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Neuroeducation: Do Educators Value Neuroscience Research?

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Abstract

Created from the Cognitive Revolution of the 1950s, the field of neurology has discovered research that suggests the way the brain best learns, stores and retrieves information. However, this knowledge is making its way into the field of education at a snail's pace (Jensen, 2005). Recently there has been a call for educators to learn neuroscience to best meet the demands they are held to in today's society. Furthermore, understanding the brain's neuroplastic potential brings a sense of optimism to the learning process for both teachers and students, which will ultimately empower students to take control of their own learning (Willis, 2012). Specifically the change agents are asking that educators be taught basic neurology to select strategies, techniques and policies that will maximize student learning potential. However, if taught basic research in the field of neurology will educators value and recognize its applications to their practices? I conducted a neuroeducation workshop for teachers and administrators (n=43) at a high school in August of 2014 to make these determinations. I surveyed the participants with closed and open ended questions after the workshop. The survey results were tabulated, charted and graphed, using Google Forms. Lastly, the workshop was evaluated by two assistant principals. The results indicated that educators do in fact value neuroscience and can make applications to their own classrooms. While the results did not indicate a dearth of neuroscience in teacher undergraduate programs; they did suggest that these educators desire to learn more in future professional development workshops.

Chapter One

Introduction

A common response I heard from students every year after learning about attention in our memory unit in my AP Psychology course was, “Why don’t *all* teachers know this?” The unit discusses the different types of attention, where students are exposed to concepts like *sustained attention*, a concept in particular that seemed to gain the most reaction from students. You see, neuroscientists have discovered that our sustained attention, or our ability to maintain our attention on one given task, is a simple equation when all systems are “normal” since there are several factors that impact attention like sleep loss, dopamine production, stress, and motivation to name a few (Oken, Salinsky, & Elsas, 2006). Sustained attention equals our age in minutes up to twenty minutes (Jensen, 2005), after which point we find ourselves shifting our focus to other stimuli or thoughts (Davis, Balda, & Rock, 2014). What frustrated my students and awed me was their quick application of the concept to their own experiences; their teachers were lecturing for 43 minutes at a time without changing the focus off of themselves every 16, 17, or 18 minutes (which is the age of my high school students). These students were expected to pay attention the *whole* time, when they just learned it was cognitively impossible, so they were ultimately bound to lose the information that was being covered. As the semester wore on, their frustration turned to rage the more they learned and applied how their teachers and administrators were not following practices that were proven in neuroscience. “Why don’t teachers do this stuff?” I could not really answer their questions, I could only lament with their frustration because it was like they were being set up for failure.

At first I was relieved that students did not talk about my course or methods like that. However, over time, the student’s frustration became mine. I became annoyed to hear students talk about the atrocities committed against neuroscience research that were occurring in the district and in the building. I would shake my head and say, “If I ran the world we would do everything according to brain research!” and we would laugh at the ridiculousness of my running the world. However, there was a grain of truth in that statement. I wanted the world to be run with this knowledge, in particular, the field of education. I began to wonder why it was not. I knew that my teaching practices were current with the neuroscience research and its applications to education, but it was not because of my pre-service education but because I taught AP Psychology and my own intrinsic motivation to learn and apply more. Soon I felt a sense of moral obligation to share this research with other educators. Maybe educators didn’t know about it? Maybe they forgot about it? I could change the world. I could advocate for this research to be at the forefront of teacher and administrator decision-making. I felt compelled to share what became my passion; to enlighten and inspire educators and to make students educational experience the best it could be. And thus began my journey into neuroeducation, an “interdisciplinary field that combines neuroscience, psychology, and education to help create improved teaching methods and curricula” (Mehta, 2009, para. 1).

The field of neurology was born from the intellectual movement in the 1950s known as the cognitive revolution. The discoveries from this field of study have emitted valuable insight into how the brain functions, which should have the field of education jumping for joy! Clearly, the brain is something that indisputably educators work with on a daily basis and a better understanding of it could only make their jobs less complicated. This is especially important considering “current educational reform efforts that are setting ambitious goals for schools, teachers and students” (Otero et al., 2005, p. 8). The field of education has been cognizant of the discoveries in neuroscience research for the last several decades. Hart (1999) stated, “Education is discovering the brain and that's about the best news there could be" (p. xi as cited in McGeehan, 2001, p. 11). Yet, here we are in 2014 and research about the brain and its applications to the field of education are seeping into the system at a snail's pace where professionals do not have a basic understanding of the neuroscience behind learning (Jensen 2005). Nor are they making decisions with the latest research applications of neuroscience to education. It is arguably negligible that they are in the field not utilizing this knowledge as it limits their capacity to best serve our students.

According to Willis (2012a), when educators learn about how the brain functions at the "level of neural networks, synapses and neurotransmitters" they tend to share that knowledge with their students. When this happens they empower their students to create a growth mind-set for learning. This allows for students to understand their ability to change their brains, which leads them to take charge of and have confidence in the learning process. "Students thrive in classrooms where teachers have the added tools from their neuroscience understanding" (Willis, 2012a, para. 12). With all of these benefits is hard to fathom why there is a dearth of neuroscience being utilized in the field of education.

Recently, a call for teachers to learn neurology has gained momentum in the education field (Sparks, 2012) for the aforementioned reasons. However, even if it is being asked of education professionals to learn, will they find the neuroscience research valuable or recognize its applications as studies suggest (Farrah & Hook, 2012)? Considering how easily my students and I saw the value and application of neuroscience in education, I could hardly believe that other educators would not. Therefore, I had to find out what would happen if I taught basic neurology to educators and see for myself if they would value it and see the applications to their profession.

I conducted a neuroeducation workshop for teachers and administrators at a high school in August of 2014. The intent of my workshop was to provide participants that attended the workshop with the basic knowledge of the neuroscience behind learning and how to maximize learning through purposeful lessoning planning and classroom management practices supported by neuroscience. In providing participants with this knowledge, I wanted to determine if education professionals value the neuroscience of learning and its classroom applications. Furthermore, I wanted to find out if neuroscience was part of their teacher education programs and evaluate my workshop for its effectiveness. To make these determinations, I surveyed the participants with closed and open ended questions after the workshop. The survey results were tabulated, charted and graphed, using *Google Forms*. Lastly, the workshop was evaluated by two assistant principals.

In discovering education professionals perceptions about neuroeducation and taking the opportunity to teach basic neuroscience we can get one step closer to making yet another shift in the field of education. We can eventually make that ever important shift to utilizing neuroscience research to make purposeful decisions about teaching and learning practices. It was my vision that by conducting this workshop, educators would continue or begin to put this knowledge to use in their classrooms, buildings, and districts to maximize students' learning potential.

The following chapter will take the reader through the journey of the birth of neuroscience as a field up through the specific findings applicable to the field of education. Some of the research in chapter two was presented in my workshop. The research that was left out of the workshop and research not mentioned will become the basis of future workshops.

Chapter 2

Literature Review

The field of education is at a pivotal point, where it is no longer the future for neuroscience to collide with education, it has already happened! The research in neuroscience obtained in the last several decades has changed the way people view themselves and the discoveries from the initiative approved by the president of the United States to map the entire brain (Nordqvist, 2013) is bound to have significant ramifications of how people will view the world. Any educator without adequate knowledge of how the brain works is significantly out-of-date (Jenson, 2008). The discoveries in neuroscience should be driving how teachers educate children, the education system and teacher education programs. Yet, a proponent argues, these applications are seeping into the education field at a snail's pace limiting education professionals' capacity to best serve students (Jensen, 2008). Likewise, there is a dearth of neuroscience research being applied or delivered in pre-service teaching curriculum and programs additionally perpetuating the issue (Jensen, 2005) and creating a greater void year by year of teachers graduating in the field of education with little knowledge of how the brain works. Willis argues, "Curriculum in schools of education has changed in response to changes in society, pedagogy and technology over the years" (Willis, 2012a, para. 3). For example, when computer technology became an ever present part of society, "schools of education appropriately included that instruction in the curriculum" (Willis, 2012a, para. 4). It is now time for the curriculum to shift again to include instruction of neuroscience research in professional teacher education programs and be part of the professional development of current practicing educational professionals (Eisenhart & DeHann, 2005; Sparks, 2012), even though the necessity for utilizing neuroeducation is not echoed by all.

