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Brenda Van Roekel

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Abstract

Recent developments in neuroscience have enabled scientists to understand and image brain activity. Brain researchers are now more able than ever before to understand how the brain works, what affects the brain, and what implications these discoveries have for education. Based upon these discoveries new methods of teaching have been devised using the term, brain-based strategies or brain-based learning. This thesis examines some of the brain-based strategies embraced by leaders in this field. It will pay particular attention to the enriched environment, the effect of emotion on learning, and the concept of sensitive or critical periods. It will examine research in these areas and contemplate the validity of findings and the implications they have on classroom practice.

Brain-based Learning: Implications for the Elementary Classroom

Recent developments in neuroscience have enabled scientists to understand and see inside the brain. Brain researchers are now more able than ever before to understand how the brain works, what affects the brain, and what implications these discoveries have for education. Neuroscience is an exploding scientific field bursting forth with new information that could transform the classrooms of the future. Pat Wolfe and Ron Brandt, educational consultants with expertise in the application of brain research to teaching, claim we have learned more about the brain in the past five years than in the past 100 years (Wolfe & Brandt, 1998).

Scientists use a variety of specialized techniques to investigate brain-behavior relations. Magnetic Resonance Imaging (MRI) shows cross-sectional images of soft tissue like the brain (Jensen 1998). "High resolution images are constructed from the measurement of waves that hydrogen atoms emit when they are activated by radio-frequency waves in a magnetic field" (Pinel, 2000, p. 107). MRI scans produce three-dimensional pictures of the brain used to map out brain structure. Positron Emission Tomography (PET) also can uncover the structure and some neurological activity within the brain (Stover, 2001). More recently, functional MRI scans, based on images of the increase in oxygen flow in the blood to active areas of the brain, can illustrate surface activity or images of sections throughout the brain. According to Pinel (2000), the fMRI has several advantages over PET. The main advantage is that it provides both structural and functional information in the same scan, thereby imaging activity in the brain. The images produced by the fMRI scanner can show exactly what areas of the brain become active when a person is exposed to a particular task. Other modern technologies such as the electroencephalogram (EEG) give researchers information about the electrical output of the brain. Magneto encephalography (MEG) uses high tech sensors to detect brainwave patterns. These tools can help neuroscientists track how much brain activity occurs during problem solving. Lab experiments with animals can also provide scientists with information about how the brain works. One of the foremost areas of examination is the impact of an enriched environment on brain development in rats.

What do these discoveries in neuroscience have to do with the classroom procedures of today? A growing body of neuroscientific research is slowly revealing how minds learn, memorize and use information. Some believe that these findings have practical implications for the classroom (Brandt, & Wolfe, 1998, Caine & Caine, 1997, Diamond & Hopson, 1998, Jensen, 1998 Kotulak, 1996, Sousa, 2000, Sprenger, 1999). They argue that although science does not have an inclusive model of how the brain works, enough is known to make significant changes in how we teach. These new ways of teaching are summarized in the term, brain-based strategies or brain-based learning. This paper examines some of the brain-based strategies embraced by leaders in this field. In particular, the model of an enriched environment will be examined and the validity of its use in the classroom will be addressed. The impact of emotion on learning and memory as well as sensitive periods of learning will be explored. This paper also contemplates criticisms of brain-based learning led specifically by John Bruer (1999a, 1999b).

Brain-based learning

According to Jensen (2000), author and active synthesizer of brain research, brain-based learning "is learning in accordance with the way the brain is naturally designed to learn. It is a multidisciplinary approach that is built on the fundamental question, 'What is good for the brain?" (p. 6). Brain based learning involves maximizing learning. It is an instructional model that integrates discoveries about what facilitates accelerated learning. It gleans information from many disciplines, such as chemistry, neurology, psychology, sociology, genetics, and biology. By considering what causes the brain to accelerate learning, teaching strategies that facilitate learning might be improved. The goal of brain-based learning is to maximize the conditions under which the brain learns best.

Every healthy brain comes equipped with the ability to detect patterns, memorize, self-correct, and create. If everyone has these abilities, why do we struggle to educate? Caine suggests that "we have not yet grasped the complexity and elegance of the way the brain learns" (1994, p. 3). We can use teaching strategies that are compatible with the way the brain works, or we can struggle with educational methods that are contrary to learning.

