Understanding brain-based instruction and the technology connection for improved teaching and learning

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Abstract
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Abstract

The purpose of this paper is to give educators a brief description of the parts of the brain, the implications of the brain on learning, and an understanding of how technology can help in this way of teaching and learning. Many experienced and well-respected brain researcher's works are cited as examples and used as references, including but not limited to Slywester, Jensen, and Kovalik. By utilizing what researchers have found, and integrating their own experience and knowledge, educators can find best practices that will help to promote student learning.
Introduction

Education and technology are both ever-changing fields. Throughout the history of American education, teachers, administrators, parents, and the general public have been at odds with each other on the issue of what is good educational practice. It seems everyone has a theory of education and can find support for their beliefs with some type of research. There are those who believe the best education is the three R's, others propose advancing technology, still others argue a whole-language approach is best, and some argue for acceleration, phonics, block scheduling, new math, and the list goes on endlessly.

In all of the rhetoric of the “correct” educational practices, educators have discovered practices that really do seem to work for the majority of our students. However, seldom, if ever, has real scientific research been available for educators to base their theories of practice. Within the past thirty years, the neuroscientific community has made tremendous breakthroughs in their field, giving educators a research base to use to account for good educational practices. This is called brain-based learning, or brain-compatible teaching (Kovalik 1997, p25).

This paper will discuss the current research on the brain and its implications for educators to improve teaching, learning, and school environment with and emphasis on technology application. The physiology of the brain will be discussed in detail with research which will explain why educators at all levels should be educated in cognitive science. Also, and perhaps more relevant to today’s classrooms, the integration of technology into daily curriculum will be explored and examples of brain-compatible technology use will be shown. The topic focused on throughout the research is how and
to what extent the brain is engaged and students are motivated when technology is integrated into the curriculum. Having a sound understanding of why all of these pieces work together is imperative to actual integration.

Methodology

Materials and information were obtained from this author’s school district’s vast library of neuroscience, and brain-compatible teaching manuals. Dr. Mike Powell, a neurochiropractor with an emphasis on student achievement supplied readings and verbal information. Study group sessions in the author’s building focused on reading material from Pat Wolf and Eric Jensen with an emphasis on application to specific building initiatives in the realm of brain-compatible teaching. A neurologist from a local University Hospital spoke to staff and suggested articles and a book to help build an integrated technology component into educational settings. Specific articles gave information on important techniques for best practices in the field of technology education. Because the sources used were recommended from experts in the field, accuracy was assured. The sources utilized also showed many case studies and specific examples. This illustrated these were not just words, but proven ideas from real classrooms across the world.

Analysis and Discussion

Life-long Learning

Instilling in students a desire to become life-long learners is not only a personal goal of the author; it is a part of her school’s improvement plan. The plan was written with
definite goals to include brain-based instruction including the integration of technology into the core curriculum. Understanding what happens within the walls of the classroom needs to correlate directly with what students need to be able to do in the outside world is imperative. It is the foundation for instruction students will value and in which they actively participate. “According to brain research, relevance is critical because it prevents downshifting as a result of stress or frustration due to boredom or failure” (Kovalik 1997, p54). Educators must make learning a meaningful and relevant experience.

The brain works best when it is able to make meaning of the information coming in and to attach it to a piece of knowledge it already has stored. From the minute we are born until we die, the brain takes in patterns as they appear, sorting and categorizing information into groups in an attempt to make sense out of our complex world. Learning takes place when the brain sorts out patterns using past experiences to make sense out of the input the brain receives (Kovalik, 1997). It only makes sense for educators to use technology in a variety of ways to help the brain make sense, sort, and restate information.

There is a great deal of value in the inter-disciplinary and cross-disciplinary models. They create much more relevance and context by helping students understand the connections in learning. In the classroom, it is the ability to see ideas in relation to others as well as how individual facts become clear in a larger bundle of information that helps students to learn. Encouraging students to see how economics relates to geography, how math and ecology link to science and politics is not difficult once the connection has been made in the instructor’s mind. Utilizing computer-generated activities, videos, hands-on researching in the integration of these types of projects will help the student’s brain make
these important connections. Through this type of discussion and learning students can make important, meaningful patterns (Jensen, 1996).

Physiology of the Brain

An adult’s brain weighs about three pounds. Many compare it to the size of a large grapefruit or a cantaloupe. It is mainly made up of water, fat and protein. It is flesh-colored and very soft and squishy since it contains no bones, cartilage, or muscle. The brain has a wrinkled covering called the cortex. “The cortex is about the size of an unfolded sheet from a daily newspaper. Yet it’s covering only a grapefruit-sized organ” (Jensen, 1997, p. 4). This shows the important role nature has in protecting the brain.

