2 indicated that there was no significant difference in teachers' self-reported practices of BBL strategies in teaching science among teachers based on years of teaching experience.
3. Results for RQ3 indicated that there was no significant difference in teachers' perceptions of BBL strategies in teaching science among elementary, middle, and high school teachers.

4. Results for RQ4 indicated that there was a significant difference in teachers' self-reported practices of BBL strategies in teaching science among elementary, middle, and high school teachers. The follow-up tests evaluating pairwise differences among the means, indicated that there were significant differences in classroom BBL practices means between elementary and middle school teachers (p = .017) and between elementary and high school teachers (p = .001). In each case, elementary teachers had the higher mean. There was no significant difference in the practice means between middle and high school teachers (p = .769).
5. Results for RQ5 indicated that there was a significant difference in teachers' perceptions of BBL strategies in teaching science between male and female teachers. The mean perceptions of BBL in science for female teachers was slightly (0.12 point) higher than the mean for male teachers.
6. Results for RQ6 indicated that there was a significant difference in teachers' self-reported practices of BBL strategies in teaching science between male and female teachers. The mean for female teachers was 0.27 point higher than the mean for males.
7. Results of RQ7 indicated that there was a significant positive relationship between teachers' perceptions of BBL strategies in teaching science and their self-reported classroom practices. There was a strong positive correlation between teachers' perceptions and self-reported practices in BBL strategies in teaching science.

Responses to the open-ended statement indicated that teachers would like additional time and materials to teach science more effectively.

The results of my survey differed slightly from the findings in the literature review. First, research cited in the literature review indicated that experience matters when it comes to effective teaching; however, my study indicated that there was no difference in teachers' self-reported perceptions and practices of BBL strategies with regard to teaching experience. Second, research cited in the literature review appeared inconclusive as to which gender was more likely to implement BBL strategies; however, in my study, females were more likely to have a positive attitude and practice BBL techniques more than males. My results did concur with the research cited in the literature review in one area – elementary teachers were more likely to implement BBL strategies when compared to middle and high school educators.

Interestingly in regard to RQ3 and RQ4, there was no significant difference among teachers' perceptions of BBL strategies based on grade level taught. However, there were significant differences in practices whereby elementary teachers tended to practice BBL strategies more prevalently than other grade levels. This finding led me to conclude that elementary teachers are using BBL strategies because they have found tactics that work; however, they are unaware of the brain compatible reasons behind their instructional methods. The literature review indicated similar findings in other educational studies demonstrating the need for BBL workshops for teachers and college courses in BBL strategies for preservice teachers. Hart (1983) said that teaching without an awareness of how the brain operates is like designing a glove without ever studying the shape or workings of the hand.

Recommendations for Practice

By examining participants' responses, the conclusions drawn from this study indicate a strong correlation between teachers' perceptions of BBL and their self-reported practices in teaching science. However, when asked about their knowledge of BBL at the beginning of the survey, only 42% of participants claimed to understand BBL and regularly incorporated the strategies into their teaching.

Notably, 43% of teachers either claimed to have not heard of BBL or were only casually aware of the concept. Additionally, 32 (15%) of the teachers claimed to understand BBL but rarely incorporated the strategies into their teaching. Many of the teachers' responses in this study mirror the results of Wachob's (2012) survey on teachers' perceptions of BBL. In his study, as in this study, teachers indicated that they would be willing to attend workshops to learn more about the brain. Because teachers work to mold minds, administrators should encourage workshops on BBL. According to Jensen (2005) teachers work with brains every day and should be experts on the subject.

I received several emails from K-2 teachers indicating that ever-increasing demands of Common Core expectations have nearly eliminated their time to teach science. They are required only to teach math and reading language arts but can incorporate science and social studies themes into their lessons. Their comments are collaborated by a national study with 1,000 participating 3rd through 12th grade teachers. The Farkas Duffett Research Group (2012) reported that 66% of the teachers surveyed indicated that teaching math and language arts was crowding out time to teach other subjects. As teachers strive to improve their students' math and reading language arts scores, administrators and teachers need to be mindful of the new gap that will be created if science and other disciplines are disregarded or are taught vaguely.

In this study 31.5% of the teachers agreed or strongly agreed that their college preservice classes were effective in providing an interactive approach to instruction in teaching science. To improve teaching science in the classroom for future students, preservice teachers should receive their training through an integrated approach of both content knowledge and instructional practices (Bybee, 2002). In this study 81.5% of the teachers indicated that they would like to participate in an interactive approach for teaching science. Additionally, 62% of the teachers surveyed in this study indicated that they needed more training in understanding how the brain learns.