For years educators have labored to teach through rote memorization of facts and skills. Real life experiences and events however, are etched in our minds with no difficulty. The brain constantly searches to make sense of experiences, seeking common patterns and relations. This suggests that the brain is predisposed to search for relations between what is being learned and what is already known. Caine (1994) summarizes that "brain-based learning involves acknowledging the brain's rules for meaningful learning and organizing teaching with those rules in mind" (p. 4). Since the brain is already searching for connections to previous knowledge, teachers need to "orchestrate the experiences from which learners extract understanding" (Caine, 1994, p. 5). Brain-based education therefore, involves designing enriching experiences for learners and ensuring that students extract meaning from these experiences.

Background

In July 1989, following a congressional resolution, Congress and President Bush proclaimed that the 1990's would be the decade of the brain. At the same time teacher, Marilee Sprenger was struggling with what to do to help some students she was teaching. In 1992 she signed up for a five-day graduate class with brain guru and author, Eric Jensen. During that week she discovered her passion for learning about the human brain. This led her to research and write about learning and memory.

During this same period, 1990 to 1996, Marion Diamond was a professor of anatomy at the University of California at Berkeley and director of the University's Lawrence Hall of Science. She was a pioneer researcher on the effect of the environment on the brain. At that time, she investigated structural changes in the cerebral cortex induced by an enriched environment.

David Sousa joined in spreading the word about brain research in his position as president of the National Staff Development Council in 1992. From 1996 to 1998 he was awarded the Expert-in-Residence grant from the W. K. Kellogg Foundation to present his ideas to educators in the Battle Creek, Michigan area. In 1997 he was invited on a 10-day trip to the Ukraine as part of an international team that presented educational research. Now he is an international educational consultant who has conducted workshops on brain research in hundreds of school districts.

Ronald Kotulak, a reporter for the Chicago Tribune was so awed by the contemporary scientists' quest to explore the brain, he began investigating and interviewing leaders in that field of brain research. This led him to write a Pulitzer-Prize winning series on the work of the leading researchers, which resulted in writing the book, Inside the Brain in 1996.

This interest in learning how the human brain works gained further "momentum in the mid-1990's when the Carnegie Corporation and the Education Commission of the States, among others, released reports attempting to show . . .implications for education policy. These reports sparked interest in the topic" (Stover, 2001, p. 28).

These and other experts, authors, and consultants are part of a growing body of brain research advocates. They conduct or study current brain research and translate it into classroom practices that are called brain-based learning strategies.

Taken together, they have done valuable research into how the brain works and what makes the brain grow new dendrites, the connections that aid in learning. They have underscored the plasticity of the brain, that is, the ability of the brain to grow as a result of environmental factors. They have made valuable contributions to our understanding of how the brain responds to new learning, giving the elderly hope in keeping their brain active to maintain clear thinking and memory.

As a result, they have become brain research consultants authoring books, presenting seminars, and developing their own organizations dedicated to the development of not only brain research, but also making these discoveries and their implications available to the public, teachers, parents and lawmakers. These consultants endorse many specific strategies that they say are based on research. These strategies are targeted for the classroom to aid in learning and memory. Although financial profit may not be the primary goal of these organizations, marketing these ideas has become popular and a successful business venture.

A critic of this movement, John Bruer, president of the James S. McDonnell Foundation, a nonprofit organization that supports scientific research, does not object to the focus on recent developments in brain research. Neither does he object to new strategies that will help people learn. He objects, however, that there are many assumptions being made from brain research results that simply are not based on fact. "Brain science has been invoked," he maintains, "to justify preexisting views about child development and early childhood policy. But the evidence has been overstated, if not actually misinterpreted. And educators, like parents, have been gulled" (Gough, 1999, p. 258).