Critics of teaching neurology to educators or applying neurological research in the field of education argue there does not need to be a focus on neuroscience in education because neuroscientists were wrong about brain functioning in the past (Bruer, 1999). It was once believed that people either thought with their right or left brain and that influenced their learning style: right brained being creative and hands-on and left brained being logical and mathematical. Neurological research progressed and it is now well understood that we think with both sides of our brain (King, 2011). However, updates to once believed research allows critics to claim there is a lack of longitudinal evidence to support teaching neuroscience to educators (Bruer, 1999). The argument is that it may be a waste of time to learn about the structures and functions of the brain and make decisions in education based on the neuroscience research because the findings could change as research continues to progress. However, the reliability of certain neurological research (as mentioned in this literature review) has been proven and remained constant (Sparks, 2012) discrediting this argument. Furthermore, how disreputable could neuroeducation be if Harvard University has both master's and doctoral degrees in it (Jensen, 2008)?

Others critics claim that the research referred to as brain-based is just taken from psychology and other fields (Sternberg, 2008) or worse, declare it false claims of neurology (Willingham, 2012). Granted there are people out there that have falsely labeled research, which has led to "neuromythology" to rise in schools (Sparks, 2012). For example, one false claim was that one's brain would shrink without water, which led to misconceptions and created distrust about brain research being used in the field of education (Sparks, 2012). However, this only points to the fact that educators need to be taught basic neurology and the applications of the research so they can best sort through the fact and fiction in their decision making (Dekker, Lee, Howard-Jones, & Jolles, 2012; Willis, 2008). Teachers that are not educated on the basic neuroscience of learning could also be spreading neuromythology to other educators and implement practices in their classrooms that waste time and effort that could be better spent on the development of evidence based practices (Dekker, et al., 2012). Besides destroying myths, teaching basic neurology and its applications to education would bring about physiological understandings and justification and a sense of professionalism. As Jensen (2005) puts it, understanding basic neurology and its applications to education allows educators to say “this is what I am doing [in the brain] and this is why I am doing it.”

Educators, at all levels in the profession, should be steeped in neuroscience to best meet the demands and expectations that they are held to in today’s society. Utilizing the neuroscience research to purposely select strategies and techniques will maximize student learning and potential as well as allow education professionals to come to a better understanding of the behaviors of their students (Jensen, 2008; Willis, 2012a). Furthermore, educators will be able to make and support decisions for their classroom, buildings and districts rooted in neuroscience research (Jensen, 2008) not just assumptions and hopes for learning.

The following pages of the literature review will discuss a fraction of the neuroscience research and its practical applications to the field of education. The literature review will begin with the birth of neuroscience from the cognitive revolution. Next, there will be a discussion of the discoveries neuroscientists have made in reference to the structures and functions of the brain providing the reader with a basic neurology foundation. Finally, the discussion will uncover the applications of those discoveries in neuroscience for education.

Cognitive Revolution

Ever since the beginning of time, man-kind has tried to understand human behavior; giving birth to the nature-nurture debate (King, 2011). Ancient Greek philosophers like Socrates and Plato argued there was not a mind and body connection to explain human behavior in that we were born a certain way and that is why we act the way we do (King, 2011). This philosophy dictates that knowledge and behavior in essence is innate. Aristotle dared to philosophize against his teacher's beliefs that a mind and body connection did in fact exist and that our external environment played a role in our behaviors and knowledge formation (King, 2011). It wasn't until Descartes (1634) began examining dead bodies that ancient philosophers' contemplations about a mind and body connection moved from philosophy to evidence in the discovery of nerves (as cited in King, 2011). Although Descartes was not accurate in his depiction of how the central nervous system worked nor did he agree with Aristotle on knowledge formation he did set precedence for others to examine the human body and discover its inner workings shedding new light and forging the idea of studying biology to explain human behaviors (Costandi, 2006).

Discoveries in the field of biology have led to all sorts of understandings of human body functioning preceding Descartes, essentially furthering an understanding of human behavior. Most noteworthy in 1936, Dale and Loewi won the Nobel Peace Prize for their research and discoveries on how nerve cells communicate with each other via electrical-chemical messages (Costandi, 2006). This discovery then paved the way for the winners of the 1950 Nobel Peace Prize winners, Hodgkin and Huxley, discovered how an action-potential is created along the axon of a nerve cell which illustrates how messages actually move through a nerve cell by ion depolarization (Costandi, 2006). These discoveries not only proved a mind and body connection that was philosophized about in ancient Greek times, but suggested how human behavior occurred. With these discoveries and the invention of the electron microscope in the 1950s, scientists in many fields began delving into researching the mind and brain (Costandi, 2006).

Much research and theorizing was being conducted in anthropology, psychology, linguistics, computer science, and philosophy in the 1950s tying our brains to our behaviors and trying to discover how our minds functioned. Some of the influential contributors Miller (2003) highlighted include: Minsky and McCarthy invention of artificial intelligence, Newell and Simon used computers to simulate cognitive processes, Chomsky was redefining linguistics with his acquisition theories and signal-detection theory was applied to perception by Tanner, Swets, Birdsall and others at the University of Michigan. In 1956, Miller published an article suggesting the limits of the human attention and the ramifications it plays on processing information (Miller, 2003). In the same year, Carroll edited a collection of papers by Whorf on the effects of language on thought (Miller, 2003). This flurry of studying the brain and its impact on human behavior gave birth to what became known as the cognitive revolution.

The cognitive revolution was born out of both discovery and rebellion. Disagreement with behaviorists like Watson who theorized that human behavior was determined by rewards and punishments and evolutionary theorists like Darwin who explained human behavior as being driven by survival and perpetuation of the species (King, 2011) helped to encourage those who believed the human experience was caused by something more. The cognitivists believed that it was human thought processes that drove behaviors and if researchers could determine how humans conduct those processes they could improve the quality of human life by attempting to control human behavior through one’s thoughts. By the 1960s prestigious universities like Harvard, Carniege-Mellon, and La Jolla all had departments studying cognition (Costandi, 2006). In the 1970s, with the advent of neuroimaging technologies, neuroscience as a collective field of study with a focus on researching the structures and functions of the brain emerges. As a result of the discoveries emitting from neuroscience research, mankind has gained valuable insight into how the brain functions, which has led to discoveries in how the brain bests learns, stores and retrieves information. More importantly, the discoveries began to uncover the time honored mystery behind human behavior.

Functioning and Structures of the Brain

Through neuroimaging technologies, devices like Computerized Axial Tomography, Positron Emission Tomography, Functional Magnetic Resonance Imaging and Electroencephalography machines that allow one to be able to view the live human brain, many discoveries in neuroscience have led to an understanding of the structures and functions of the brain. This information is important to understanding human behavior as each structure of the brain is responsible for different aspects of human behavior. When a structure does not function properly, human behavior is affected, and changed. The following discussion will be limited to the structures and functions of the brain that play key roles in perception, learning, memory and movement.