Although the brain makes up less than 6% of an adult’s total body weight, it consumes about 20 to 25% of the body’s energy (Jensen, 1997, p. 5). The brain gets its energy from the blood, which brings it nutrients such as glucose, protein, and oxygen. Twenty percent of the oxygen taken in by the body is sent to the brain. The brain also needs a lot of water to function well (8 glasses per day). The blood, which supplies all of the brain’s nutrient needs, is sent from the heart at a rate of “...about 198 gallons a day” (Jensen, 1997, p. 6). Jensen also states that another source of energy for the brain is sounds.

All of this information has direct implications for classroom teachers. Allowing students to have water as they need it, encouraging a high protein snack during the day, and utilizing sound to stimulate, motive or calm the room are all techniques to integrate into any classroom. These facts are just basic information on general brain facts. Once
one delves deeper into how and why the brain uses these nutrients to process, retain, and share information, more relevant integration of brain-compatible learning can take place.

**Brain Systems**

The brain has very complex systems at work in it, Sylwester’s (1995) interpretation of MacLean’s model of the triune brain is perhaps the easiest to understand and work with, from an educational perspective. The triune brain model basically shows the brain divided into three separate but equally important areas, yet working simultaneously (see Appendix A for illustration). The triune model focuses on a hierarchical organization of the brain, beginning with the basic function of survival in the brainstem and from there, moving on to emotions in the limbic system and finally the highest level, the cortex, where reasoning and logic take place. This model is very simplistic in nature and that the brain is not really a hierarchy as this model suggests. Nonetheless, this model is very workable and is useable in educational circles. This model is also easily explained to students when talking about behavior and understanding how their brain works. Understanding these three main regions of the brain can help teachers, students, and parents to build stronger connections in the learning process.

**Brain Stem.** This area of the brain is sometimes referred to as the reptilian brain since it deals with the physical survival and the overall functions of the body’s major systems such as digestion and circulation. This area of the brain is considered common with the behaviors animals have in survival mode, thus the name reptilian. The reptilian brain consists of the brain stem and the cerebellum. The cerebellum controls automatic movement such as walking. Jensen (1996) states that the behaviors of this part of the
brain are instinctive, fast acting, and survival-oriented. It is the part of the brain that is responsible for learner behaviors such as:

- social conformity- common habits, grooming, clothes, etc.
- territoriality- defending “my stuff, my desk, my room”
- mating rituals- flirting, touching, attracting another
- deception- often forms of subvert aggression
- ritualistic display- trying to get the social attention of peers
- hierarchies- the dominance of leaders or “top dog” behaviors
- social rituals- the repetitive and predictable daily behaviors (p.21-22)

When the emotional part of the brain (limbic system) feels afraid or angry, the reptilian area of the brain takes over, basically overriding the other parts of the brain and goes into a “fight or flight” type response for survival purposes. This response has been demonstrated many times in classrooms and playgrounds around the world. Once an adult understands this mode, they will be more equipped to deal with the child in this type of a situation. Their reasoning and logical thinking devices are not in action and therefore they cannot think rationally. Allowing for the child to come out of this brain stem mode will help to come to a reasonable solution.

Limbic System. The limbic system, is the area of the brain where emotions are located. The limbic system is folded around the brain stem and consists of the amygdala, hippocampus, thalamus, and hypothalamus. These structures within the limbic system are connected to each other and other parts of the brain. They range in size from an olive to a walnut (Jensen, 1996). The major functions of the limbic system are to regulate emotions, which have a great influence on what our brain stores in long-term memory and to
override both rational thought and innate brainstem response patterns. We tend to follow our feelings and this is the reason why (Slywester, 1995).

The amygdala is made up of two almond-shaped structures that are about the size of a fingernail. Its main functions are to connect emotions with events in our world, sort through sensory data that is received, and determine if it is worth paying attention to and storing for future use. “...it is most concerned with our survival and the emotional flavoring or interpretation of feelings in a situation” (Jensen, 1996, p.27).

The hippocampus is really two structures the size of a finger that are connected to the amygdala. The main focus of the hippocampus is to change the most important experiences from short-term memory into long-term memory. The hippocampus helps to store our memories by putting the emotional content of the experience with the event.

The thalamus is the size of a walnut and the hypothalamus is approximately the size of an olive. The thalamus tells the brain about the things happening outside of the body. The hypothalamus tells the brain about the things happening inside the body such as appetite and blood content.