In his 1999 book, *The Myth of the First Three Years*, Bruer argues that this new approach to learning is not a result of the new scientific evidence. It is a product of more than 30 years of psychological research. He states that the so-called brain-based learning strategies can be found in any current textbook on educational psychology. Bruer argues, "None of the evidence comes from brain research. It comes from cognitive and developmental psychology; from behavioral, not the biological, sciences; from our scientific understanding of the mind, not from our scientific understanding of the brain" (Bruer, 1999a, p.649). Bruer contends that the biological data from brain research is more appealing to educators. He continues that neuroscientists make bold statements about brain science and education that he feels are speculative, not fact, and it is very difficult to separate the science from the speculation.

Brian-based Strategies

The remainder of this paper will examine some of the research and strategies presented by the brain- based learning consultants to determine whether the strategies presented are indeed based on relevant research or on speculation as Bruer maintains. The three strategies most discussed in brain-based learning literature are that of an enriched environment, the input of emotion, and the concept of sensitive periods in development.

Enriched Environment

Some scientists think the brain begins degenerating, or losing cells at birth. Others think cell deterioration begins at about age twelve and continues until death (Jensen, 2000). However, studies have shown that enriched environment can actually stimulate brain growth. Even though there may be fewer cells, it is possible to have increases in the connections between the cells.

Animal Studies.

Two of the initial animal studies that set the stage for the brain-based learning movement were done by Rosenzweig (1968) who studied, the effect in rats of a few hours a day of enriched experience on brain chemistry and brain weight. Another by Fuchs (1990) investigated the effect of environmental complexity on the size of certain rat brain structures such as the superior colliculus.

Rosenzweig studied the effects of continuous enriched environment, 24 hours a day over a period of 80 days. The results showed significant positive changes in brain size in the rat (Rosenzweig, 1968). Later Rosenzweig, Love, and Bennett, (1968) completed a series of five experiments showing the effects of just a few hours a day of enriched experience on brain weight. In the first experiment, 40 male rats were assigned to four groups. A 24 hour EC (Environmental Complexity) group, an IC (Impoverished Condition) group, a 4.5 hour EC group, and a 2.5 hour EC group.

The animals in the EC group were housed in a large EC cage with "toys" such as metal boxes, ladders and running wheels. The arrangement of the toys was changed daily, and some toys were rotated among a larger stock. For 30 minutes a day the animals were placed in a Hebb-Williams maze device, with the pattern barriers being changed daily.

The animals in the IC group lived singly in cages with solid sidewalls. The cages were placed in an isolation room. Group 3 lived most of the day in colony cages, three rats to a cage, in the same colony room as the EC cages. During 4.5 hours of the day they were placed in an EC cage and a half hour in the Hebb-Williams maze, a device used to investigate the intelligence of many different species. Group 4 was treated the same as group 3 only they were given 2.5 hours a day of exposure to the EC cage.

Decapitation and analysis procedures were done blind to the experimental condition. Brains were sliced into sections and measured for tissue weight.

The results of Experiment I and II were similar in that they showed how readily the brain can be affected by experience. The 2-hour a day of enriched experience was sufficient to produce significant increases in the weight of the cerebral cortex. The 4.5 and 2.5 hour EC groups reveal effects very similar to those of the animals that remained in the EC throughout the day and night. The experimenters were not sure why two hours of enriched experience produced as large or larger an effect as did continuous exposure. Perhaps 24 hours of exposure produces an overload of information, which inhibits learning, or a few hours a day is enough to absorb all the information gained in the EC. It is thought that the 24-hour groups habituate to the enriched environment. Diamond (1998) suggests that it is essential not to force a continuous stream of information into the developing brain, but to allow for periods of consolidation and assimilation in between.

Experiment III was designed to determine how 2-hour EC and Standard Colony (SC) animals would differ from IC littermates. Since the enriched-experience animals spent most of the day in the standard colony condition, it was necessary to test whether the colony experience might have produced the cerebral differences from the isolated animals. The colony group did not differ significantly from the isolated group in any measure. "Two hours a day in the enriched situation caused the EC to differ from the (SC) group while 24 hour a day in the colony situation in the busy experimental room did not cause the SC to differ from the IC group" (Rosenzweig,1968, p.822). The differences must be caused more by the 2 hour a day of EC rather than the 22-hour a day Standard Colony.