The brain is divided into three separate but connected regions: forebrain, midbrain and hindbrain (King, 2011). The hindbrain, first to develop from and evolutionary perspective, consists of the spinal cord, medulla, pons, cerebellum, and reticular formation. The primary job of the spinal cord is to send messages to and from the brain to the body. This pathway sends messages from the body's external environment via sensory receptors to the brain for interpretation as well as sends messages from specific regions in the brain sending signals to cause movement (de Haan & Johnson, 2002). The medulla is responsible for heart beat and breathing; if damaged these automatic functions cease and one dies. The pons play a role in the regulation of our sleep cycle allowing one to relax before sleep. The reticular formation alerts one to fight or flight and helps one to pay attention to the environment and is responsible for one's different arousal levels. Finally, the cerebellum helps one to balance and is responsible for coordination of muscles. It also plays a role in one's procedural memory so one does not have to relearn things like the skill of tying shoes, playing the piano or typing every time one encounters these tasks (Thatch, 1996).

The midbrain houses the hippocampus, amygdala, thalamus, and hypothalamus. It is often referred to as the limbic system. The thalamus is the "crossing guard" of the brain (Jensen, 2008). It is responsible for all sensory input coming into the brain and directing it to the proper region of the brain for interpretation except for smell. The hypothalamus is located below the thalamus. It is the "thermometer" of the body trying to maintain a normal body state. It is responsible for maintaining body temperature, thirst, hunger, sex drive, and blood pressure but can play a role in pleasurable feelings (King, 2001) as wells as drug addiction (King, 2011). The amygdala is partly responsible for fight or flight and our emotions especially fear and aggression. The hippocampus is not only responsible for storage of memories but also assisting in the formation and retrieval of memories. It is important to understand that not all memories are stored in the hippocampus but in various regions in the brain depending on the type of memory (King, 2011).

The hindbrain and midbrain are all structures that operate on an unconscious level. Therefore, most of what goes on in the brain happens unconsciously. The part of our brains that allows one to be aware, recognize, talk about what one is feeling and thinking is the forebrain or the cerebral cortex (Gazzaniaga, Ivry, & Mangun, 1998). The cerebral cortex is divided into four lobes: the occipital responsible for processing visual information, the temporal for hearing and smell, the parietal for movement, maintaining focus, spatial awareness and touch, and the frontal for sensory motor processing and thinking.

At the microscopic level each brain structure of the forebrain, hindbrain and midbrain are all comprised of and connected by special, microscopic cells called neurons. It is important to understand that the brain structures do not work alone but in tandem with each other which is called parallel processing (King, 2011). Neurons are the nerve cells that communicate with electrical-chemical messages between each of the structures of the brain. It is the job of the neuron to send electrical chemical messages within each brain structure and out to other structures and parts of the body; this allows one to do everything from thinking, speaking, walking, remembering, feeling and sensing. Neurons are comprised of several different parts all essential in understanding how the brain functions.

The neuron is comprised of five main parts. The first, dendrites are branch like structures of the neuron that receive information from the sensory receptor cells or from the next neuron in the circuit as neurons are all connected to each other like a highway of circuitry (King, 2011). The dendrites send the message to the second main part: the soma. The soma is where the cell body converts the message into an electrical impulse (which is what an EEG machine reads) and then sends the message down the third main part called the axon. The message is sped up along the axon by a fatty substance that surrounds it called the myelin sheath (King, 2011). The message makes its way down the axon and arrives at the fourth part called the terminal buttons (more branch like structures at the end of each neuron). The terminal buttons house vesicles containing chemicals which are stimulated by the electrical message to release their chemicals into the synaptic gap (open space between “connecting” neurons), thus sending the message to the receptors on the end of the dendrite of the next neuron in the circuit. This process is called action potential which can reach speeds of up to 220 miles per hour (Greenfield, 1997). The chemicals that are released are called neurotransmitters, which is the fifth main part of a neuron. It is believed that there are potentially one hundred or more different types of neurotransmitters that are released by neurons, which are responsible for telling parts of the body what to do, thus being responsible for the actions and reactions of behavior (King, 2011). Some of the most well understood neurotransmitters are epinephrine, norepinephrine, dopamine, serotonin, acetylcholine, glutamate, and endorphins.

Epinephrine puts the body in a state of alert and prepares one for fight or flight. Norepinephrine is also responsible for preparing the body for fight or flight and may play a role in feelings of depression because of its role in one’s activity level. Dopamine is responsible for conscious motor activity and enhancing pleasurable feelings. Serotonin is responsible for our moods, specifically calming them. It is also responsible for memory, sleep, appetite, and regulation of body temperature. Acetylcholine is responsible for enhancing REM sleep and plays a role in memory. It is most notable for its role in voluntary and involuntary muscle movement. Glutamate is responsible for solidifying the memory and learning processes. Endorphins are responsible for deadening pain and producing the feelings of euphoria.

So what does all this mean for educational professionals? Teachers are expected to educate minds but it is ironic as Berninger and Richards (2002) argue that most of them are given little to no professional preparation about the structures and the functions of the brain. The beauty of knowing how the brain is structured and functions can help educators purposely plan lessons and make decisions for how the brain best learns, stores and retrieves information.

Applications to Education

The mystery and awe of the human brain is that the structures do not function in isolation, learning doesn't occur in isolation either. It is the job of educators to create an environment conducive to learning. If educators understand the research surrounding the way the brain best learns they can better make decisions to increase and enhance student learning (Willis, 2012a).

Learning by definition is the ability to identify or predict associations among variables, predict and express concepts accurately, and store, retrieve and predict concepts accurately in context over time (Jensen, 2005). This means that learning is a highly complex process that requires all structures of the brain (King, 2011). Learning is quite literally growing dendrites and strengthening neural connections and pathways. This means that learning changes the structure and function of the brain, which is called neuroplasticity.

The concept of neuroplasticity is not entirely understood, but for a long time it was believed that as we age the connections in our brain became fixed (Michelon, 2008). However, through the use of fMRI scans neuroscientists now understand that plasticity is the capacity for the brain to change forming and making new connections between neurons and structures in the brain (Michelon, 2008) throughout one's lifetime. This is exactly what happens when one learns, which means that intelligence is not fixed (Begley, 2007; Willis, 2010).

The brain (in any stage of development) has the "power to grow new neurons, rezone regions that performed one task and have them assume a new task, and change the circuitry of neural connections in the brain" (Begley, 2007, p. 230). Neuroscientists have discovered that the "brain devotes more cortical real estate to functions that its owner uses more frequently and shrinks the space devoted to activities rarely performed" (Begley, 2007, p. 230). This means that the size of the regions of one's brain and the strength of our connections are based on the premise: If you don't use it, you lose it. If one wants to strengthen those regions, then the pathways have to be used. This neuroscience research is very powerful for the field of education.

When students are taught that their intelligence is not unchangeable but malleable, and they have control over it, students are less likely to give up or withdraw effort when they meet a challenging demand (Blackwell, Dweck, & Trzesniewski, 2007). Therefore it is invaluable that educators teach students the concept of neuroplasticity (Willis, 2010). Likewise when educators learn this it increases their optimism and motivation in the classroom (Willis, 2012a). To visualize the concept of neourplasticity one must understand what happens in the brain when one learns something new.

Inside the brain, when we learn something new neurons are growing dendrites and connect themselves into multiple networks of interrelated data. The more the network fires (sends messages) and connects the better the brain is able to retrieve information in what is commonly known as memory. Therefore, learning and memory go hand-in-hand in a symbiotic relationship. To understand one it is necessary to understand the other.

The vast majority of what teachers do on a daily basis is teach students new information or skills. What is actually happening in the brain when this occurs? Learning is actually growing and connecting dendrites in various structures of brain. Before anyone can learn anything new one must first be paying attention (Jensen, 2005). Secondly, one must connect the new information or skills to previously learned information; dendrites can only grow out of previously established neurons (as cited in King, 2011). For example, if a teacher were to teach a student about what sensory memory is and the teacher says that it is the first process in memory that helps one to pay attention to the environment. That is a very hard concept to “wrap one’s head around”, but if teacher capitalized on a student’s prior knowledge of the concept of a filter and the teacher said that sensory memory is like a filter. This filter (sensory memory) would allow the student to determine what is important in their sensory environment and make it through to be stored in their memory system. Tying sensory memory to a filter helps one to attach the new information to something one already knows thus allow for dendrite growth to take place. The more one deepens an understanding about the new information, by learning about sensory memory through potentially a visual or a tactile experience, and understanding more complex aspects of it the more neural networks one connects in the brain. Essentially when one learns, neural networks (pathways) are being built like “roads” in our brains. However, we don’t want to just build roads, we want to “drive” on them too.