The final open-ended item allowed teachers to share their thoughts on teaching science. Twenty-seven of the 216 teachers chose to reply. Overwhelming, teachers indicated a need for more time and supplies to teach science effectively.

Based on the results of this study, the following six recommendations for practice were made:

- Workshops should be offered to train teachers in BBL techniques. Once teachers are aware of the strategies, they should be encouraged and held accountable for incorporating the strategies into their daily lessons in all disciplines.
- Preservice teachers should receive training in BBL strategies as part of their required coursework.
- Preservice teachers should be trained and finish their studies feeling empowered to incorporate hands-on activities into their science lessons.
- The state of Tennessee needs to mandate a separate time for science and social studies to be taught rather than merely incorporating those disciplines into the ELA block.

- Each school should inventory its science resources and distribute the list to every teacher. Often, resources are already in the building but teachers are unaware. Once the items have been inventoried, if it is determined that the schools are lacking in adequate science supplies, the school's PTA or BEP money should be used to purchase necessary items.
- School leaders should be creative in their use of time to ensure that science and other core disciplines are actually being taught in all grades.

Recommendations for Further Research

The purpose of this study was to investigate Brain Based Learning (BBL) techniques. Participants of the study included 216 K-12 full-time, regular education teachers from eight Northeast Tennessee school systems who taught a minimum of one science class during the 2013-2014 school year. In this study some of the stated null hypotheses were rejected and others were retained. Overall, results showed a positive correlation between teachers' perceptions and self-reported practices in BBL strategies in teaching science. These seven recommendations are proposed for adding to the research on BBL and teaching science:

1. This study should be replicated using additional school districts to give greater accuracy and reveal whether there is a consensus elsewhere.
2. This study was focused exclusively on the discipline of science; it could be modified to all subject areas.
3. This study involved K-12 teachers; the survey could be modified and redistributed to college professors to determine the use of BBL in their courses.

4. This study should be replicated comparing public school teachers' perceptions and practices of BBL in teaching science to charter or private schools, where more scheduling flexibility is afforded.
5. In this study it was learned that some of the early grades in several school districts do not provide a specific time for science instruction. Rather, science instruction is to be incorporated within the ELA time. A study should be conducted to compare third grade science scores from the past when science was taught separately to present third grade science scores where math and ELA are the main disciplines of focus.
6. With the current decline in science instruction during the early years, a long-term study should be conducted to track K-2 students to determine how many of them will choose a science discipline upon entering college compared to currently enrolling college students.
7. A qualitative study could be conducted comparing teachers' self-perceptions of BBL strategies in teaching science to actual classroom practices.

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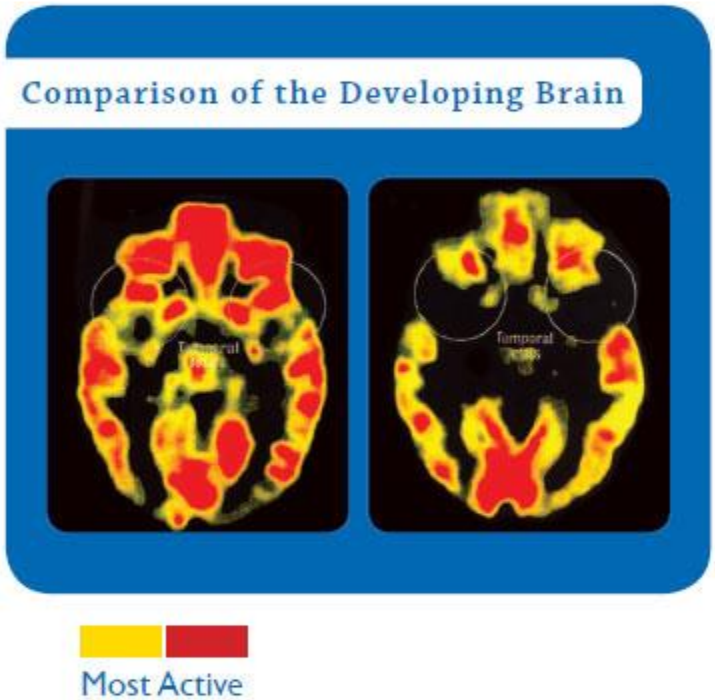
APPENDICES