In Experiment IV the experimental animals lived in individual cages except for the 2-hour daily EC period. Again the 2-hour EC group showed increased brain weight. Experiment V housed the EC and IC groups in the same room rather than an isolation room, as in the other experiments, and in the same type of colony cages. The EC's had 2-hour a day of enriched experience, a daily injection of saline solution and daily handling. The saline solution was used as a part of a larger design on the interaction of drugs with EC. Once again, 2 hours of Environmental Complexity was enough to produce significant differences in brain weights.

The study by Fuchs (1990) reports similar results: significant brain growth as a result of enriched environmental condition. This study, however, focused on the growth of a particular brain structure, the superior colliculus, a subcortical structure involved in visuomotor function. In this study, 22 male Long-Evans hooded rats were kept in translucent breeding cages for the three to four postnatal weeks. Littermates were paired according to body weight. One member of each pair was assigned to an individual cage (IC) and the other to the environmental complexity (EC) group. IC rats were housed singly in stainless-steel mesh cages. Their EC littermates were together in a large cage with a variety of toys. For the first nine to ten weeks the EC rats were transferred to a second play cage for 1 hour each day and the toys were rearranged daily in both cages.

After approximately 48 weeks, brains of the rats were measured. The superficial gray layer of the superior colliculus was 5.2% thicker in the EC compared to the IC group. This suggests that brain structure can be affected by environmental complexity.

<u>Implications for the classroom</u>

Taken together, these studies show that the brain changes physiologically as a result of experience. Wolfe and Brandt (1998) claim, "the environment in which a brain operates determines to a large degree the functioning ability of that brain"(p. 8). The connections between cells that are made as a result of our experiences form our personal cognitive maps. If brains grow new neurons when stimulated, this suggests learners can increase their intelligence even as they age.

In other words, if a child is born with the genetic potential to be a genius, but is raised in non-enriched environment, the chances of actually becoming a genius may be reduced. However, if a child with an average genetic make up is exposed to a nurturing and intellectually stimulating environment, the child may develop beyond their genetic potential as a result of the enriched environment.

The metaphor of a banquet further describes the relationship between genes and the environment. Kotulak (1996) explains that the brain gobbles up the external environment through its sensory systems and then reassembles the digested world "in the form of trillions of connections which are constantly growing or dying, becoming stronger or weaker depending on the richness of the banquet" (p. 4).

Diamond, concurs with Kotulak as she summarized the data from research on enriched environment as follows:

> With increasing amounts of environmental enrichment, we see brains that are larger and heavier with increased dendritic branching. This means those nerve cells can communicate better with each other. With the enriched environment, we also get more support cells because the nerve cells are getting bigger: Not only that, but the junction between the cells, the synapse, also increases in dimension. These are highly significant effects of differential experience (as cited in Jensen, 2000, p. 149).

Diamond (1998) observes that just as brain size increases with environmental complexity, it also decreases in size when there is less input. Decreased stimulation will diminish a nerve cell's dendrites. She suggests that this has far-reaching implications for aging adults. Brain research seems to implicate that if adults exercise their brain, they may be able, to some extent, to maintain clear thinking and memory rather than succumb to brain deterioration so commonly associated with aging.

In support of this idea, studies have shown that IQ is not fixed at birth. Ramey directed studies of early educational intervention involving thousands of children at dozens of research centers. Starting with children as young as six weeks, Ramey showed that they could raise the infants' scores on intelligence tests by 20 points by enrolling impoverished children in intervention programs (as cited in Jensen, 2000, p.152).

In light of what has been learned from brain research, educators now realize they are either promoting the growth of dendrites or letting them whither and die. The challenge is to determine what constitutes an enriched environment and which strategies are actually based on the current research. Caine (1994) refers to orchestrated immersion, which is "to take information off the page and the chalkboard and bring it to life in the minds of students" (p.115).

All are not convinced, however. John Bruer (1999a) cites the experiments of Rosenzweig, Fuchs and others as cause for debate. He suggests that the complex environment used in the rat experiments are really quite like the rats' natural environment in the wild. Generally, children are not kept in cages, so we have no way of knowing what would be the equivalent of an enriched environment for humans. The word "enriched" itself may carry cultural bias. Bruer claims the experiments on rats do not necessarily imply that enrichment will affect children's' brains in the same way complex environments affect the brains of rats.