When one practices the information and skills learned, one is able to drive on those neural networks because the practicing allows for messages to be send down the neurons and all its connections (Willis 2010). That message carries the information that one learned. Educators want that network to fire as often as possible because it thickens the dendrite and produces more myelin sheath around the axon (King, 2011). Meaning, the more practice, the better retrieval of the information learned essentially increasing the likelihood of success on an assessment. This is why formative assessment is so vital to the learning process. The more a student practices (formative assessment), the speed of the message will increase, traveling faster through the neural network so we can utilize the information or skill in real time otherwise the message could never get to us to be used. Every time a neuron fires it is thought that memory trace is left on the neural network, which is why memory and learning go hand in hand. Educators not only want to make connections in the brain but also want to retrieve information from the neural networks, which is where memory comes in.

The most widely accepted model for memory for the past several decades is the Multi-Store Model to explain information processing developed by Richard Atkinson and Richard Shiffrin (King, 2011). This model explains how the human mind encodes, stores, retrieves, and integrates new information. The model begins with the sensory memory. The sensory memory is a filtering system of the external environment. One is constantly bombarded with sensory information sights, sounds, smells, etc. at every given second of the day. The sensory memory holds the information for a fraction of a second and determines if the information is relevant (de Haan & Johnson, 2002). There is some evidence that sounds are held a bit longer than visual information, maybe up to 20 seconds (Gazzaniga, Ivry, & Mangun, 1998; King, 2011). By some estimates, 99 percent of all sensory information is discarded almost immediately upon entering the brain (Gazzaniga, 1998). Basically what is taking place in the sensory memory is a filtering process of what our brains should pay attention to.

Attention has always been a central concern of educators, often referred to as engagement. Inevitably a student is going to claim that they do not remember being taught information. The teacher knows they have taught the information but clearly the student has not retained it. In most cases, this is due to lack of engagement of the student. The brain's ability to focus and maintain attention is critical to learning and memory (Hung, 2003) and is a key element of classroom management and student motivation.

Teachers are competing against a gamut of other stimuli to gain the attention of their students' sensory memory: the lighting and room temperature, friends in the classroom, the sound of the heater, the students walking by in the hallway, the breathing and fidgeting of other students in the classroom, the posters on the wall and of course the students own stream of conscious thoughts. Teachers tend to criticize students for not paying attention however, there is no such thing as “not paying attention,” the brain is always paying attention to something, students just might not be paying attention to what teachers want them to be (Wolfe, 2001, p. 81). It is understandable why learning deficits are created in students with ADD or ADHD with their limitations in attention. To get students to learn and remember, teachers need to engage the focus and attention of sensory memory.

When someone is working hard to pay attention, fMRI scans have shown increased neural firing in the prefrontal cortex, which is located in the frontal lobe of the brain and in the posterior cortex, which is located in the parietal lobe (Wolfe, 2001). Neuroscientists also have discovered from EEGs that when people are trying hard to concentrate their brainwave patterns emit beta waves. This means that we can tell when one is engaged, however teachers do not have these neuroimaging technologies in their classrooms to scan each students’ brain to determine if they are paying attention. To the rescue comes the neurological research! Neurologists have discovered there are multiple factors that play a role in student engagement: novelty, glucose levels, emotional states, meaning, coherence and timing.

First, brains are designed to pay attention to unique information in the environment. The evolutionary purpose of this was to increase the likelihood of survival because a novel stimulus prompts one to pay attention in case of danger (Wolfe, 2001, p. 83). We have kept this predisposition to pay attention to the novelty and teachers can take full advantage by adding novelty to their lessons. Educators can do this through any of the senses with visuals, movement, sounds, etc. Teachers should never start class the same way every day or the same strategies and techniques over and over because the brain habituates them and then students pay attention elsewhere (Jensen, 2005). Currently, technology can help to aid and bring about novelty in the classroom. By changing things up in lesson planning it adds that dash of novelty to keep students engaged.

Secondly, glucose levels also play a role in engagement. Neurons need glucose to fire inducing action- potential; it provides the energy they require to function properly. When humans eat, glucose enters the bloodstream providing the fuel the body needs for learning and memory, especially glutamate neurons (Gao, van Beugen, & de Zeeuw, 2012). When glucose levels are low it makes it hard to learn and thus hard to store and retrieve information (Jensen, 2005). It is in a teacher's best interests to allow students to drink and eat in class, of course nutritious choices should be kept in mind, but disallowing food sets students up to fail at engaging in the lesson.

Additionally, emotions of all kinds can inhibit and encourage engagement. Students pay attention when it is safe to pay attention (Jenson, 2005, p. 36). If students feel like they are not safe, meaning they are being bullied by peers or that a teacher will put them in a situation where they are embarrassed they are in a situation that keeps them from being engaged. As a result, they are worried about those feelings instead of the lesson. These situations activate the fight or flight response, stimulating the thalamus and amygdala and the release of norepinephrine and epinephrine into the system (Howard, 2000). Teachers who cause or allow threatening situations put students' systems under stress where their brain is operating in the limbic system instead of in the prefrontal cortex making learning much more difficult (Erlaurer, 2003, p. 13). Educators want students engaged and operating in the prefrontal cortex, because this is where critical and complex thinking takes place and the information will less likely lost during memory construction (Willis, 2012a). To keep students operating in this region, teachers can utilize the positive role emotions can play in learning. Music and visuals can evoke an emotional response and increase engagement in students. Likewise, a teacher's use of their own excitement as a social contagion (King, 2011), can also encourage excitement in students. Furthermore, when educators insert surprise and "cliffhangers" in the content (Jensen, 2005) as well as utilize simulations, games or role playing and encourage competition or involve risk and urgency, it promotes positive emotions, lessen stress and increasing engagement (Hung, 2003; Jensen, 2005).

Another way to increase engagement is making information meaningful and explaining how it will be relevant to students in the future (Erlauer, 2003). The brain wants to know if new information is important and will be used in the future (McGeehan, 1999). If students do not find the information meaningful they will disregard it and pay attention elsewhere. As teachers we can make learning meaningful through projects, simulations, real-world problem solving, grouping and regrouping material, critiquing and analyzing information, resequencing the content, using graphic organizers, and summarizing and retelling the content from another point of view (Jenson, 2005, p. 37). It is also essential to explain objectives to students so they can find meaning in the lesson. If the brain cannot make sense of the incoming stimuli it probably won't pay attention to it (Wolfe, 2001, p. 84). Relevancy or meaning in the lesson and coherence go hand-in-hand.

Finally, timing is key to engagement. Jensen (2008) suggests that teachers follow a strict guideline for direction instruction, sticking to an amount of time one speaks to correspond with the age of the students and not exceeding 20 minutes straight of direct instruction because this is the limit of the human brain's sustained attention (King, 2011). For example, sophomores and juniors in high school ages would range from 15-17 years old. According to Jensen (2005), this means that educators should not conduct any given task, strategy, technique, etc. for longer than 15-17 minutes to ensure students are engaged. Teachers who lecture for the entire class period run the risk of losing their student's attention, especially if it is habitual. Jensen suggests that teachers change up the lesson strategy after the appropriate time that corresponds with students' age. In considering the neurological research, teachers are able to purposefully plan their lessons to incorporate all or some of these strategies to increase engagement and focus the sensory memory so what they teach does not get filtered out of the memory system.

