Creating Enriched Learning Environments: Lessons from Brain Research

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Introduction

Brain research is offering up new avenues of thought regarding teaching and learning. No longer are good teachers conveying information, facts and principles; they are in tune with how the brain functions, and teach using brain-compatible instruction to increase student achievement and their own job satisfaction. Learning the best way to learn has become as important as learning the subject matter (Sprenger, 1999).

The development and identification of brain-compatible teachers takes on new importance as education moves further into the Information Age. Educators need to build an adequate foundation grounded upon the principles of educational psychology, biology, neuroscience, and pedagogy to bridge the gap from the outdated Industrial Era model of schooling to the current Information Era model. It is no longer acceptable to remain with the traditional controlling, lecture-based, fact-gathering approaches to teaching; filling our students' "empty" brains with unrelated, non-relevant information. Brain-based instructional reform is a challenge facing both public schools and institutions of higher learning.

Ever since President George H. Bush declared the 1990s the Decade of the Brain, educators have struggled to interpret what current brain research may mean for teaching and learning. Proponents of brain-based reform are convinced that recent findings in neuroscience are applicable to the classroom, citing numerous studies and theoretical writings to advance their beliefs. Others are more cautious, carefully weighing both sides of the issue, trying to discern how one might apply research findings to educational settings. Critics of brain-based reforms state that is still too early to jump on the brain-based bandwagon; that educators should stick to the tried and true methods of teaching and learning that have been proven successful over time. Others are indifferent toward neuroscientific research.

Considering that "no one is born with a cognitive interest in anything" (Leamnson, 2000, p. 38), it is imperative that educators learn about the brain and its central role in learning. Many teachers have intuitively taught in ways that "seemed right", incorporating group projects, multiple intelligences, and challenge into their lessons (Kovalik & Olsen, 1998a). However, many teachers, at all levels from Pre-K to college, are not able to articulate how their pedagogy contributes to academic achievement, or why it does not. It is time to investigate principles from the current body of literature concerning brain-compatible teaching and learning, in order to facilitate moving teaching from an art to a science (Marzano, Pickering & Pollock, 2001).

This paper will provide a framework for brain-compatible teaching by first offering an explanation of how learning occurs in the brain. Next, the paper is organized around a model for creating an enriched learning environment that emerged from a recent study that includes the characteristics of: emotions, problem-solving, lowered stress, and threat, physical systems, experience, and teacher characteristics. Lastly, implications for current practice are explored.

Learning and Connections

Learning is a process of building neural networks (Wolfe, 2001). When a neuron is stimulated by incoming sensory stimuli, nerve impulses travel down the neuron's axon to the synapse, where neurotransmitter chemicals are released. These chemicals travel across the synapse terminal to the next neural dendrite. A series of electrochemical reactions causes the second neuron to fire or produce a signal, which in turn may cause more receptor sites on other neurons to fire as well. During the process of firing, dendritic branching occurs when the environment is enriched (Jensen, 1998). If the pattern is repeated through practice or rehearsal, the neuron group tends to fire together and form a network (Sousa, 2001). *Long term potentiation* (LTP) refers to the process of synaptic awareness and sensitivity where different combinations of chemicals can generate changes in the number of receptor sites. Memory is formed here, in small components called *engrams* (Sousa, 2001). Engrams combine to form neural networks, and hence learning and memory systems are constructed. Diamond and Hopson (1998) offer the analogy of "neural forests" to help visualize this phenomenon.

Interactions with the environment stimulate dendritic growth (Caine & Caine, 1991; Diamond, 1967; Jensen, 1998). Humans learn through experimentation, exploration, and thought. Stimulation, repetition, novelty and challenge all promote brain growth. Brain plasticity, or the ability to change the structure of the brain, is the result of genetics, experience, and the environment. If connections are not used or practiced, or the brain is not stimulated, neural pruning occurs. The implications for education are enormous, as educators seek ways to teach in a brain-compatible manner.