Is the idea that an enriched environment affects development a new one? It certainly is not. Brain researchers are not the first to explore the effect of environment on development. Harlow conducted experiments that have become classic in the history of psychology. In his experiments, baby monkeys were removed from their mothers a few hours after birth and reared without parental care. The infants developed abnormal behaviors. They often sat and stared for long periods, or would rock back and forth. Despite later efforts to rehabilitate them, the monkeys had disturbances in social behavior (Baron, 2001, p.316).

In the 1990's 45 Romanian children experienced extreme deprivation in an overcrowded orphanage in Romania. Of these, 30 of the children experienced one or more years, where staff workers gave infants little or no personal attention. The other 15 were adopted within a month or two of their births. The deprivations inflicted on Romanian orphans caused many to be below the third percentile in weight and height. According to Dr. Mary Carlson, neuroscientist at Harvard University, some showed profound failure to thrive and at age 10 were the size of 3-year-olds (as cited in Blakeslee, 1995). Despite criticisms like these by Bruer, situations like this suggest that early environmental factors do affect development, which most likely includes brain development.

Emotion Aids Memory

Brain research also suggests that emotion stimulates brain activity. Sprenger (1999) states, "Without a doubt, emotional memory strategies are the most powerful" to activate storage areas in the brain. She bases this claim on the results of LeDoux's (1996) studies in which he found that both positive and negative emotions cause the brain to release certain neurotransmitters and hormones that aid in memory retention.

The emotional impact of any lesson or life experience may continue to influence long after the specific event. It is the emotional system that decides what is committed to long-term memory. Humans remember the best and the worst. Jensen (2000) states that there is powerful evidence that embedding intense emotions, such as celebration, competition, or drama in an activity may stimulate the release of adrenaline, which may enhance the memory of the learning. Therefore, if teachers can add emotional input into learning experiences to make them more meaningful and exciting, the brain will consider the information more important and retention will be increased.

With this in mind, Jensen (2001) suggests several strategies to be used to evoke emotional responses in the classroom. To help a child to be ready for learning he advises using discussion, singing, writing, music or drawing to provide an emotional outlet. Stories and myths are powerful strategies in presenting new material. They are powerful because they bind information and understanding. History tends to be presented as inert surface knowledge when it is actually a powerful, emotional story. Debate over historical issues allows emotions to build. Integrating great literature that includes emotion, mystery, tension, and climax will aid in memory and understanding. Another strategy for including emotion in teaching is for teachers to show enthusiasm for their content area (Sprenger, 1999). Students may find it contagious. If teachers share their feelings about what they are teaching, students may find they have similar feelings.

Even though many of these strategies are based upon the studies of LeDoux, Le Doux himself cautioned educators at a 1996 brain and education conference (as cited in Bruer, 1999a, p. 649), “These ideas are easy to sell to the public, but it is easy to take them beyond their actual basis in science”.

Although these teaching strategies may be effective and may have been stimulated by results of LeDoux's studies, to say that each idea for the classroom is based solely on brain research is not true. Jensen (2001) himself cautions not to regard brain research as proof that certain strategies work. Because of the complex variables involved in brain research, it irresponsible to say, "brain research proves." Jensen suggests that educators say, "The studies suggest that XYZ may be true about the brain. Given that insight, it probably makes sense for us, under these conditions to use [these kinds of] strategies in school" (Jensen, 2001, p. 76).

Sensitive Periods in Development

Many brain based learning consultants including Brandt and Wolfe, (1998) endorse the concept of sensitive periods. They find that some abilities are acquired more easily during certain sensitive periods. Through PET scans, scientists find that during the period from birth to age 10, the number of synaptic connections continues to rise rapidly until age 10 but then begins to drop and continues to decline slowly into adult life. The brain appears to develop some capacities with more ease during childhood than in the years after puberty. From this, Jensen (1998) concludes that "the brain learns fastest and easiest during the school years" (p.32).

There seem to be sensitive periods for learning or "windows of opportunity" when some abilities are acquired more easily. The example of vision is given by Brandt and Wolf (1998). If a baby experiences a lack of visual stimulation at birth from blindness or cataracts, the brain cells designated for vision will atrophy or be diverted to another task. If sight is not gained before the child is three years old, the child will never be able to see. The window of opportunity has closed. Not all windows close as tightly as vision.