Continuing with the memory process, once sensory information is deemed significant (attention is paid to it) it moves into the working memory. The working memory most likely occurs in the prefrontal cortex (Jensen, 2005; King, 2011). Working memory allows one to integrate current perceptual information with stored knowledge, and to consciously manipulate the information (think about it, talk about it, and rehearse it) perhaps well enough to ensure its storage in long-term memory (Wolfe, 2001, p. 93). In most learning situations students are required to hold some bits of information in consciousness while manipulating other bits of information that are relevant to the task. Being able to see how information fits with other information keeps one from missing information and makes up for the limited capacity of the working memory. However, the capacity of the working memory is seven plus or minus two pieces of information lasting for 15-20 seconds without constant attention and/or rehearsal (Gazzangia, 1998). Due to this factor, it is nearly impossible to consciously process two trains of thought at the same sensory modality. This is not to say that one cannot do two things at once in the working memory. What this means is that it not possible manage two cognitive processes (thoughts) at once. For example, students cannot write and listen and the same time because it requires the same stream of cognitive thought, students are bound to miss something because one can only process either the thought to write or the thought of listening. It is not possible for students to take all the notes that a teacher speaks out loud without a visual, handout, or outline. It would be better for students to have an outline of the notes to fill in or a visual of them on the board to refer to, to help with these two competing cognitive processes. What would be best all together is for teachers to wait for students to write the notes and then speak to lessen the competition in the neural network.

The working memory is also responsible for storing information and skills long-term in the memory system. The key to this is allowing students time to work with and manipulate the information or skill in a non-threating, low stakes environment through the use of formative assessment. This process will allow them to create multiple connections in the neural networks in their brain. They need to make the connections with other bits of information themselves because they need to store it into the neural connections in *their* brain, so the teacher has to provide them with opportunity to do this. This increases the likelihood of the information staying longer in the working memory and ultimately in the long-term memory. The reason for this is the more connections there are the more chances for the network to be activated. The more activation the deeper the memory traces (engrams) are in the network and the more likely the memory will be successfully retrieved out of memory. Formative assessment can also provide valuable insight to the learning and memory process of the student and should drive the teacher's instruction (Hattie, 2012). If students do well on the formative assessment a teacher can move on in their instruction, if not the student needs feedback to change the connections they have made in their brain. One critical aspect of memory storage is accuracy. Teachers need to be aware of the brain's ability to fill in information that is lacking to complete a picture and allow time for error correction to take place (Jensen, 2005). This means that our long-term memory is not always accurate or stored properly. Teachers need to use formative assessments to make sure that students have properly stored information and provide timely feedback so they can correct any storage inaccuracies.

Formative assessments can also provide a means for elaborative rehearsal, which is also essential for long-term memory storage. Elaborative rehearsal involves making meaning of the content, which increases the likelihood that information would make its way into the long-term memory. The brain is constantly trying to make meaning out of information that it is presented with. If one does not make meaning, the information is easily forgotten because it is not linked in an existing neural network in the brain (Ornstein, 1998). One of the most effective ways to make information meaningful is to associate or compare the concept with a known concept, hook it to something familiar, or to one's own life story (Wolfe, 2001, p. 103; King, 2011). This also creates multiple networks of connected information in the student's brain increasing the likelihood of long-term storage. Teachers can create the opportunity for this by allowing students to create visuals or show visuals for topic or concepts. The can also have students come up with their own analogies or metaphors in their formative assessments or utilize analogies and metaphors in their instruction.

Emotions are not only important to attention but can also increase the likelihood of long-term storage. It turns out that epinephrine and norepinephrine enhance memory for the event that activated the stress response (as cited in King, 2011). Research suggests that anything that educators do to create emotional and motivational interests quite naturally involve this system and result in stronger memories (Cahill, Prins, Weber, & McGaugh, 1994). All of the aforementioned strategies to enhance attention would also work to store content effectively into the long-term memory.

The long-term memory allows one to be able to recall and retrieve information that has been learned. The ability to remember is essentially a process of reconstruction or reactivation of the neural network of the brain. There are two types of long-term memory significant to learning: procedural and declarative memory. Procedural memory allows one to be able to store automatic processes for routine activities; priming and movement helped retrieve these memories and take place in the prefrontal cortex, parietal cortex and cerebellum. Declarative memory stores and retrieves information one has to write or speak requiring conscious effort. One part of the declarative memory is the episodic memory which is responsible for remembering where and when information was acquired. Semantic memory is responsible for general knowledge about the world. Long-term memory is strengthened over a period of time if the neural path is continuously being activated, the more efficient the synapse becomes and the less likely the memory is to fade (de Haan & Johnson, 2002; Jensen 2005; King, 2011). This increase in efficiency is what neuroscientists called long-term potentiation. They believe LTP occurs in several parts of the hippocampus and then are moved to other areas of the brain for long-term storage, which is referred to as consolidation. Consolidation is also essential for long-term memory along with LTP. Neuroscientists do not know exactly the time requirement for consolidation but they know that it requires sleep, specifically REM sleep (as cited in King, 2011). As Jensen (2005) suggests, when students not get enough sleep their memories of what they learned in class do not get properly stored, decreasing their chances for success on assessments. This could also be why students claim to not remember what happened the day before in class or not learning information. The seriousness of sleep is one topic in which neuroscientists continue to investigate.

Summary

The neuroscience research has further applications to the field of education than mentioned in this literature review. However, the research mentioned should in fact be the driving force behind how teachers instruct students and manage their classrooms as well as how teachers are taught to be educators. Several proponents believe teachers should have basic knowledge on structures and functions of the brain so as to best understand the neurological research to maximize their students' learning potential (Jensen, 2005; Sparks, 2012, Willis 2012a). Furthermore, the discoveries in neuroscience should be driving decision making in the education system. Critics want to spend their time arguing that there does not need to be a focus on neuroscience in education (Bruer, 1999; Sternberg, 2008) but their arguments cannot outweigh the overwhelming and unwavering neurological evidence that supports it. While it is important to still include the views of psychology and other fields in education the reasoning behind educational practices need to be steeped in neuroscience to provide a physiological justification and a sense of professionalism. Teachers' strategies and techniques might not *all* be proven by brain research yet but that does not mean that brain research is not valuable to education (Willis, 2008). The following chapter will outline the plan to conduct a neuroeducation workshop for educators.

Chapter 3

Methods

I designed a workshop on brain-based teaching for teachers, counselors and administrators at a high school on August 27, 2014 for 55 minutes. The objectives for participants in the workshop were to be able to (a) describe what happens in the brain when learning occurs, (b) evaluate one's own teach practices to maximize student learning (Hattie, 2012) and (c) apply knowledge of the science of learning to classroom situations.

After the workshop, I surveyed the participants to measure their attitudes on the value of neuroscience, to determine if neuroscience was part of their education programs and to evaluate the effectiveness and value of my presentation (Appendix B). To promote survey participation I made the survey anonymous and included it at the bottom of the Google Doc (Appendix C) I shared with the staff. Lastly, the workshop was evaluated by the assistant principals of the building for its effectiveness and value.

Workshop Development

The goal of the workshop was to provide participants the basic neuroscience of learning and help participants apply that knowledge to their teaching practices to maximize student learning. I developed these objectives because I wanted teachers to have the basic neuroscience foundation that describes how the brain works so they can plan their lessons purposefully and justify their decisions with information from the field of neuroscience. I pulled the information from the literature review under the structure and function heading and applications to education section (de Haan & Johnson, 2002; Greenfield, 1997; Jensen, 2008; King, 2011). The objectives and research chosen was also made based on the school's goal for increasing engagement in the classroom based on a student survey that was conducted in the spring of 2014.