Cortex. The cortex is the highest level in the triune brain model. The cortex is often called the cerebral cortex and is made up of the cerebrum and the neocortex. The word cortex means bark (like a tree’s bark). It covers the brain in a similar manner as bark covers a tree. The cortex is home to the neuron’s cell bodies and the cerebrum, which is beneath the cortex and is where the axons extend. The cerebrum is divided into four main sections, or lobes. Jensen (1996) describes these lobe functions as:

1. Frontal lobe: problem solving, will power, and planning
2. Parietal: reception of sensory information
3. Occipital: primarily deals with vision

4. Temporal: deals with hearing, language and some memory (p.28-29)

The cortex is the part of the brain that gives us the abilities such as language, reading, problem-solving, writing, creative talents such as drawing and music as well as thinking and long-range planning.

All of the different systems of the brain, the brain stem, the limbic system, and the cortex simultaneously work together in one complex pattern-building machine (Jensen, 1996, p.31). Information is passed from one part to the next, connecting through emotions, patterns, experiences, and forming them into new categories of information. All the while it is adding them to previous knowledge through the organization and patterning of the neurons and the connections the dendrites make with axons. The brain is wonderfully complex, but understandable enough in its parts and as a whole for educators to utilize this knowledge to help students achieve and grow.

How Technology has helped Brain Research

Without the aid of modern technology, we would still be struggling to figure out the basics of the brain. Abbott (1997) states that technology such as computerized axial tomography (CAT) and magnetic resonance imaging (MRI) allows scientists to create graphic, three-dimensional images of the brain. Now the functional magnetic reasoning imaging (FMRI) is available at a substantially lower cost and has helped to boost our understanding and knowledge of the brain. With this type of advanced technology, we are learning about the brain at a rapid pace. Because of these recent technological innovations, we know much more about brain cells and how they function (Abbott, 1997).
Implications of Brain Research for Schools and Educators

Brain research has given educators an opportunity to begin discovering how the brain learns. While neuroscientists are increasing their understanding of the brain and its functions, they are still long way from being able to say they comprehend the brain and its workings completely. However, scientists have provided enough information about how the brain learns so that educators can begin applying this new knowledge to their educational practices.

The application of this research is of particular importance to educators and their use of technology in the classroom setting. Technology can be used in subtle ways such as music and lighting to enhance mood and the limbic system (Gibbs, 1995,p.53). Video, pictures, and real-time experiences can create relevant experiences to help attach to students’ prior knowledge. As Dockterman (2002) states, the incredible resources that the computer and the Internet put at one’s fingertips can provide access to ideas to integrate into dazzling presentations. These are general ways in which technology can be integrated into a brain compatible classroom. Later in this paper specific techniques will be discussed in further detail.

Learning

Learning is a survival mechanism. It is a natural phenomenon that is innate, a basic need. The brain continually searches for meaning in everything it experiences. The brain likes new and stimulating experiences and tries to connect these experiences to prior ones. Technology can play a key role in stimulating and connecting to the learner’s prior knowledge. Many simulations, games, movies, and musical cds can be integrated in order to achieve a higher degree of learning and retention. The brain cannot be stopped
from searching for meaning; it can only be channeled and focused (Jensen, 1999, p.36). It seems that learning is the process by which dendrites connect to axons. Valiant (1997) suggests “It appears that learning consists of the growth additional neural connections stimulated by the passage of electrical current along nerve cells (neurons) and enhanced by chemicals (neurotransmitters) discharged into the gaps between neighboring cells (synapse)” (p.3). If learning is connections that dendrites make with axons, educators need to know what practices should be exercised in order to enhance the connections that are made, and how or to what extent technology can assist in making these connections. They also need to understand the practices that have a negative effect upon the neuronal connections.

Perkins (1992) writes that “Learning is a consequence of thinking” (p.78). Wolfe (1994) contends there are steps to the learning process. First, the brain’s attention must be captured, then the brain becomes engages in the activity. It is evident in today’s society that computers, video games, and movies capture many young children’s attention. As educators, we must take what the research is telling us, and combine that with what we know about children’s motivation. With this knowledge, it seems as if common sense should be telling us to utilize technology for this first step of learning whenever it is necessary. Once the attention is captured, the brain tries to fit the experience it is having at the moment into existing memories and categorizes it into a similar memory. In the case of a brand-new experience, the brain must create a new category and begin building it with new experiences.
Environment and Learning

Learning can be enhanced or inhibited by the environment surrounding the learner. Environments that are safe, free of threat, interactive collaborative, comfortable, visually stimulating, and highly challenging are environments that encourage higher order thinking, curiosity, and learning (Gibbs, 1995, p.41). Technology can be utilized in various ways to help create this type of preferred environment. “Relaxed alertness” is the phrase Caine and Caine (1991) used to describe an environment that is “low-threat and high-challenge.” In an environment of relaxed alertness, people are better equipped to take risks and are more likely to use higher order thinking skills instead of mainly using rote thinking.