This same phenomena is evident in language development. Although an adult is able to learn a second language, for instance, it is much easier for a child under ten years old. For example, "A Japanese baby can distinguish "r" from "l" but, absent the "l" sound in the Japanese language, loses this ability after age 3" (Blakeslee, 1995, p. 1). It seems that after age 10 most people cannot learn to speak a second language without on accent. Likewise, unless deaf children are exposed to some form of language before age 5, they behave as though they have a severe speech deficit, when in fact they simply have not acquired an oral means of communication.

Another example of this sensitive period of development is found in the study by Chugani (as cited by Bruer, 1999a) as the basis for these claims. Chugani and his colleagues studied the PET scans of 29 epileptic children, ages 5 days to 15 years. They found that there was a high plateau period for metabolic activity in the brain that lasted from about three years of age to nine years of age. Because PET scans need to be conducted by injecting radioactive substances, scientists are prohibited from doing PET scans on normal healthy children. Despite this drawback, this study was significant because it was the first study that was able to trace brain development from infancy through adolescence.

Criticisms of the brain-based learning movement

There are several criticisms encountered the discussion of the brain-based learning movement. One criticism is that this brain research has not revealed anything new. Another critique is that too many policy-making decisions are based on inadequate research.

This is nothing new

It appears that psychology and neurology have come to the same conclusion by pursuing different lines of investigation. Basic neuroscience research is usually done at the molecular, genetic or cellular level. This is in contrast to the applied cognitive sciences, which have used animal studies, or human clinical studies that show that early experience affects later behavior.

Both are claiming to be the authority. Both are clamoring for credit for the discoveries that have been made claiming the beneficial effect of an enriched environment on learning and development. Who should be given credit? Are the claims made based on firm research?

One viable accusation that Bruer makes concerning brain-based learning is that there is nothing new in this approach. One must remember perhaps 40 years ago all classrooms were comprised of lecture based, quiet classrooms with students in their seats, doing worksheets, allowing for very little movement. Gradually teachers have been moving towards a more active brain-friendly approach.

Despite this criticism, brain research has aided educators in knowing these changes have been helpful. Some neuroscientific findings have validated what good educators have always done. Others are causing teachers to take a closer look at educational practice. Teachers have been using various brain-compatible strategies for years. Brain research findings help teachers focus on the strategies that are effective. It provides scientific basis for what were previously regarded as just good ideas. It is important to know why certain strategies work, lending purpose and professionalism to teaching in the classroom.

Educational Policy

Findings such as these have been the focus of scientists and government officials alike. A report resulting from the April 1997 White House Conference on Early Brain Development (as cited in Bruer, 1999a) stated, "By the age of three, the brains of children are two and a half times more active than the brains of adults – and they stay that way throughout the first decade of life."

Although this has been the impetus for much government spending on early education, Bruer (1999a) contends that, "None of the evidence comes from brain research. It comes from cognitive and developmental psychology; from behavioral, not the biological, sciences; from our scientific understanding of the mind, not from our scientific understanding of the brain" (p.648).

According to Bruer the claims made by brain researchers concerning sensitive periods are an example of the lack of substantial scientific research he thinks is typical of the brain research consultants. As Bruer searched for the scientific research to support this claim, he found that researchers consistently referred to the study by Chugani (as cited in Bruer, 1999a). However, this study is limited in its findings. Upon further examination, Bruer observes that Chugani did not study how quickly 5-year olds learn as opposed to 15-year-olds. Bruer objects to linking a critical period of learning to this plateau of activity in the brain. The assumption that scientists and consultants rely on is that periods of rapid brain growth are the sensitive period. Bruer contests that this is neuroscientific speculation. He does believe there are times when learning is easy, but this belief is not based on neuroscientific evidence.

Bruer claims that this type of speculation is common when research is presented to educators. He states, "The brain-based education literature represents a genre of writing, most often appearing in professional education publication, that provides a popular mix of fact, misinterpretation, and speculation. That can be intriguing, but it is not always informative" (Bruer, 1999a, p. 654).