Appendix A

Image of Normally Developed Brain Compared to Under-Stimulated Brain



Normal Brain **Under-Stimulated Brain**

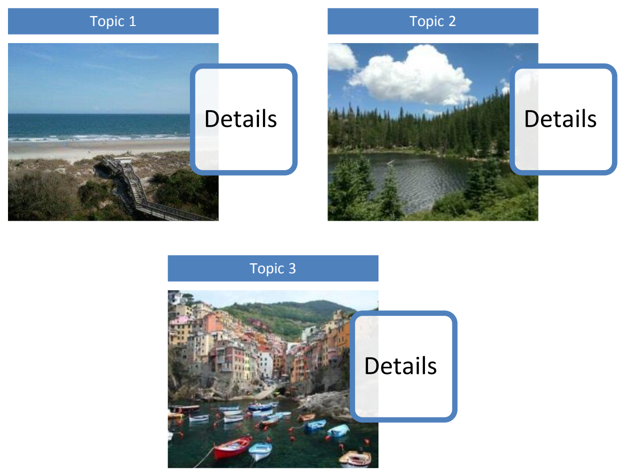
The graphic above has MRI images indicating brain activity. The image on the left depicts a normal healthy brain in a stimulating environment. The image on the right indicates a brain that is emotionally stressed and lacking stimulation resulting in decreased development of neural connections.

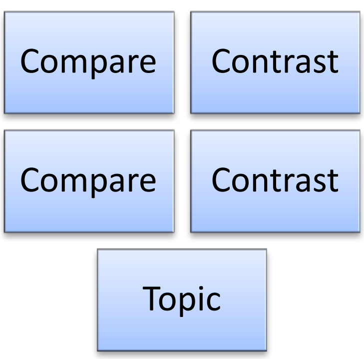
Image used with permission from http://greatstartkids.com/the-business-case/

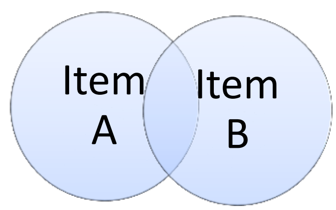
Appendix B

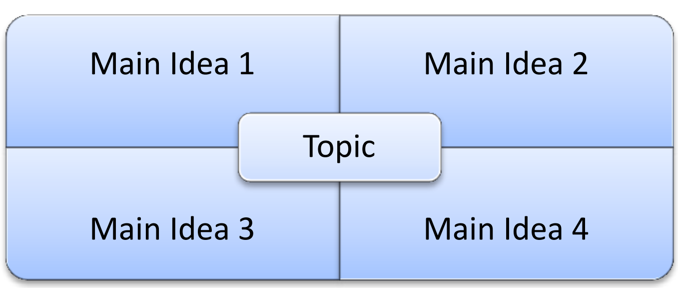
Examples of Graphic Organizers

Graphic organizers are used to organize writing projects, to help in decision-making and brainstorming. A few examples are included below:









Appendix C

Brain Based Learning: K-12 Teachers' Preferred Methods of Science Instruction Survey

Dissertation Questionnaire – For my dissertation, I am interested in learning more about teachers' perceptions and practices in the discipline of **SCIENCE**. Please be honest in your responses; your answers are totally anonymous and will in no way be linked to you or your school system. Thank you so much for taking the time to assist me in my research.

1. Before beginning the survey, please confirm that you meet **ALL** of following three criteria for the 2013-14 school year.

   1) Regular full time teacher
   2) Teach in grades K-12
   3) Teach science in some capacity

   _____ If **YES**, Please continue with the survey.
   _____ If **NO**, Please discontinue the survey.

Part 1 Directions: Please respond to the following questions or statements based on your status during the **2013-2014 school year.**

2. What is your gender?

   _____Male
   _____Female

3. How many years have you been teaching?

   _____1-5 years
   _____6-10 years
   _____11+ years

4. What grade range did you teach during the 2013-2014 school year?

   _____Elementary (K-5)
   _____Middle School (6-8)
   _____High School (9-12)

Background and Training

5. The term Brain Based Learning (BBL)

   _____is new to me.
   _____I have heard of it but am not sure what all is included in the concept.
   _____I understand BBL but rarely incorporate it in my classroom.
   _____I understand BBL and regularly incorporate it in my classroom.