Enhanced school environments do not view children as empty slates needing to be filled by the teacher. “Both student and teacher are viewed as knowledgeable workers in a brain-based learning environment” (Valiant, 1997, p.4). These brain-friendly environments focus on involving the child through personal reflection (metacognition), interaction with peers, adults, and manipulatives, real-life application of materials, creating through writing, music, dance, and drama, through total immersion into the subject matter. Technology can be utilized in all aspects of this educational method to help students make connections in their own meaningful way, facilitated by the teacher, but created by the child. A brain-based environment supports understanding instead of coverage of material. It takes into account the greatest retention comes from doing not from being told how to do it. Much educational software is created with this idea in mind; some Quest programs actually take students into real-life being there experiences where their opinion counts.
The facts supporting why brain-based instruction is good educational practice, continues to grow. Researchers have shown that humans use their whole body to learn (Caine & Caine, 1997, p.1). The brain is not a factory assembly line in which one task is completed at a time and then passed along to be added parts. The brain does not operate in just the right or left hemisphere, but rather has “... a capacity to deal with parts and wholes simultaneously, and it is by working with the whole person that this simultaneous functioning becomes possible” (Caine & Caine, 1997, p.1). Not only does the whole brain effect learning, but also our entire body comes into play as apart of the learning process.

Since it has been shown that experiences and the environment affect the brain, it is also reasonable to expect that they have an effect on learning. Teachers or parents have often been heard encouraging students to eat a ‘good breakfast’ before school, especially while being tested. This is good advice. Learning can be enhanced or inhibited by physical things such as nutrition, the amount of sleep, and physical comfort. Poor nutrition, lack of sleep, and physical discomfort negatively affects learning (Gibbs, 1995, p.21). With these things considered, it can easily be seen that the whole body must be considered for optimal learning. Although technology in the classroom cannot help a lot with nutrition and sleep, except to show students examples and programs explaining the reasoning behind their importance, technology can help to enhance the physical comfort level of the room itself, and thus help the individual student feel more comfortable.

The décor of the classroom may be seen as unimportant to actual “learning,” when in fact it is an integral piece of the curriculum development process (Kovalik, 1997, p.32). Many aspects of classroom composition may seem trivial or just subjective teacher
preferences. For example color, plants, lighting and decorations are really valuable to overall learning. The surroundings of a classroom and the school building can make or break the way a student perceives the importance of education. Today the evidence is overwhelming that enriched environments do grow a better brain (Jensen, 1999, p. 37).

Technology in the form of lighting should be as natural as possible. Windows are preferred, but many classrooms do not have that luxury. Therefore, florescent bulbs should be replaced with day-glow lighting. This is not only good for the eyes; it eliminates the low buzz that is often very irritating especially to those with Attention Deficit Disorder. Lamps should be used to soften corners of the room and to lighten reading areas. They create a warm, home-style environment as well as help students who need more light to feel comfortable. For students who require a dimmer atmosphere, lamps give enough sidelight to allow overhead fixtures to be turned off randomly throughout the day (Kovalik, 1997).

“Good lighting, ventilation and flexible access to technology distinguishes successful classrooms” (Kirby, 1999, p. 34B). Taking into consideration Maslow’s hierarchy of needs, one can see the importance of appropriate classroom temperature. Unfortunately this is often outside the teacher’s control and can cause frustration. Administrators and custodians must understand what is best for students and how important it is to keep a climate that is warm enough to work in and cool enough to stay alert. PTA’s may consider putting money into technologies of air conditioners or space heaters depending on the climate. Overall, the environment must be conducive for learning and it takes the involvement and understanding of the learning community to make the environment appropriate for students.
Brain-based Learning

Just as the whole body is involved in learning, so is the whole brain. According to Caine & Caine (1991) the notion of left/right brain functioning is no longer considered totally accurate. It is accurate to describe the left side of the brain as being the side that processes things better in sequence, from part to whole, and that it wants structure. It is also correct to think that the right side of the brain processes things from whole to part, is comfortable with randomness, and likes spontaneity. However, the notion that these two hemispheres operate independently of each other is not accurate. Both hemispheres are linked together and process information at the same time. The brain appears to be made up of two sides or cerebral hemispheres, one on the left and the other on the right. They are connected by fibers called corpus callosum. “Schools—or any place where learning is encouraged—should therefore provide the opportunity to develop all abilities (e.g. right and left brain compatible activities) even as we continue to prefer some things over others” (Caine & Caine, 1991, p37). With this in mind, educators must take into account the whole child when designing lessons and units.