Bruer addresses three strands of what he refers to as the myth of the first three years. These strands are early synapse formation, critical periods, and enriched environments. Bruer does not actually dispute the idea that the first three years of life are extremely important, he believes the findings that have evolved from neurobiology have been overstated if not actually misinterpreted. He takes exception to the notion that brain science can currently give specific guidance to parents and teachers. Bruer (1999b) claims that there is a huge gap from brain science to educational practice.

Therefore, schools should not base educational policy on brain research alone. Budgets, goals, resources, community interests, and standards need to be considered. Researchers also caution educators to resist the temptation to adopt policies on the basis of a single study. However, schools need to regard the brain research as a valuable tool. To ignore what we know about the brain would be irresponsible.

Some critics of brain research argue that the research changes too rapidly to be of value. Many fields such as medicine, communication, and technology are undergoing rapid changes. That does not mean we should disregard our newfound knowledge. We are obligated to incorporate our new findings into our current knowledge and use it to enhance what we already believe is effective teaching.

Bruer does believe in making the world a better place for children. He sees value in and encourages parents and childcare providers to talk, sing, and interact with babies. He does not dispute the importance of high-quality day care or early childhood education. He just feels that using brain research to justify activities and social programs is premature.

Bruer points out some generalizations that are important to regard in all policymaking based on research. He recommends that policy makers be wary of absolute, categorical statements. Watch out for possible overgeneralizations. Do not place too much weight on single studies. And watch out for arguments that rely on unpublished scientific data (Gough, 1999).

Despite Bruer's criticisms, the two themes in his book, *The Myth of the First Three Years (1999b)*, are quite optimistic. He agrees with many brain researchers that brain development is not completed by age 3. Instead, the brain remains plastic, able to learn throughout life. Secondly, the brain wants to learn and it is very difficult to stop it.

Conclusion

If the experience of the ages did not exist and there were no other knowledge of human experience, if there were only brain research on which to base educational strategies, educators would be in a sorry state. Brain research in itself would not have much to offer. However, there is a great deal of knowledge about learning, which has been acquired through many avenues of study. It is possible to draw from many sciences to further our understanding of how the brain works. Knowledge about brain function is relevant, especially when used to supplement other sources. Man is not just a vessel for the brain, which can be filled and stimulated by following prescribed strategies. Educators learn from many aspects, the psychological, the biological and the sociological. Scientists and educators must not lose sight of man as a whole.

It is true brain research is in the infancy stage. There is so much more to learn, but using that as an excuse to dismiss this new body of knowledge as a fad is like calling the Wright Brothers' first flight at Kitty Hawk a failure because it only went a few hundred yards. Brandt suggests that "much remains unclear, and we surely will misinterpret some findings as we try to make sense of the partial information currently available. If so, we must be open to clarification, some of which will come with newer findings. Educators would be foolish to ignore the growing body of knowledge about our brains" (Brandt, 1999, pg. 241).

Jeeves notes that "scientists, equally knowledgeable, have interpreted the same scientific evidence in different ways" (Jeeves, 1993, p. 87). Each enters the discussion influenced by deeply held, personal non-scientific beliefs. Each scientist, philosopher, psychologist, and researcher has their own world view which influences their thinking and interpretations of research. Personally held values do interact with the interpretations of scientific data. This suggests that brain researchers, having classical psychological theories in their schema may be searching to substantiate what they already know from psychology through their brain research. They may be interpreting brain research findings in light of what they already know from their psychological background. At the same time, Bruer views the research findings through his psychological point of view as well. The only difference may be that the brain researchers credit their own research, while Bruer claims psychology as the basis for these findings.

Man's view of human nature, of what makes the brain work, of the mind/brain connection has changed through the years (Jeeves, 1993). Various influences have come to the forefront only to be replaced by newer research developments. It is the Christian's opportunity then, to seek the truth regarding past findings with respect to various current trends in thinking.

What is of ultimate value, is not a particular research finding or viewpoint, but rather seeking truth and living lives to God's honor, realizing we are not just a physical property, but rather a spiritual being in a relationship with an Almighty God. Such a point of view can bring these scientific viewpoints into perspective. As a Christian servant to students, it is the teacher's responsibility to learn and use the strategies from brain-based learning that are valid which can aid in students' learning experiences.