Specifically, the research from the literature review that I used for the workshop focused on the neuroscience research for planning lessons purposefully, creating a positive classroom environment that fosters learning and empowering students to practice metacognition (Cahill, Prins, Weber, & McGaugh, 1994; Erlaurer, 2003; Gazzangia, 1998; Hattie, 2012; Jensen, 2005; Wolfe, 2001) . My presentation explained why it is important for educators to start a lesson with objectives, access prior knowledge, use multiple strategies, have a positive environment and utilize formative assessment. Then my presentation explained how researchers have found evidence that intelligence is not fixed (neuroplasticity) and the impact of empowering students with the knowledge of the science behind learning (Hattie, 2012; Willis, 2010; Willis, 2012a; Willis, 2012b). This focus then helped to me to design the activities and structure the workshop because I knew exactly what from my literature review I wanted to cover.

The structure (Appendix A) that I chose to design the workshop was constructed from a workshop planning template (Tufts,1999) and the activities for my workshop came from a resource on adult learning theory (Tate, 2004). I chose the template to help me organize my thoughts and plans to make sure I didn't miss anything in the process of conducting a workshop. It was imperative that I structured my workshop with the brain in mind, meaning that I modeled the practices that I taught to maximize participant learning as well as create a teachable moment.

My workshop was planned for 55 minutes, organized into 20-20-15 minute chunks for each objective respectfully. Considering that the participants were all over 20 years of age, segmenting the workshop in this way was in line with research on the brain that indicates people can sustain attention for a period of time that matches their age in minutes (Jensen, 2005; King, 2011). I designed my presentation to begin with learning targets (objectives) to capitalize on the brain research that states that the brain is constantly searching for meaning (Jensen, 2008; Wolfe, 2001). This was planned to focus my participants on what they should get out of the presentation. I purposely mention the relevancy of the material that I wanted to present to educators, again to capture the attention and focus of my participants and align with the brain research (Jensen, 2005; King, 2011; Wolfe, 2001). While designing the learning targets I planned and purposely included visuals, videos, discussions, evaluations, applications and analogies considering the brain research on how engage people and support them in making multiple connections in the brain during the learning process (Jensen, 2008; Tate, 2004; Willis, 2010; Wolfe, 2001). To correspond with adult learning theory, I also included authors for educators to extend their knowledge beyond the presentation (Tate, 2004).

I used cloud-based presentation software to conduct the workshop called Prezi (Appendix B). I chose Prezi because of the quality and highly engaging capabilities. I also created a handout (Appendix C) that was placed in a school-wide Google Drive resource folder for all participants to access during and after the workshop. It was created to ensure they had access to the Prezi for future reference and to evaluate their own practices or to share with others.

Workshop planning took place from May of 2014 through August 24, 2014. Approximately 28 hours were needed to review relevant literature for the workshop presentation, design the workshop materials, and construct the evaluation procedures and instruments.

Participants

There were 43 practicing and student teachers, counselors, and two administrators with varying levels of experience in the education profession that attended the workshop on August 27, 2014. To promote participation in my workshop administrators made my workshop part of in-service that over half the staff was present for (the others were at the district office for Educator Effectiveness training).

Workshop Evaluation

I chose to evaluate my workshop through a survey (Appendix D) and an evaluation done by two assistant principals. The survey was designed to gain perceptions on the value of the neuroscience research, obtain prior knowledge of neuroscience research and evaluate the workshop for effectiveness. The survey questions were written consulting best practices in designing surveys (Watson, 1998), specifically for word choice and sentence structure. There were 12 items on the survey with one demographic item, nine Likert scale items (Treadwell, 2011), and two open-ended response items. The Likert scale items were items 2-10 and asked participants to indicate their level of agreement to a statement, using a five point scale that ranged from strongly agree to strongly disagree. Items 11 and 12 were open ended response items. Items 2, 4, 8, 9, 10 were used to provide information about their perceptions of value, while item 3 provided information on their previous experiences related to the content of the workshop. Items 5, 6, 7, 11 and 12 were used to determine the effectiveness of the workshop. The demographic item asked participants to indicate the number of years they had been teaching, which was designed to determine if there was a pattern in their responses that may have been influenced by their years of teaching experience.

The survey was designed to take less than ten minutes to complete and intended to be taken at the end of workshop. It was linked to the Google Document (Appendix C) that was shared with all participants for quick access to help ensure participants would take the survey. Participants were given the expectation to complete the survey by the end of the day the workshop was conducted.

The survey results were tabulated, charted and graphed, through *Google Forms*, for easy comparison by individual question. *Google Forms* broke down each Likert scale question into number of participants that responded and the corresponding percentage for each level of agreement on the scale as well as created a pie chart for visual comparison.

The evaluation by the assistant principals was conducted via email by prompting them to evaluate my methods, effectiveness and value of the workshop. The assistant principals were to be contacted prior to the workshop to ask for this evaluation and given one week to write up a written evaluation.

Chapter 4

Results

This chapter is organized into three sections surrounding the implementation of my workshop and the findings from the evaluations. The implementation section focuses on how my workshop was actually conducted based on my plan from chapter three. The evaluation results are reported in two sections, which include the findings from the workshop evaluation survey, and the evaluation comments from two administrators.

Implementation

The objectives for participants in the workshop were: (a) describe what happens in the brain when learning occurs, (b) evaluate one's own teaching for maximizing student learning and (c) apply knowledge of the science of learning to classroom situations. The goal of the workshop was to give participants the basic neuroscience behind learning and how to apply that knowledge to their teaching practices to maximize student learning. I was able to pull in all the information from the literature review that dealt with the functioning of brain on a neural level, the application of what happens in the brain when learning occurs and how to maximize that process (see Appendix B, under heading "What happens in the brain when we learn?") to support participants in reaching the learning objectives. I had planned to touch briefly on the memory process and its applications to education; however I vaguely touched on it because of time constraints.

While conducting my workshop I focused on the neuroscience research for planning lessons purposefully, creating a positive classroom environment that fosters learning and empowering students to practice metacognition (see Appendix B, under heading "Applications to

Education”). My presentation explained why it is important for the brain to start a lesson with objectives, accessing prior knowledge, using multiple strategies, having a positive environment and utilizing formative assessment (see Appendix B, under heading “Applications to Education”). Then my presentation explained how intelligence is not fixed (neuroplasticity) and the impact of empowering students with the knowledge of the science behind learning (see Appendix B, under heading “Applications for Education”). By this point I was already over my fifty-five minutes.

My plan to structure the workshop into 20-20-15 minute chunks for each objective did not work out. It ended up taking 25 minutes to cover the first objective and then another 35 minutes for the second objective, which left five minutes for the last objective and the survey. I made a decision to go over the time limit for a total of 80 minutes. While I was able to extend this time period, I had to cut my discussion times and omit my evaluation plans. This left the survey to be completed outside of the session allotted time.

I was able to include all the plans to align to the brain research to my presentation when I conducted my workshop. I was able to do this by beginning my presentation with learning targets (objectives) and relevance (see Appendix B, under headings “Learning targets” and “Why do we care?”) to capitalize on the brain research that states that the brain is constantly searching for meaning and relevancy. I was also able to utilize all the strategies I had planned to support participants in making multiple connections in the brain during the learning process, to increase engagement and extend the content (see Appendix B) through visuals, videos, discussions, evaluations (see Appendix C), applications and analogies (see Appendix B).

Since the workshop extended over the allotted time, I asked the participants to complete the evaluation survey on their own time after the workshop. I sent out an email reminder with a message of appreciation for attending the workshop. To encourage participants to complete the survey, I chose 4 leaders of the breakout sessions and asked them to remind participants to complete the survey; none of which was part of the original plan. After the workshop, I also asked the principals to write an evaluation instead of emailing them. It ended up that I emailed them as well later that day to act as a reminder to provide me with an evaluation of the value and effectiveness of the workshop.