One of the most comprehensive and concise ways of looking at brain-based education is that offered by Caine and Caine (1991) through their list of core principles of brain-based learning: (See Appendix B for Caine and Caine’s insights and details on the twelve principles)

Twelve Principles of Brain-Based Learning:

1) The brain is a parallel processor;
2) Learning engages the entire physiology.
3) The search for meaning is innate.
4) The search for meaning occurs through “patterning”.

5) Emotions are critical to patterning

6) Every brain simultaneously perceives and creates parts and wholes.

7) Learning involves both focused attention and peripheral perception

8) Learning always involves conscious and unconscious processes.

9) We have at least two types of memory—a spatial memory system and a set of systems for rote learning.

10) The brain understands and remembers best when facts and skills are embedded in natural spatial memory.

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

12) Each brain is unique. (p. 13-27)

Understanding and utilizing these principles should be at the root of educators’ core philosophies regardless of the age or ability level of students involved. Technology can be used as an important piece to help students’ access, process, and understand what they have learned. It should not be another added burden, but rather a piece of the puzzle to help students succeed.

Standards

Taking a close look at the national standards set for different curricular areas allows for integration of the areas with the least amount of redundancy. Educators need more time with students to be able to teach all that is required of them. Integrating content areas is a very logical solution to this problem of time. By using technology in this process even more time can be allotted for the independent gathering of information, the processing of information, and the sharing of information. Through this process, it
allows students to see: 1) Content areas overlap; 2) Learning really does not stop when reading or any other specific class is over; 3) Learning can take place in a variety of different settings; and 4) Technology can be used in an efficient way to support learning (Churma, 1999).

Kimura focused studies of the brain in areas of educational connections with real experiences and in a manner that combined as much information as possible. In this research the standards for social studies, language arts, and technology were analyzed with the focus of comparing and contrasting the information in an attempt to combine goals into a cohesive, brain-compatible theory. “The whole picture is worth more than the sum of all its parts-they will all serve as powerful hooks on which you can anchor the mass of details” (Kimura, 1990, p58). The following section of this paper presents the core standards, which could be integrated to create cohesiveness within a middle-childhood curriculum:

English/Language Arts Standards: The national standards that can be combined with others through an integrated unit are limited only by the amount of time allowed to the project at a given time. These standards from the National Council of Teachers of English (Churma, 1999) are just a few that can be easily integrated.

- Exposure to a wide range of print
- Conduct research on issues by generating ideas and questions
- Students use a variety of technology and informational resources to gather, synthesize and communicate knowledge (p.31)

Social Science Standards: Social studies standards are from the National Council for the Social Studies (Churma, 1999). Stated below are the standards that would
integrate and be geared specifically to the intermediate school level. They also include geography as a part of social studies, making an integration piece prior to teacher manipulation of materials.

- Culture-understanding time, continuity and change
- People, places and environment
- Global connections
- Geography of maps and human systems
- How human actions affect human systems (p.32)

Technology Standards: Technology integration is an appropriate way to ensure interactive learning, real-world practice and motivation for hard to reach students. Technology standards can be applied to this integration theory so effective methods are being utilized. The following standards from the Technology Foundation are ones, which easily fit with the prior mentioned content areas.

- Basic operations and concepts
- Develop a positive attitude towards technology uses that supports life-long learning, collaboration, personal pursuits and productivity
- Students use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences
- Use technology resources for problem solving and making informed decisions (p.49)

Through the use of standards educators can ensure they are doing not only what is required of them, but also what is researched practices for student learning.
Curriculum Integration Options

Once the standards are set, the major concepts of brain-base learning are understood, classroom environment is enhanced, and curricular goals are decided upon, teachers are ready to integrate what they know is best for students into their classroom. Many different companies and organizations have researched brain-based theories and have done a lot of work in the realm of curricular integration including Scholastic, Classroom Connect and Tom Snyder Productions. Dockterman (2002) has many different valuable ideas for communication, curriculum, and student involvement with technology. He believes the best use of technology is when is it utilized to fit what educators need, rather than to reconfigure what is in place. He continues by stressing, if teachers can be helped to harness the power of today’s technology as a tool to enhance and support their efforts, computers can make a positive difference in the quality of teaching and learning.

Classroom Connect is a company that has spent a lot of time researching real-time experiences for educational purposes. Since Classroom Connect began in the 1990s, it has developed a series of quest situations. The first one started in 1994 when a group of researchers figured out a way to bring a learning expedition to the classroom. Its purpose was to give students a chance to collaborate in an investigation as the experience unfolds (Fox, Todaro, Paxton & Philbrick, 2000). Quests are a way to integrate many goals and objectives from social studies, language arts, technology and more depending on the implementation choice of the teacher. They also allow for math integration and scientific explorations. Mapping is integrated into daily course routes; new cultures and people are introduced as they are met throughout the exploration. Reading is purposeful and written response is taken into consideration as the experts decide what to do while they are in the
midst of researching and exploring different countries around the world depending on the quest origination. Cunningham and Allington (1994) offer that children who are going to become completely literate must be in a classroom where authentic reading and writing pervade the school day and the curriculum; this is a critical component of a high-quality classroom.

There are many other opportunities to integrate technology into the classroom without as much time and dedication required as the quest opportunities. Dockterman (2002) describes many different software programs for student use all of which can be integrated without it being a difficult stretch for most educators. Inspiration is a brain-compatible way to allow students to web concepts, mind map, and turn thought into an outline. Many software programs encourage decision making in real world applications such as Tom Snyder Productions, Decisions, Decisions. As Dockterman (2002) states, technology can help teachers to support content acquisition in powerful ways. Multimedia authoring tools can make direct presentation of content visually compelling and more memorable for students. Well-designed computer games can make the repetition of content fun. And interactive software can engage students in content-rich narrative situations that give dramatic context and meaning to the information they are acquiring. Above all educators need time to understand how important the role of technology is in meeting the needs of all students.

Conclusions and Recommendations

In conclusion, educators, administrators, PTAs, and school boards need to be aware of the implications of integrating technology within the core curriculum. Understanding how the brain works and learns is the foundation for the belief in
curriculum integration with an emphasis on authentic learning experiences to enhance student understanding.

The District Curriculum Coordinator must be aware of the benefits of the integration of curriculum. The coordinators from the content areas need to work together to find the best practices in order to set goals and objectives that are reasonable, attainable and infusible. They must understand that integration and infusion of technology is not a separate piece of the curriculum, but must be tied to the ways teacher and students can meet the goals and objectives set by the district.

Finally, real-world connections must be made. One way to do this is to survey our business partnerships to find out the qualities, skills and characteristics they want to have in the people they hire. A needs assessment of what the local businesses need and want in their employees will help gear student learning to areas they must be prepared for in order to be productive workers. They will see the real-world connection and be more willing to work at when there is a reason in their mind beforehand.

Teachers, students, parents, business, administrators, all must understand why integration, real-world connections, and environment is so important to student achievement. Educating our clients as well as our teachers is a must before brain-compatible education can embrace technology and help our students become successful and productive workers. Teachers need to be well trained in the areas of brain research and its implications upon educational practices. They need to attend workshops, and classes and to begin talking to their peers about what they have discovered. They need to actively reflect upon their current and past practices and then synthesize those experiences within what they are currently learning. Sylwester (1997) states: “Teacher
education programs will have to change. I can’t imagine a person preparing to become a teacher these days without having access to cognitive science” (p. 18). Teacher preparation frameworks need to consider utilizing brain research to help their students with the basic knowledge of the brain’s function in learning.

Abbott (1997) captured the essence of why brain research is so vital to the future of education when he wrote:

Formal schooling, therefore, must start a dynamic process through which pupils are progressively weaned from their dependence on teachers and institutions and given the confidence to manage their own learning. Surely it should be the child who is tired at the end of the term, and not the teacher” (p. 9-10).

For educators, it is imperative that time is allotted to their own learning when it comes to understanding the brain and its ability to learn. Often too much time is focused on the “what” in education, as far as what curriculum needs to be covered, and “what” is going to be on the standardized test. More time needs to be spent on the “how” and “why” so that the “what” can come more naturally and effectively.
References


MacLean's Triune Brain Model adapted from Sylwester's work

Appendix A

**MacLean's Triune Brain Model** adapted from Sylwester's work

Appendix B

Twelve Principles of Brain-Based Learning from Caine and Caine (1991)

Principle One: The brain is a parallel processor. Thoughts, intuitions, pre-dispositions, and emotions operate simultaneously and interact with other modes of information. Good teaching takes this into consideration. This is why we talk about the teacher as an orchestrator of learning.

Principle Two: Learning engages the entire physiology. This means the physical health of the child—the amount of sleep, the nutrition all affect the brain. We are physiologically programmed, and we have cycles that have to be honored, so moods must be taken into consideration. An adolescent who does not get enough sleep one night, will not absorb much new information the next day. Fatigue will affect the brain's memory.

Principle Three: The search for meaning is innate. This means that we are naturally programmed to search for meaning. The principle is survival oriented. The brain needs and automatically registers the familiar while simultaneously searching for and responding to additional stimuli. What does this mean for education? It means that the learning environment needs to provide stability and familiarity. Provision must be made to satisfy the hunger for novelty, discovery, and challenge. At the same time, lessons need to be exciting and meaningful and offer students an abundance of choices.

We want to know what things mean to us. In education, one of the things we have to allow for is children having rich experiences and then give them time and opportunities to make sense of their experiences. They have to have a chance to reflect and to see how
things relate. One of the richest sources of learning, from the point of view of the brain, is the learning available to us in these experiences.

**Principle Four: The search for meaning occurs through “patterning”**. Patterning refers to the organization and categorization of information. The brain resists having meaningless patterns imposed upon it. “Meaningless” here means isolated and unrelated pieces of information. When the brain’s natural capacity to integrate information is evoked in teaching, vast amounts of seemingly random information and activities can be presented and assimilated. The brain tries to make sense of the information by reducing it to similar patterns.

Patterning is everywhere. We want to impose our patterns on what we see, and breaking patterns is difficult. It’s as if we spend the first few years as an open system taking in information and experiences and drawing conclusions, and then the rest of our lives we go around proving that what we have learned is in fact so.

The ideal process in learning is to present information in a way that allows the brain to extract patterns rather that to attempt to impose them. The brain is capable of taking in enormous amounts of information when information is related in a way the brain can pattern appropriately.

The ideas behind thematic teaching and integrated curriculum are based on this principle of looking for patterns and seeing interrelated patterns. One topic can be related to all kinds of different topics, and when we do this, the brain tends to remember many more things. This is a way to teach meaningfully. Patterning is behind this principle.

**Principle Five: Emotions are critical to patterning**. One thought needing to be erased is the notion of the affective domain, the cognitive domain, and the psychomotor domain.
We have been taught this for years, even though the evidence from brain research indicates this is not the case. The brain cannot be separated into emotions and cognition. It is an interesting web of factors. Everything has some emotion to it. In fact, many brain researchers now believe there is no memory without emotion. Emotions are what motivate us to learn and to create. They are in our moods and are our passion. They are a part of who we are as human beings.

One problem with cognitive psychology is the way it tries to explain the role of emotions while adhering to a very traditional scientific model. If one would take it apart, look at the pieces and see whole is all about, it would work with all things. Try to do it with concepts like love or compassion.

The other piece important to the role of emotions is how we support each other. We are social creatures. We need each other and we need social activities. When students in a class are more interested in what Johnny is doing tonight or what Mary is wearing, they are acting out of their social nature. The notion of a community of learners and communities in schools working together is very critical. Cooperative learning can take a place here. Teachers should become skilled in these ideas because they are innate drivers in us all.

**Principle Six: Every brain simultaneously perceives and creates parts and wholes.** Neuroscientists across the country have studies the twelve principles. One of the things noted was they were very hesitant to speak with educators because they were frightened of what they would do with the information. Educators had gone wild with the right brain/left brain research. They had based entire consulting firms on it. But to these neuroscientists it was greatly oversimplified it. So as we went back over the research, we
said, "Yes, there is something to the hemispheric theory." However, the real message for educators is both sides need to be engaged, which in real life we do.

**Principle Seven: Learning involves both focused attention and peripheral perception.** Think about this room. What are the peripheral messages inherent in a room such as this one? What are the messages about how you behave? The peripherals play an important role. Children learn from everything. Everything goes into the brain. In the early years, they literally become their experiences. Therefore the environment is very important, and if they learn something in the classroom and never use it outside the classroom, then that learning, those connections, stop there. In other societies, children are immersed in learning in the school, in the home, in the community. Their knowledge is used and expanded upon. They interact with each other in this rich learning environment.