Through the years, elementary school teachers have often struggled whether to do more elaborate activities that are perhaps more fun, but certainly require more time, or to stick with the simpler learning experience, one less exciting, which will cover the material faster. When reading the brain based strategies presented, one realizes that these strategies not only encourage an intrinsic motivation for learning, but they aid children in stimulating brain activity that will help them remember and make connections in the future.

John Bruer is correct, in that not all strategies have a firm brain research basis. Some strategies are a result of assumptions. However, even Bruer does not always disagree with the strategies themselves, he objects to brain-based learning consultants' false claims. He feels that policies are made without enough scientific evidence to support expensive projects. He feels that some consultants are capitalizing financially on the current brain research bandwagon. A case in point would be when teachers burned vanilla incense in the classroom to stimulate brain development or when "the then-governor of Georgia, in the late 1990's, proposed the state give free classical-music cassettes to new mothers to play to their newborns" (Stover, 2001, p.28). These both were misguided efforts typical of the type of policy making that frustrate those who value research.

On the other hand, brain research and brain-based learning consultants have, through effective marketing, brought many new creative classroom teaching strategies to light. This group of researchers and consultants must be given credit for a new wave of interest on the part of classroom teachers to try non-traditional strategies that may trigger better learning. The brain-based learning community has successfully translated scientific research into practical strategies that can be embraced by the classroom teacher.

Some of these strategies may include stimulating the senses to trigger memory. An example would be to use a food typical of a geographic location to help students recall that particular unit of learning. Memorizing facts with the aid of music or movement is sometimes an effective teaching strategy. The writing of a story that includes characters' emotions would be a strategy that would aid in memory.

Of what value are the sciences if the classroom teacher cannot connect them to the issue at hand? Some of these theories about how the brain works may have been around for years, but at least the new brain consultants have been the ones to invite the teacher to jump on the bandwagon and join in discovering what makes learners learn best. As Stover states, "The impact [of brain-based learning] is noticeable: Greater emphasis on early education, literacy, and new instructional techniques . . . have led to higher test scores (Stover, 2001, p. 29).

One still must be cautious and prudent when interpreting research. A wise policy is to look for both the basic neuroscience research and match it with data from applied psychology or cognitive science.

Critics who worry about where the research comes from are missing the point. Educators need to combine the findings of brain research with those of other fields to diversify and strengthen the applications to the classroom. Neuroscience is not the only source of research; it is an important part of a larger picture. When we combine the findings in "neuroscience with those in sociology, chemistry, anthropology, environmental studies, psychiatry, psychology, education, and therapy, we get powerful applications" (Jensen, 2000, p.77). The varying perspectives from these sciences must come together, break down the walls of controversy and join in an effort to move forward our understandings of basic neuroscience and relevance for the classroom.

Teachers are obligated, through study and experience, to use many of the strategies presented, and then discern which are most effective in the classroom. Brain based research has established validity for some of the less traditional activities that are done. This may include writing spelling words in colorful chalk on the sidewalk, creating a poster rather than completing a paper-pencil worksheet, or creating a play about historical figures rather than writing a report. What has been learned about how the brain works has justified strategies that a few years ago were considered good ideas but without any scientific basis. It is true that the strategies that are effective one year may not work the next, but a teacher would be foolish to completely ignore this growing body of knowledge. Because learners are unique, teaching takes many shapes, sizes, formats and packages to be successful.

The point here is that all share the same mission. No matter what field of science is preferred, all want to make positive, significant contributions to learners everywhere. As Jeeves (1994) writes,

> For those who feel that there is something very special about Man, it is understandable that they view with concern, verging on antagonism, the attempt to dissect him, his mind and his behaviour, from a scientific point of view. At the same time, many who work in the field hope that their efforts can open up for Man new vistas of life, health and achievement, if their findings are properly used. (p. 101)

Scientists and educators alike need to bring down the walls of separation that exist. Uniting in harmony and respect they must forge forward into new vistas of discovery that will enable all children to learn and perform to their God-given potential.

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