Part 2 Directions: Please use the following scale to respond to each statement. **ONLY consider your science classes when answering.**

1 – Strongly Disagree
2 – Disagree
3 – Neither Agree nor Disagree
4 – Agree
5 – Strongly Agree

6. When I was in K-12, I had at least one teacher who inspired me in science by using interactive science lessons. 1 2 3 4 5

7. My pre-service classes in college prepared me to teach science in an interactive approach. 1 2 3 4 5

8. I have attended workshops to learn how the brain learns. 1 2 3 4 5

9. I would like to attend a workshop to learn new interactive approaches for teaching science. 1 2 3 4 5

10. I need more training in understanding how the brain learns. 1 2 3 4 5

<u>My Perceptions about BBL, Science, and Learning</u>

11. Laboratory-based science classes are more effective than non-laboratory science classes. 1 2 3 4 5

12. The temperature of my class is comfortable to most of my students. 1 2 3 4 5

13. I would have more science experiments if I had more time to teach science. 1 2 3 4 5

14. Boys generally enjoy science more than girls. 1 2 3 4 5

15. It is important to switch activities throughout every science lesson. 1 2 3 4 5

16. It is important to provide trust and hope in the classroom setting. 1 2 3 4 5

17. I am always looking for new ideas for teaching science. 1 2 3 4 5

18. I view HOW students learn as important as WHAT I should teach. 1 2 3 4 5

19. It is important for my students to feel comfortable in my class. 1 2 3 4 5

Directions: Please use the following scale to respond to each statement. **ONLY consider your science classes when answering the questions.**

1 – Strongly Disagree
2 – Disagree
3 – Neither Agree nor Disagree
4 – Agree
5 – Strongly Agree

20. I rarely have my students completing science experiments because it takes too much time for planning and gathering the materials. 1 2 3 4 5

21. Different learning approaches are a waste of time in the K-12 setting. 1 2 3 4 5

22. The purpose of my classroom is to create a supportive, challenging, and complex environment where questions are encouraged. 1 2 3 4 5

23. It is important for students to feel appreciated in my class. 1 2 3 4 5

24. I think it is important for each lesson to have real-life application. 1 2 3 4 5

25. There are enough science supplies in my school to teach most lessons in an interactive way if I so choose. 1 2 3 4 5

26. Lecturing is just as good as teaching through hands-on activities. 1 2 3 4 5

27. Teaching with how the brain learns best is just a fad and will cycle away like so many other educational ideas. 1 2 3 4 5

28. It's important for my students to feel welcome in my classroom. 1 2 3 4 5

29. My students feel comfortable asking me questions. 1 2 3 4 5

30. I like my students and have a good rapport with them. 1 2 3 4 5

31. Teaching other subjects leaves me with little time to teach science. 1 2 3 4 5

32. I have access to the appropriate curriculum and materials for teaching science when needed. 1 2 3 4 5

33. I have so much material to cover, I don't have time for group work or science activities. 1 2 3 4 5

34. How students learn plays an important role in the classroom environment. 1 2 3 4 5

Directions: Please use the following scale to respond to each statement. **ONLY consider your science classes when answering the questions.**

1 – Strongly Disagree
2 – Disagree
3 – Neither Agree nor Disagree
4 – Agree
5 – Strongly Agree

35. Preparing students for the high-stakes' test leaves me little time for classroom discussions and activities. 1 2 3 4 5

36. I would be willing to initiate various learning strategies if there was more time to do so. 1 2 3 4 5

37. I make an effort to exhibit a positive, warm, and caring attitude with my students. 1 2 3 4 5

38. I set the class temperature level to suit my tastes. The students can adjust accordingly. 1 2 3 4 5

39. Students seem to enjoy my science class. 1 2 3 4 5

40. I encourage my students to learn about their classmates' interests. 1 2 3 4 5

41. My class is too crowded to have students working in groups. 1 2 3 4 5

42. I have a class to teach; I don't have time to worry about different students' learning styles. 1 2 3 4 5

43. The noise of group activities makes me uncomfortable. 1 2 3 4 5

<u>My SCIENCE Classroom Practices</u>

44. I rarely give my students a chance to talk to one another because they will get off task. 1 2 3 4 5

45. I teach with a variety of strategies each day to accommodate the different learning styles of my students. 1 2 3 4 5

46. When/If science homework is given, students generally answer questions from the book. 1 2 3 4 5

Directions: Please use the following scale to respond to each statement. **ONLY consider your science classes when answering the questions.**

1 – Strongly Disagree
2 – Disagree
3 – Neither Agree nor Disagree
4 – Agree
5 – Strongly Agree

47. I use storytelling as a part of my science lesson. 1 2 3 4 5

48. I switch activities often throughout the course of the science lesson. 1 2 3 4 5

49. I have established rules and follow them closely. 1 2 3 4 5

50. The temperature of my class is comfortable to most of my students. 1 2 3 4 5

51. I strive to make real-world connections between the science content and my students lives. 1 2 3 4 5

52. I use lecture as my preferred class delivery method. 1 2 3 4 5

53. I use plants and/or aromas to create a homey feel. 1 2 3 4 5

54. I often find myself using sarcasm when answering my students. 1 2 3 4 5

55. I work at making a real life connection of the topics being taught. 1 2 3 4 5

56. I use or encourage some form of movement in my classroom to help focus attention and improve learning. 1 2 3 4 5

57. I use humor when teaching my science class. 1 2 3 4 5

58. On any given day, I do most of the talking in class. 1 2 3 4 5

59. I use mnemonics or word strategies to teach science concepts to my students. 1 2 3 4 5

60. I often give my students problem-solving tasks that result in different solutions. 1 2 3 4 5

61. I perform science demonstrations for my students. 1 2 3 4 5

62. My students often work in pairs or small groups. 1 2 3 4 5

63. I need to have order and quiet in my classes. 1 2 3 4 5

Directions: Please use the following scale to respond to each statement. **ONLY consider your science classes when answering the questions.**

1 – Strongly Disagree
2 – Disagree
3 – Neither Agree nor Disagree
4 – Agree
5 – Strongly Agree

64. I generally teach science to the whole class at one time. 1 2 3 4 5
65. I discourage classroom chatter, even on topic; it makes me uncomfortable. 1 2 3 4 5
66. My class frequently participates in hands-on science experiments. 1 2 3 4 5
67. I am quick to give constructive feedback on assignments or labs. 1 2 3 4 5
68. I use graphic organizers or concept maps in my science class. 1 2 3 4 5
69. On most days, I expect my students to listen quietly and take notes. 1 2 3 4 5
70. It's important for me to make the students feel welcome in my classroom. 1 2 3 4 5
71. My students have time to discuss the science topic of the day with one another. 1 2 3 4 5
72. Most of the experiments in my class have only one right outcome. 1 2 3 4 5
73. I prefer a busy, active classroom environment. 1 2 3 4 5
74. I use lamps and/or natural lighting when possible. 1 2 3 4 5
75. I use music in my science classroom as part of the instruction. 1 2 3 4 5
76. I have posters on the wall for indirect instruction. 1 2 3 4 5
77. I encourage student questions and discussions. 1 2 3 4 5
78. The students' seats are usually in straight lines. 1 2 3 4 5
79. I use plants and/or aromas to create a homey feel. 1 2 3 4 5
80. I usually have the students quietly taking self-notes or recording teacher-given notes. 1 2 3 4 5
81. I use music in the background as students are working in groups. 1 2 3 4 5
82. **Feel free to add anything you would like regarding the teaching of science.**

Thank you very much for your participation in this study! Your time and thoughtful responses are greatly appreciated. If you have questions or would like the results of this study when completed, you may contact me at dlmansy@aol.com.

Appendix D

Letter to Directors of Schools

Ms. Donna Lachman Mansy
Robin Hood Lane
Johnson City, TN 37604

June 9, 2014

Dear Director of Schools:

I am an Ed.D. candidate at East Tennessee State University and am in the dissertation portion of my program. My research is on teachers' preferred instructional delivery method in the discipline of science.

I would like permission to survey the K-12 regular education teachers in your district through the use of an online survey. I would like to send an email with a link to the survey asking them to participate. Their participation would be voluntary.

Attached is a copy of the survey. After the survey is completed, in a separate window, teachers will have the option to enter their email address and be entered to win a $50 gift card from Amazon.

Please respond by email at your earliest convenience.

Sincerely,

Ms. Donna Lachman Mansy
District Science Coordinator
Washington County Department of Education
ETSU Doctoral Student

Work #: 423-213-3962
Cell #: 423-330-5656
Fax #: 423-753-1149
Email: lachman@goldmail.etsu.edu

Appendix E

IRB APPROVAL – Initial Exempt

ETSU

East Tennessee State University
Office for the Protection of Human Research Subjects • Box 70565 • Johnson City, Tennessee 37614-1707
Phone: (423) 439-6053 Fax: (423) 439-6060

IRB APPROVAL – Initial Exempt

July 10, 2014

Donna Lachman Mansy

RE: Brain Based Learning: Investigating K-12 Teachers' Preferred Methods of Science Instruction
IRB#: c0614.15e

On **July 10, 2014**, an exempt approval was granted in accordance with 45 CFR 46. 101(b)(2). It is understood this project will be conducted in full accordance with all applicable sections of the IRB Policies. No continuing review is required. The exempt approval will be reported to the convened board on the next agenda.