**Principle Eight: Learning always involves conscious and unconscious processes.**

Students learn much more than they ever consciously understand. Most of the signals that are peripherally perceived enter the brain without our awareness and interact on unconscious levels. This is why it is said that learners become their experience and remember what they experience, not just what they are told.

What is called “active processing” allows students to review how and what they’ve absorbed so they begin to take charge of their learning and of the development of personal meaning. Meaning is not always available on the surface. Meaning often happens intuitively in ways often not understood. So that, when one learns, both conscious and unconscious processes are used. In teaching, a teacher may not reach a
student immediately, but two years later he may be in another class and say, “I get it now.” The teacher is apart of that, but no longer present.

**Principle Nine: We have at least two types of memory—a spatial memory system and a set of systems for rote learning.** The spatial memory system (or autobiographical system) does not need rehearsal and allows for instant memory of experiences. It is very important for educators to understand these two systems and how they work. In the taxon memory system things are learned by rote. Information is memorized, but it doesn’t mean it is useable. The taxon system has nothing to do with imagination or creativity. It conforms very readily to the information-processing model of memory. With this system, students are motivated by reward and punishment; many trials are usually needed; and the brain is usually fatigues since there is stress on a limited number of brain cells. This is the model schools are based on. Teachers have limited education to “programming” these taxon systems and “teaching to the test”. It is easy to see why people would say that our education system is based on teaching to the test (and forgetting afterwards) is not very successful.

The local memory system is very global. It does not stress on a particular area. When one experiences something deeply meaningful, new connections are created. Things go in all at once. The local memory experiences register automatically. It is motivated by novelty, and it is always operating. This system cannot be stopped and the taxon system turned on by saying, “stop that and memorize this”. Memorization is memorization, not learning.

Learning means that information is related and connected to the learner. If it is not, there is memorization, but not learning. There are still things one must memorize,
things that need to be repeated. Multiplication tables are very useful, but children must also understand the concept of multiplication.

The locale memory system puts it all together as a picture. It does not just show a person one piece at a time and adding it together like a mathematical formula, coming up with a whole. That is the big message of research: parts are contained in a whole, and the whole has parts. It sounds very simple, but it is not when lessons are developed.

**Principle Ten: The brain understands and remembers best when facts and skills are embedded in natural spatial memory.** The solution is to embed taxon learning by immersing learners in well-orchestrated, life-like, low-threat, high-challenge learning environments. Information need to be taken off the blackboard, and made to come alive in the minds of learners, and to help them make connections.

**Principle Eleven: Learning is enhanced by challenge and inhibited by threat.** In the classroom, “downshifting” is seen as threat related to a sense of helplessness. It has implications for testing and grading, for the notion of the teacher as the controller, for empowerment, for performance objectives. The learner must be engaged in learning. Not that educators should throw performance objectives and tests out, but one must understand what happens to the human brain under these conditions.

Research is being done on how certain conditions affect learners, and if one wonders about dropouts, a formula that will produce some dropouts is: the teacher is in control, there are predetermined outcomes, the student is graded with little regard to feedback, and there are timelines on the activity. This will produce some students who will downshift, will dislike learning, and will be totally demotivated. On the other side, students who “ace” this process become test-taking experts.
The hippocampus, which is located just above your nose and above your ears in the center where they intersect, is part of the limbic system. It has proportionally more receptors for stress hormones than any other portion of the brain. It is also critical in forming new memories and is linked to the indexing function of the brain. It allows us to make connections, to link new knowledge with what is already in the brain. It is like a camera lens. Under threat related to helplessness, it closes off. We then move back into well-entrenched behaviors. It opens up when we are challenged and are in a state of “relaxed alertness”. When the learner is empowered and challenged, they begin to get the maximum possibility for connections. That is why the brain needs stability as well as challenge. If short-term stability is lost, then long-term stability must be substituted.

Many children come to school downshifted because they come from an environment of threat. There is threat in the home—threat related to abandonment of one form or another is probably the most destructive of all. Children from a stable home can take a little downshifting in school and are fine. Children that come from a home where there is instability and a sense of abandonment cannot take short-term downshifting. They need more stability in the classroom.

Relaxation techniques are things that can reverse the stress hormones in the body, which result from stress related to threat and accumulate over time. Rest is the basis of the activity and stopping the incredible treadmill they are on. Vacations are perfect examples of relaxation and rejuvenation. Children need to be taught that learning takes time, and they need to understand their natural rhythms.

**Principle Twelve: Each brain is unique.** This looks at learning styles and unique ways of patterning. Humans have many things in common, but are also very different. We need
to understand how we learn and how we perceive the world and to know that men and women see the world differently.