Workshop Evaluation Findings

The survey was given to all participants in the workshop via a Google Forms link in their workshop materials (see Appendix C). There were 35 respondents to the survey of the 43 participants in the workshop for a response rate of 81%. The survey took no more than an estimated five minutes of the respondent's own time to complete. I did not set up the survey to require that each question on the survey was addressed, and as such, not all respondents completed every question (e.g., item 9).

The results (see Table 4.1) indicated that the respondents were fairly evenly split between 0 to 15 years of teaching experience (n=18), and 16 to over 30 years of teaching experience (n = 17). Table 4.1 depicts the number of participants who responded to the survey and their years of teaching experience.

Table 4.1

Evaluation Survey Respondents by Years of Teaching Experience

Teaching Experience (years)	Respondents (*no.*)	Respondents (%)
0 - 5	6	17
6 - 10	8	23
11 - 15	4	11
16 - 20	8	23
21 - 25	8	23
26 - 30	0	0
> 30	1	3
Total	35	100

One of the purposes of my workshop was to attempt to determine if education professionals value the neuroscience of learning. I asked five questions in my survey that helped to determine perspectives on this (items 2, 4, 8, 9, 10). In regards to the question that it is important for teachers to know what happens in the brain when humans learn, 100% of the respondents agreed or strongly agreed. When asked if the information learned in this workshop would have been beneficial at the beginning of a teaching career 30/35 respondents agreed or strongly agreed. In regards to pre-service teachers being educated about what happens in the brain when humans learn, 34/35 agreed or strongly agreed. When asked if the information from the workshop should be taught to students, 86% (30/34) of the respondents agreed or strongly agreed. Furthermore, I asked respondents how the information from the workshop would change their lesson planning or teaching practices. The responses on the open-ended items were read, and similar responses were grouped together into categories. The category with the highest frequency is reported below.

In the open-ended responses, five participants described the importance of making connections, five recognized the need for practice or repetition, and two explained that they plan to support students in making connections through formative assessment. Two respondents did not indicate a need for change because they "already knew" the information, and as one put it, "this validates what I am doing now".

The final question on the survey was also in an open-ended question that asked if there were any further comments or suggestions. There were 11 responses to this item. Two of the participants described the importance of teaching neuroscience to students, four provided positive accolades for the effectiveness of the presentation, and two made specific reference to learning more neuroscience.

The second purpose of my workshop was to determine if neuroscience research was part of teacher education programs. Seventy-one percent of the respondents agreed or strongly agreed, which indicated that the majority of participants had experienced some form of the content in their education programs. When compared by years in education to neuroscience curriculum there was no discernable pattern that emerged (see Table 4.2).

Table 4.2

Neuroscience Experience in Undergraduate Degree Programs

Years in Education	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
0-5		1	1	3	1
6-10		4		2	2
11-15			1	3	
16-20		2		7	1
21-25			1	5	1
26-30					
30+		1			

The final purpose of my workshop was to evaluate my presentation for its effectiveness in forms of usefulness. When respondents were asked if the information in this session was beneficial to their present day instruction 100% agreed or strongly agreed. Most (34/35) of the respondents agreed or strongly agreed that the information in the session would help them plan lessons more purposefully. Similarly a strong majority, (31/34) of the respondents agreed or strongly agreed that the information from the session would help them plan interventions for students. Sixty-six percent of the respondents would like to have more neuroscience application in education sessions in the future.

Administrator Evaluation Findings

Two of the administrators in the workshop were also asked to evaluate my presentation for its effectiveness and value. They both provided written feedback for their evaluation. In their evaluation there were six comments that pointed to the workshop being highly effective at meeting the purpose and objectives of the workshop. Furthermore, there were five comments that specifically pointed to the positive value of the workshop for educators (see Table 4.3).

Table 4.3

Administrator Evaluation of Workshop

Administrator	Effectiveness	Value
A	"Modeled appropriate methods"	"Staff were engaged in dialog"
	"Presented in an easy to understand format"	"Will help staff maximize learning potential of their students"
	"Engaged staff and helped them retain information"	
B	"Strengthened staff's dendrites"	"Provided opportunity for staff to self-reflect"
	"feedback from staff was positive"	"extremely valuable…presentation should be in all teacher's toolboxes"
	"stated and clearly accomplished learning targets"	"teachers reported being able to apply the information immediately"

The comments from the two assistant principals as well as the survey evaluation were used to inform recommendations for future directions as described in chapter 5.

Chapter Five

Conclusion

The purpose of the workshop evaluation was (a) to attempt to determine if education professionals value the neuroscience of learning, (b) to determine if neuroscience research was part of teacher education programs, and (c) to evaluate my presentation of the research from the field of neuroscience and its applications in the education field. The research literature that I explored stated that educators should be steeped in neuroscience to best meet the demands and expectations that they are held to in today's society to maximize student learning and potential as well as come to a better understanding of the behaviors of their students (Hattie, 2012; Jensen, 2008; Otero et al., 2005). The research also stated that teachers should be able to explain why they do the things they do in a classroom and that explanation should be rooted in neuroscience not assumptions and hopes for learning (Jensen, 2005; Willis, 2012a). I conducted a workshop that attempted to meet these suggestions at a high school on August 27, 2014. Participants that attended this workshop were provided with the basic knowledge of the science of learning and its applications to education. I believe that my workshop objectives matched what the research said educational professionals need to know. Furthermore, I believe that I was effective in communicating the content as indicated by responses on the survey and comments from the evaluators, as well as their individual responses to me on the survey and after the workshop. The results from the survey support this claim, for example, one respondent said, "This is the work that we should be doing. Students and teachers need to understand how learning happens." Likewise, the evaluations I received from the assistant principals were positive and communicated that the workshop was effective at meeting the learning targets (objectives).

When the workshop was completed, I surveyed the participants to measure their perceptions on neuroscience in education as the findings from the literature review told me that there are assumptions out there that educational professionals would not value or recognize this knowledge (Hook & Farrah, 2012). The survey results were tabulated, charted and graphed, using *Google Forms*. The survey results clearly showed that teachers value the information about the science of learning. I can conclude that this result is valid, considering the 13 comments respondents specifically explained how they would change their practices to match the research in neuroscience; clearly recognizing the application of this Also, two participants asked specifically in the comments section for more sessions and more in-depth sessions on neuroscience.

Most participants also felt that learning about how the brain function at the level of neural circuits, synapses and neurotransmitters is important to share with their students because of how it empowers students to take control of their own learning and motivates them to learn (Willis, 2010; Willis, 2012a). There were specific comments that recommended teaching the science of learning to middle school students and high school students during homeroom. Several participants even came up to me to reiterate their comments as they were so inspired to share their thoughts. One participant wanted a specific video clip to show to all of his students so he could communicate the information with them.

However, one area of the survey results did not meet my expectations from my findings in the literature review. I had expected that most participants would not have had a background or prior knowledge of neuroscience. However, the survey did not point to void in the participants' knowledge about the neuroscience of learning from their pre-service education as Jenson (2005) suggested. The survey showed that most participants felt that they received this information in their undergraduate curriculum. I find it interesting that my survey results do not match the findings in my literature research.

Limitations

The evaluation survey as a whole could have been worded in such a way that participants could determine a pattern (all strongly agree are considered positive responses). Also, potentially many people attended the same universities that included neuroscience in the undergraduate education curriculum. Likewise, there may have been several participants with science backgrounds in the workshop that tend to have some neuroscience background, which is part of their major curriculum. Regardless, the results do not match the findings from the literature review. Interestingly enough, participants indicated that they already knew this information, but they wanted more sessions and advanced sessions in future workshops. This begs me to question why? Why do they want more if they already learned it? Is this something that we constantly need to be reintroduced and reminded of in the education field to put everything we do into perspective? In future workshops I would like to explore this by interviewing or asking response items that would address these questions. It should also be mentioned and stressed I conducted this survey with only the perceptions of 35 education professionals from the same building, which limits results for being a good representation of the total population of education professionals.