- xform New Protocol Submission; External Site Permissions; Email to Teachers (stamped approved 7/10/14); Follow-up Email to Teachers (stamped approved 7/10/14); Survey; Invite Letter to School Directors; Permissions to use a photo & the survey; CV

Projects involving Mountain States Health Alliance must also be approved by MSHA following IRB approval prior to initiating the study.

Unanticipated Problems Involving Risks to Subjects or Others must be reported to the IRB (and VA R&D if applicable) within 10 working days.

Proposed changes in approved research cannot be initiated without IRB review and approval. The only exception to this rule is that a change can be made prior to IRB approval when necessary to eliminate apparent immediate hazards to the research subjects [21 CFR 56.108 (a)(4)]. In such a case, the IRB must be promptly informed of the change following its implementation (within 10 working days) on Form 109 (www.etsu.edu/irb). The IRB will review the change to determine that it is consistent with ensuring the subject's continued welfare.

Sincerely,
Chris Ayres, Chair
ETSU Campus IRB

Association for the Accreditation of Human Research Protection Programs, Inc.
Full AAHRPP Accreditation

Accredited Since December 2005

Appendix F

Letter to Teachers

June 9, 2014

Dear Teacher,

My name is Donna Lachman Mansy, and I am a doctoral candidate in the Educational Leadership and Policy Analysis (ELPA) program at East Tennessee State University (ETSU). I am currently conducting research for my dissertation. The purpose of my study is to determine teachers' background, perceptions, and practices of instructional delivery in the discipline of science. The committee chairperson for my study is Dr. Don Good, a professor in the ELPA department of the College of Education at ETSU.

Your school system has agreed to participate in this study. As a full-time, regular education teacher who teaches science in some capacity in a K-12 grade setting, I invite you to complete a survey regarding your instructional methods for teaching science. The survey should take approximately 10 minutes to complete.

Participation in the study is completely voluntary. Please feel free to answer honestly. All response will remain confidential and anonymous. Three counties have been invited to participate. All results from the surveys will be compiled together with no identifying information desegregated by county.

After completing the survey, you will have the option of entering your email in a separate window to be entered to win a $50 gift card from Amazon. I hope you will consider taking part in this study as the results may help area school systems improve science instruction delivery methods, and it will certainly help me complete my dissertation.

Please complete the survey as soon as possible.

Thank you for your time and consideration of this request. If you have any questions or concerns, please feel free to contact me at (423) 213-3962 or at lachman@goldmail.etsu.edu.

Sincerely,

Donna Lachman Mansy
Doctoral Candidate
Educational Leadership and Policy Analysis
East Tennessee State University

VITA

DONNA LACHMAN MANSY

Education:	East Tennessee State University, Johnson City, TN, Ed.D., Educational Leadership, December 2014.
	East Tennessee State University, Johnson City, TN, Additional Certification in General Science, Biology, and Administration.
	East Tennessee State University, Johnson City, TN, M.Ed., Master of Education, 1983.
	East Tennessee State University, Johnson City, TN, B.S., Bachelor of Science in Education, 1982.
Professional Experience	District Science Coordinator (Funded by Race to the Top Grant), Washington County Department of Education, Jonesborough, TN, 2010 – Present.
	Teacher (Grades 5-8), Washington County Department of Education, Jonesborough, TN, September, 1982 – May, 2010.
	Adjunct for two Summer Workshops in Science Methods, East Tennessee State University, Johnson City, TN.
Professional Affiliations:	National Science Teachers Association (NSTA)
	National Science Education Leadership Association (NSELA)
	Fellow of the Tennessee STEM Leadership Academy (TSLA)
	Member of the East Tennessee STEM Hub Advisory Council
	Kappa Delta Pi International Honor Society in Education

Awards and Honors:

2009-2010 - Head of the Environmental Green Team at Boones Creek Middle School (BCMS)

2005-2010 - Lead Mentor Teacher for BCMS

1999-2000 - Teacher of the Year for Washington County

1999-2000 - Teacher of the Year for Boones Creek Middle School (BCMS)

1995-1996 - Career Ladder Level 3 Teacher - My class was one of three selected to be filmed to serve as a model for the state.

1983 - Conservation Teacher of the Year

1983 - EXCEL Teacher of the Year

1982-1983 - Teacher of the Year at West View School