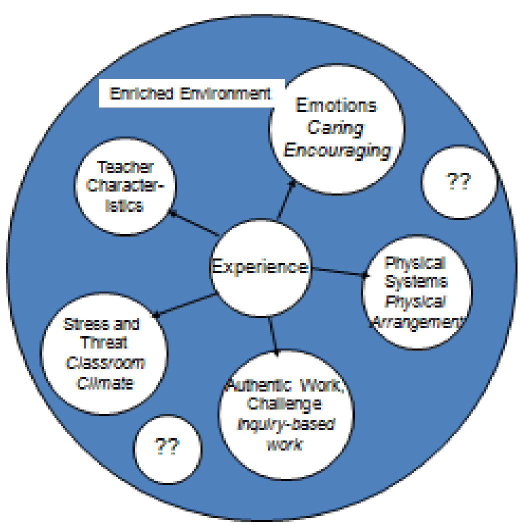
The Role of an Enriched Environment

In order to promote dendritic growth, the brain requires stimulation. However, many typical teaching methods insist on veridical answers and singular approaches instead of encouraging creative insights, multifaceted answers and alternative thinking (Jensen, 1998; Sylwester, 1995). An environment that has mostly predictable or repetitive stimuli fosters boredom in the brain, making it turn inward for new and novel stimuli (Sousa, 2001). Hence, student achievement is not advanced and often discipline problems arise due to lack of stimulation. Slavkin (2002) states: "Failure to produce stimulating learning environments and take advantage of students' interests and knowledge are likely to result in passive memorization, weak pedagogical practices, and limited learning" (p. 22). Creating an enriched environment through new learning experiences and challenges is vital to brain growth.

Diamond's (1988) work with rat cortices in the 1960s is considered to be a seminal study of the importance of environments on learning. Rats from the same litter were randomly assigned to either an "impoverished" environment consisting of a toyless cage with no other companion rats, or an "enriched" environment consisting of a toy-filled cage with several other companion rats. The enriched environment included other stimuli: colored panels around the perimeter, music, natural lighting, a comfortable temperature, and occasional rearrangement of the toys to foster problem solving. Each group of rats ran timed mazes as a measure of intelligence. After 80 days the rats' brains were dissected and Diamond found that the rats from the enriched environment had thicker visual cortices by 6.2 percent than those from the impoverished environment, including more dendritic branching, larger cell bodies and more growth spines (Diamond, 1988). This study has led to several recent studies on enriched environments in school settings, i.e. Dekal (2001), Brown, Burch and Zellner (2002), and Ramey and Ramey (2003).

I conducted a recent qualitative study that explored the characteristics of brain-compatible instruction, and determined if those characteristics are incorporated into teacher preparation programs and classroom practice by identified exemplary teachers (Radin, 2005). A literature review revealed several characteristics of brain-compatible instruction that were validated and expanded upon by interviews with a panel of ten well-known educational theorists. In addition, interviews with exemplary classroom teachers affirmed the findings. The following model illustrates the overarching concept of an enriched environment that emerged from the study. The inner circles indicate major components of that environment which will be addressed in this paper.

Radin Model of an Enriched Environment



Role of Physical Systems/Physical Arrangements

Enriched learning environments include both tangible and intangible elements that support student learning. The tangible components may consist of the following: clean, well-lighted classrooms that are pleasant smelling, well laid out for multiple uses, aesthetically pleasing, uncluttered, exhibit student work, a comfortable temperature, and contain multiple resources for topics currently under study (Hoge, 2002; Jensen, 1998; Kovalik & Olsen, 1998b). Other ideas offered by practicing teachers included: plants, posters, class pets, and thoughtful seating arrangements.

Important as these components are, the intangible components are even more important but harder to create. The intangibles include a safe, non-threatening environment, social collaboration, active engagement in hands-on and minds-on learning, integration of multiple intelligences, opportunities for inquiry and problem solving, and real-life relevant activities (Given, 2002; Jensen, 1998, Smilkstein, 2001; Sylwester, 1994). The classroom teachers in the study elaborated further by offering the following ideas: fun, encouragement, caring, high expectations, and reasonable discipline procedures. Both the tangible and intangible components will be explored in greater detail in the following sections.

Role of Emotions in Learning

Teachers play a crucial role in nourishing the emotional health of their classrooms, not only the lessons to be taught. Emotions in learning are an important factor in determining the goals students set for themselves, the things they choose to attend to, and even their depth of processing (Byrnes, 2001). Making the classroom an emotionally safe place to be in turn creates a desire or maybe even a passion for learning. Therefore, it is crucial that educators familiarize themselves with some basic brain physiology that deals with emotions.

Emotion regulators in the brain include the brain stem, the limbic system, and the cerebral cortex (LeDoux, 1996; Sylwester, 1994). The brain stem, which monitors involuntary activity, keeps the brain at a general level of attention by filtering incoming sensory information. The limbic system, associated with emotion and memory processing, is linked to several other modules, including the frontal lobes in the cerebral cortex. Sylwester (1994) notes that the limbic system "is powerful enough to override both rational thought and innate brain stem response patterns. In short, we tend to follow our feelings" (p. 63). The frontal lobes are the part of the brain that organize, monitor and prioritize what the brain will pay attention to. They are also important in the regulation of the body's emotional states and judgments, even to the extent that they can override undesired and automatic behaviors (Sylwester, 1994). Kovalik and Olsen (1998a) refer to feelings and emotions as the "gatekeepers" to learning, and assert that learning is a "bodymind" activity. Jensen (1998) concurs, adding that "emotions affect student behavior because they create distinct, mind-body states" (p. 75). Damasio (1994) adds that the body and brain form an "indissociable organism" which he compares to a brain-body partnership (p. 88).

As a first step in learning, Leamnson (2000) connects students' engagement and pleasure in learning with teacher effectiveness, citing pleasure as a biological process. He provides a neural explanation for learning being enhanced or speeded up as a result of emotion engagement. Jensen advocates embracing emotions in the learning process, not avoiding them. He cautions that the emotions triggered must not be extreme, but appropriately "middle ground" (Jensen, 1998, p. 78).

Recommendations from the literature regarding the incorporation of emotions into learning include: making learning joyful by incorporating games, music, drama, storytelling and simulations (Given, 2002; Jensen, 1998; Rieber, Smith & Noah, 1998; Schenck, 2003; Sylwester, 1995; Wolfe, 2001), celebrating achievements with acknowledgements and fun (Jensen, 1998), incorporating physical rituals into classroom routine (Jensen, 1998; Roberts, 2002), helping students to make personal connections to their work through journals, discussions, sharing, stories and reflection (Given, 2002; Smilkstein, 2001), providing opportunities for metacognitive and self-regulatory activities (Schenck, 2003; Sousa, 2001), and promoting a positive classroom climate by modeling enthusiasm and passion and by guiding and mentoring students in supportive ways (Erlauer, 2003; Given, 2002; Greenleaf, 1999; Jensen, 1998; Kovalik & Olsen, 1998b; Schenck, 2003; Smilkstein, 2001). Practicing teachers added the following components: creating a homey atmosphere, open communication, being fair, and looking for students' strengths.

Role of Stress and Threat in Creating Classroom Climate

Directly related to the role of emotions in learning is the role of stress and threat. Biologically, when fearful sensory input enters the brain, the autonomic system and stress hormones are activated. The thalamus relays immediate input to the amygdala, the emotional center of the brain. Depending upon whether the amygdala perceives the incoming stimuli as threatening or not, signals are sent to the cortex to deal with the threat rationally, or the amygdala bypasses the cortex to deal with the threat in a "knee jerk" reaction (Ratey, 2002). During this process the release of adrenaline, vasopressin and cortisol are released throughout the body, causing changes in the way one thinks, feels, and acts.

A typical biochemical response to a perceived threat, whether physical, environmental, academic, or emotional is the "fight, freeze, or flee" response (Jensen, 1998). The brain may downshift to lower order thinking. This response manifests itself in various ways as the brain tries to ensure the body's survival. Physiological changes include increased metabolism of fat and glucose, dilation of pupils, constriction of heart arteries, relaxation of the bronchial tube, modification of blood chemistry, and slowed digestion (Erlauer, 2003). Threats that are not alleviated can lead to a situation termed *chronic stress*. Behavioral manifestations may include withdrawal, violence, aggressive behaviors, or the reverse: increased attention and engagement (Jensen, 1998).

On the list of possible threats and stressors to learners are such things as home life, personal relationships, harassment, bullying and abuse, and health concerns, to mention a few. School-related stressors are often perceived as non-caring teachers, teasing and sarcasm, homework deadlines, peer pressure, school violence, the potential for humiliation or embarrassment, and feelings of inferiority (Erlauer, 2003; Jensen, 1998). The consequences of unrelieved stress include impairment of memory and reasoning skills, increased susceptibility to illness, elevated blood pressure, even shrinkage of the hippocampus (Lupien, 1998). Learning may be inhibited and narrowed. The results can be a state of helplessness, wherein students become less aware of their surroundings and contexts, and turn inwards to protect themselves from further threat (Caine & Caine, 1991).

In order to address the stress/threat balance and create a positive classroom climate, teachers should emphasize relationship building, both peer-peer and teacher-student (Erlauer, 2003; Jensen, 1998; Roberts, 2002). Stress management techniques such as deep breathing, time management, relationship skills and exercise are also recommended (Jensen, 1998). Setting clear expectations through the use of rituals, rules or agreements, and rubrics do much to alleviate students' stress (Erlauer, 2003).

Educators should strive for an atmosphere of *relaxed alertness*, that is, a climate high in challenge and low in threat (Jensen, 1998; Smilkstein, 2001). Other recommendations include: building relationships and a sense of community in the classroom and school-wide (Erlauer, 2003; Jensen, 1998; Kovalik & Olsen, 1998b; Roberts, 2002), empowering students to set their own realistic goals (Kovalik & Olsen, 1998a; Slavkin, 2002; Sylwester, 1994), and establishing behavior guidelines for the class that incorporate intrinsic rewards. Teachers should model behaviors and values expected from the students at all times (Erlauer, 2003; Kovalik & Olsen, 1998b).

Classroom teachers supported these components by stating that they meet students where they are, not where teachers expect them to be. The exemplary teachers are also positive encouragers who aren't afraid to be tough when the situation calls for it.

Role of Authentic Work, Problem Solving, and Challenge

Sousa (2001) notes, "now that we have a more scientifically based understanding about today's novel brain, we must rethink what we do in schools and classrooms" (p. 28). A big part of the rethinking requires a look at what educators ask students to do in the classroom. The brain is an open parallel-processing system that continually interacts with the physical and social worlds outside. Learners constantly strive to make sense of their world. This is one of the biggest challenges facing the brain: trying to connect sense and meaning, and trying to search for patterns (Hart, 1999).

Connecting sense with personal meaning-making can happen when teachers begin their instruction by establishing connections to prior knowledge and current experience (Smilkstein, 2003; Sousa, 2001). Meaningful curriculum content is crucial. Kovalik and Olsen (1998a) caution that the traditional curriculum offered in most of today's schools is "out of sync with the body-mind definition of learning" (p. 36). They suggest that there is little in today's traditional curriculum that students, particularly teenagers, find useful or relevant. Textbooks containing irrelevant factoids do not empower learners. Instead, personalization of information, learner empowerment and choice make neural connections stronger (Brandt, 1997; Diamond & Hopson, 1998). It is from this personal foundation, which includes the variables of cultural practices and beliefs, that new learning can grow.

Problem solving in instruction is very brain-compatible because multiple neural pathways can be accessed and developed during the process (Erlauer, 2003; Jensen, 1998). Denny states that "problem solving is to the brain what aerobic exercise is to the body" (cited in Jensen, 1998, p. 144). Educators should be wary that the problems to be solved are not mere hypothetical problems with canned, convergent outcomes (Wolfe, 2001). When instruction or discussion is paired with hands-on activities, group work, demonstrations or experiments, different areas of the brain are engaged and neural connections are grown. Basically the brain is engaged in discovering multiple answers to a problem, instead of finding the one correct (veridical) answer. The result is that reasoning, critical thinking and other higher-level thinking skills are engaged, regardless of whether a solution or answer is found. Neural growth occurs because of the process, not because of the solution.

Teachers should create a learning environment high in challenge, relevance and problem solving where students can build their own understanding of the content, organize it, and think it through using their own cognitive models, while constantly providing useful learner feedback.

Implementing authentic work, challenge, and problem solving in an enriched environment includes: providing students with choices in their learning (Erlauer, 2003; Given, 2002; Jensen, 1998; Kovalik & Olsen, 1998b), incorporating a variety of teaching and learning styles during instruction (Given, 2002; Greenleaf, 1999; Sousa, 2001; Wolfe & Brandt, 1998), and providing opportunities for experiential learning through field trips, hands-on activities, simulations, models, guest speakers and experiments. Students should be active participants in their own learning. Linking the information to be learned with current events, stories, myths, legends and metaphors fosters more powerful learning and better retention (Greenleaf, 1999; Smilkstein, 2001; Wolfe, 2001; Zull, 2002).

Classroom teachers added the following ideas, based on their experiences: asking the right type of questions, having students learn by teaching each other, and connecting their content area with other content areas in an interdisciplinary model.

Conclusions

The question of applying neuroscience in the context of education remains controversial. Brain-compatible instruction is not a program, a formula, or a package for teachers or schools to follow. It is not a panacea that is going to solve all of our educational problems. However, in order for educators to be *articulate professionals,* it is vital that we know about the biological basis of learning and move teaching to an "applied science of the brain" (Zull, 2002, p.4). Providing an enriched environment is the first step in orchestrating successful student learning and achievement. If teachers are to assume the roles of brain changers or brain sculptors, knowledge of current brain research as it applies to education is valuable and enriching. In this era of high accountability, educators need to continue to better understand what conditions, environments and instructional practices can improve learning for all students.

One of the theorists in this study offered the concept of "rough draft" learning, where teachers often sacrifice accuracy for simply getting something "close" (Radin, 2005). Teachers should know how to increase the importance and relevance of learning in order to upgrade rough drafts to improve meaning and accuracy. As noted by the American Federation of Teachers (2000), it is vital that teachers learn from scientific research how people learn. The following quote sums it up:

> Imagine all the teachers teaching well, experts in nature-nurture interactions, who *fill the mind* in individually tailored ways, guided by scientifically supported principles of the brain and instruction, and by cultural sensitivity. (Berninger & Richards, 2002, p. xvii).

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