Future Directions

If I were to conduct this workshop again I would extend my time to an hour and a half. This would allow for longer whole group discussion which proved valuable at catching misconceptions with the learning targets (objectives) and prior knowledge. For example, one participant had believed the “neuro-mythology” that intelligence is fixed and asked for clarification to change his thinking. It would also allow time for participants to more thoroughly reflect on their own teaching practices and how they can change them to match the neuroscience research. For example, starting lessons with objectives (learning targets) to focus the brain to find meaning in the lesson (Jensen, 2005; Wolfe, 2001). I would also close with having participants reflect back on the neuroeducation practices I modeled in my workshop so they have more concrete examples of this for their own understanding.

If I were to use this survey again I would want to modify it to clear up the possible reason why many of the respondents claimed they had neuroscience in their undergraduate teaching curriculum, which didn’t match with the findings from the literature review (Jensen 2005; Sparks, 2012; Willis, 2012b). First, I would add a response item to the survey to ask participants what college or university they attended to ensure results would be less skewed. I would also want to ask more poignant questions about their prior knowledge of neuroscience. I would need to make changes in the wording of my question about participants’ undergraduate curriculum to be more specific to neuroscience in education courses not in their undergraduate major coursework. I would also want to omit the use of the Likert scale for this particular response item to be “yes or no” and give options an open-ended response item to explain where and when they learned neuroscience in their undergraduate curriculum.

Recommendations

In finding out that education professionals value the research in neuroscience and its applications to education we can make the shift in education to utilizing that research to make purposeful, data-driven decisions about teaching and learning practices, instead of just assumptions and hope for learning. The focus of education needs to reside on the learner, while the role of teaching is still important; educators cannot just assume that if they covered the material the student has learned it. There is a process that must take place in the brain for learning to occur and if teachers are cognizant of this process they are more likely to make decisions for the learning process that will foster and maximize student learning potential. I feel this also means that we need to not be afraid to use the neuroscience language to speak about teaching and learning.

In the future, I see this as a workshop that new teachers should have to attend as part of their new teacher orientation. It will be seen as a way we do business at our school, we focus on learning and make decisions about what we do based on research in neuroscience. It could potentially be part of the curriculum for all students to learn (Willis, 2010) as was suggested by the respondents in the survey evaluation. Also, per teacher feedback on the survey, I will be providing subsequent workshops on neuroeducation, most likely starting with the teenage brain, followed by how to best engage students based on neuroscience research, and finally how to incorporate metacognition into lesson planning and teaching practices.

Currently, many districts are looking at scheduling changes and it is my hope that they look at the neuroscience research on adolescents and sleep to make that decision (Society for Neuroscience, 2011; Harvey, 2014). Neuroscience research can also be used to make further changes in the education system like those suggested by the mindfulness movement and movements to bring meditation into the school day to build students' skills in focusing their attention (Begley, 2007). As Begley (2007) stated, “I think if people just knew more about the brain, it could help make the world a better place” (p. 76). I couldn’t agree more.

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Appendix A: Workshop Development Worksheet (Adapted from Tufts University, 1999)

Instruction Components Worksheet	
Curriculum	1. Describe what happens in the brain when learning occurs. 2. Evaluate your own teaching for maximizing student learning. 3. Apply knowledge of the science of learning to classroom situations.
Materials/Equipment/Resources Worksheet	
Room (1st choice)	Cafeteria
Alternative Location	The Hub (Library Media Center)
Materials	Laptop/Computer, LCD projector, wireless mouse *participants asked to bring Chromebooks

Scheduling Worksheet	
Total Session Time	**55 minutes**
Activity Outline	*Allotted Time*
Science of learning- Objective 1	20 min
EQ: What happens in the brain when we learn something new?	(8 min)
Lecture, video clips, virtual tour of brain, visuals	
Synapse Strengthener: Explain essential question above to partner	(2 min)
EQ: What happens in the brain when we practice new learning?	(8 min)
Lecture, video clips, visuals	
Synapse Strengthener: Explain essential question above to partner	(2 min)
Neurosciences meets Education: How to Maximize Student Learning- Objective 2	20 min
Lecture, visuals, discussions to evaluate teaching practices	
	10 min
Application of Classroom Situations- Objective 3	
Discussion Activity with partner	5 min
Post-workshop Survey	
Total Plan Time	55 min

Pre-Session Planning Worksheet		
Items	*To Do*	*Approximate Lead Time*
Pre-Planning	Permission to conduct workshop Plan In-service	May 2014 July 2014
Contacts	High School Principal	N/A
Rehearsing and Testing Activities	Classroom 216	August 26, 2014

Risk Management Worksheet	
Risk Factors	*Solutions / Back-ups*
• Teachers may already know science of learning • Technology may fail	• Share knowledge in large group discussions • Have print outs of the Prezi • Have alternative activities that do not make use of technology

Appendix B: Prezi Presentation

Brain Based Teaching Presentation

(click link to access Prezi or www.tinyurl.com/brainsession2)

Appendix C: Google Doc for Workshop Participants (Adapted from Hattie, 2012)

Brain-based Teaching: What works in education

evaluate your teaching practices

HOW WELL AM I…?

- Growing new dendrites by connecting old to new
- Creating multiple connections in the brain through various strategies
- Establishing an optimal classroom environment
- Monitoring learning and providing feedback to ensure accurate connections
- Believing that all students can reach success and teaching them to become their own teachers

MAXIMIZING STUDENT LEARNING PERSONAL CHECKLIST:

- 1. I am actively engaged in, and passionate about teaching and learning.
- 2. I provide students with multiple opportunities for learning from surface to deep thinking.
- 3. I know the learning targets of my lessons and share them with my students
- 4. I am open to learning and actively learn myself.
- 5. I have a warm and caring classroom environment where errors are welcome.
- 6. I seek regular feedback from my students.
- 7. My students are actively involved in knowing about their learning.
- 8. I have a wide-range of teaching strategies in my “teacher toolkit”.
- 9. I use evidence of learning (formative assessment) to plan my next lesson.

Appendix D: Workshop Evaluation

Brain-based Learning Perception/Interest Survey

1. **Years of teaching experience**

- 0-5
- 6-10
- 11-15
- 16-20
- 21-25
- 26-30
- 31+

2. Understanding what happens in the brain when humans learn is important for teachers to know. *

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

3.Understanding what happens in the brain when humans learn was part of my undergraduate curriculum. *

a. Strongly Agree

b. Agree

c. Neutral

d. Disagree

e. Strongly Disagree

4. The information learned in this session would have been beneficial to my instruction in the beginning of my teaching career. *

a. Strongly Agree

b. Agree

c. Neutral

d. Disagree

e. Strongly Disagree

5. Pre-service teachers (undergraduate) should be educated about what happens in the brain when humans learn. *

a. Strongly Agree

b. Agree

c. Neutral

d. Disagree

e. Strongly Disagree

6. **The information learned in this session is beneficial to my (present day) instruction.** *

a. Strongly Agree

b. Agree

c. Neutral

d. Disagree

e. Strongly Disagree

7. **The information from this session will help me plan lessons more purposefully.** *

a. Strongly Agree

b. Agree

c. Neutral

d. Disagree

e. Strongly Disagree

8. **The information from this session will help me plan interventions for my students.** *

a. Strongly Agree

b. Agree

c. Neutral

d. Disagree

e. Strongly Disagree

9. The information from this session should be taught to students. *

a. Strongly Agree

b. Agree

c. Neutral

d. Disagree

e. Strongly Disagree

10. I would like to have more sessions about neuroscience in education. *

a. Strongly Agree

b. Agree

c. Neutral

d. Disagree

e. Strongly Disagree

11. How will the information in this session change your lesson planning/teaching practices?

12. Further Comments/Suggestions: