The Brain : What Teachers Need to Know

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"The Brain: What Teachers Need to Know"

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Each day thousands of educators enter the classroom to teach students from two years old to eighty years old. But what do these teachers know of the "machines" that they so diligently try to work with? I speak now of our students' brains, for the brain is the "machine" of knowledge. The brain is meant to learn. That is its job. Our job as teachers is to help it. Mechanics study to learn everything they can about the cars they work on. Computer technicians are expected to know the intricate workings of a computer. Investors need to know not only the mechanics of trading stocks, but also the trends and theories of a global economy. As educators, we need to know the brain, for it is in understanding how the brain works that we will best be able to help our students acquire the knowledge that they seek, whether that be learning a second language, as is the focus of this paper, or approaching any other topic in life.

Neuroscience is a relatively new science and our assumptions and findings change on a regular basis. This does not mean, however, that educators should sit back and wait for perfect understanding of the brain to be reached before striving to apply the principles of "brain-based teaching." Sylwester compares brain-based teaching to buying a computer. He says that the computer revolution is just that -- a revolution. New technologies, new ideas and new machines are being developed daily. Does this mean that one should sit back and wait for the perfect computer to be developed before learning about computers and using them in daily life? The idea seems absurd. So, although we don't know all there is to know about the brain -- in fact, far from it -- we do know enough to have a profound impact on the way we think about education. It is my purpose to present readers with a summary of important aspects of brain-based research and to show how that research can be applied to daily language teaching.

What many teachers will find as they read, in fact, is simply a scientific justification for practices that already occupy a significant part of their daily classroom routine, but could only be explained to questioning administration and legislative funding committees as "It just works, that's all I know," or "It just feels right." The opportunity to justify one's methods and theories through tangible scientific discoveries could be invaluable, especially for those methods that are often seen as "new age" or "non-traditional." Most teachers will also find suggestions from neuroscience that will change their day-to-day practice, whether with minute alterations or substantial changes. Ultimately, brain-based teaching serves to benefit us all -- teachers, students, parents and administrators.

Brain Basics

Each human brain weighs about three pounds. It is close in size to a grapefruit and made mainly of water. What most of us picture when we think of a brain are the intense "folds" that surround its outer surface. These folds are called the cerebral cortex. The cortex is about as thick as an orange peel. If we were to flatten it out, it would be about the size of a single page of a newspaper (Jensen, 1998). The cortex is connected to other areas of the brain with millions and millions of nerve cells and its extreme variability is what some scientists assert to be responsible for making us "human" -- great flexibility in the way we learn.

Scientists divide the brain into four major areas called "lobes," which are each primarily responsible for certain functions. For example, one lobe helps us with acts of judgement such as goal-setting, future planning and problem solving. Another lobe is in charge of hearing, some forms of memory, and most functions of language, and yet another lobe is in control of vision. Another area of the brain helps us to process complex sensory and language functions (Jensen, 2000). Within each of these lobes are smaller areas of the brain that scientists have also isolated and named. The area in the middle of the brain is often referred to as the limbic system. This is our emotional system and it contains an area called the "amygdala," which both creates emotions and uses those emotions to process new input (Jensen, 1998).

Other parts of the brain are the cerebrum, cerebellum, and brain stem. The cerebrum is the biggest area of our brain and is comprised of what is known in pop culture as the "right brain" and "left brain," a dichotomy that is not as clearly defined as most of us would like to believe. The cerebellum, often called our "little brain" maintains all kinds of body functions as well as storing certain types of memories. The cerebellum is attached to the brain stem, often called the reptilian brain because it resembles the fully developed brain of a reptile. As you might guess, this is the oldest part of our brain and seems to contain a more "instinctual" level of functioning. It is what we might call our survival-driven area of the brain (Ornstein & Thompson, 1984).

The concepts presented thus far comprise a simplified model of the brain to be sure, but understanding just these simple concepts will facilitate important teaching changes that we will explore throughout this paper.

The Modular Brain

As we have seen, the brain is divided into many different areas that perform many different functions. It is known, for example, that there is no one "language processing area" as Chomsky assumed with his famous "language acquisition device." Instead, for one word such as "love" there are many different parts of our brain working to understand "love." There is the phonetic area that knows the sounds of each letter "l-o-v-e," an area that recognizes "love" as a verb and an area that recognizes "love" as a noun. One area stores a functional definition of "love" and another area stores an emotional memory (probably several) of what "love" means to that individual. There will be a visual representation of "love" and so on (Restak, 1994).

What we know about each of these areas of the brain is that a healthy brain is a parallel processing brain. This means that when our brain is performing optimally, we access these different "knowledges" of "love" at roughly the same time, so that without ever considering it (and without any concerted effort in our native language) we pull many of these "knowledges" of love together when needed. Robert Ornstein puts it this way, "In fact, we have lots of minds and they are specialized to handle different chores... But the multimind does not postulate that we are completely out of control, only that we do not know often enough what is in our mind or, rather, which portion of the mind is operating at any one time" (2003, p. 22).

Physiologically, we can see this happening through a technology called Positron Emission Tomography (PET). PET scans show us the amount of activity occurring in different areas of the brain depending on the task at hand. PET actually tracks the amount of glucose, a primary form of energy, that the brain is consuming. By showing us which areas are consuming more glucose, PET helps us track the many areas that are working when we perform a certain task, such as processing a word like "love."

As you might imagine, the brain consumes enormous amounts of energy in order to perform these processes. Although the brain only accounts for about two percent of one's body weight, it uses twenty percent of one's body's energy (Jensen, 1998). What is happening that takes so much energy? A lot! Although this paper will focus solely on cognitive processes in the brain, we should remember that the brain also controls everything else our bodies do -- mobility, organ function, breath, posture and on and on.

The cognitive functions alone, however, are amazingly complex and active. The human brain is composed of cells called neurons. Each cell is made up of a cell body, dendrites and an axon. These are the things that actually process all of the information the brain receives -- literally thousands of messages per second. Think of your fingers as dendrites; they feel out and process any new information you encounter. Attached to your fingers is your hand, a compact little body like the cell body where any information your fingers just gathered can "pool." Next is your arm, which is like an axon. Axons take the information from the cell body and, if it is important enough, pass it on to other cells whose dendrites take the information, transfer it to the body, send it down the axon and so on (Sylwester).

This process is how we learn -- by making connections between neurons. The more important the information, the more connections will be made. Not only does the number of connections increase with importance, but the rate of transmission also increases. This increased speed is made possible by a fatty substance called "myelin." As neurons are used more frequently, the axon is coated with myelin which speeds the connection with other neurons (Jensen, 1998). Therefore, there is now scientific proof for the "use it or lose it" adage.

The process of myelination also has consequences when we think about the way in which information is stored in the brain. As old connections strengthen and new axons reach to form new connections, the brain actually grows and reshapes itself. This is what neuroscientists refer to as brain plasticity. The brain is constantly evolving. Getting "smarter" simply means forming new connections and using those connections until they are quick and easy (myelinated). Think of knowledge as a map of neurons in your brain. Knowledge you use often takes you down tried and true routes in the brain. Soon you no longer have to strain to follow the map. New knowledge, however, forms a new route in your brain and it may take a while before you can easily travel that route without concentration. Consistent usage of a brain route makes the road smooth and easy to follow. Eventually myelination paves that road, allowing you to travel even faster. Thus, a new route may be bumpy at first, but after several trips, your way becomes easier. Thus, "Modules [of the brain] are not fixed and immutable, but reorganize themselves on the basis of experience" (Restack, 1994).

This, in part, explains why some people are more "intelligent" in some subject areas rather than others. Howard Gardner (1993) asserts that we have "multiple intelligences." What Gardner is actually asserting is that we can be "smart" in many ways. For example, if we are "smart" in sports, the neuron connections in the mobility area of the brain are highly developed. In the same way, a writer has well developed connections in the linguistic area of the brain (as varied and numerous as those are). Similarly, a musician has well developed connections in the auditory, musical and mathematical areas of the brain.

Although controversial, Gardner's theory of multiple intelligences makes sense when we look at research by brain experts like Richard Restack. Through extensive study with brain-damaged patients, Restack (1994) has come to believe that our brain is distinctly modular. In a healthy brain, each module connects with several others in order to guarantee a "normal life." In a brain-damaged patient, however, one or more of these modules may not perform properly. For example, patients with a damaged frontal cortex may function normally in all other areas, but are unable to plan for the future, make complex decisions or set goals. Patients with damage to the Broca's area can understand language, but cannot produce it because the brain damage has "taken away" their oral linguistic intelligence. Based on his research, Restack also draws conclusions about "normal" brains: "In the undamaged brain, one sensory channel may dominate the others. Thus, [we can find] the person who learns better from listening than from reading the same material" (p. 68).

Implications for teaching

The educational implications of modular brain theory are substantial. Perhaps the most obvious is the need to incorporate varied teaching strategies and approaches into our classrooms. Now what teachers have known for years -- that while one student may understand a linguistic explanation, another might need a graphic to grasp the concept -- has been scientifically documented. It is crucial that teachers plan their lessons to involve all the intelligences so that each student has the opportunity to be a successful learner. Traditional classrooms rely heavily on logical and linguistic intelligences. It is not the purpose of this paper to explain the intelligences in depth, but rather to make teachers aware of the need to learn to teach to all of the intelligences, or in other words, to all areas of students' brains.

In 1993 Gardner made the revolutionary claim that there are seven intelligences: musical, bodily-kinesthetic, logical-mathematical, linguistic, spacial, interpersonal and intrapersonal. In 1995 he added an eighth intelligence to his list: naturalistic intelligence. Because we know that different areas of the brain are responsible for different types of functions, Gardner's multiple-intelligence theory makes sense. Use this knowledge to help you reach every student in your classroom. Be creative -- use music or poetry (musical), draw pictures or use graphic organizers (spacial), have your students write in journals (intrapersonal), try group work (interpersonal), create activities that get students out of their seats and moving around the classroom (kinesthetic).

When incorporating a multiple-intelligence approach into the classroom, some of the first questions a teacher may have is, "How do I know which "intelligences" are present in my classroom?" and "Should I give my students a multiple-intelligences evaluation?" My response to the latter is a definite "no." Brain-based research tells us why. Even though we can identify distinct intelligences, we also know that these intelligences are not completely isolated. Due to parallel processing, they aid one another to form a well-rounded, intelligent person. Thus, although it is important to teach to students' strong intelligences, it is also beneficial to develop all the intelligences in every student. By incorporating multiple-intelligence activities into every lesson, you not only allow every student to access the knowledge, but encourage students to use all areas of their brains as well.

Learning to use all areas of the brain can help a student become more successful. For example, a good writer may have a highly developed linguistic intelligence, but when she writes poetry she relies heavily on both her musical and linguistic intelligences. One might also use different intelligences for learning different tasks. One student may feel extremely comfortable using his logical-mathematical intelligence to understand the rule for forming plurals in English, but may rely on his spacial intelligence to understand the concept of plurality. This is yet another reason to vary the strategies teachers utilize when presenting and practicing new material in class.

The issue of memory-recall naturally follows any discussion of presenting new material to students. Because we process each piece of information according to the neurological connections that have been formed, it makes sense that the more connections we make, the easier it will be for us to recall that particular information later. This is because there will be more possibilities for retrieval. "Teaching therefore needs to require and invite learners to make connections to what is already organized and stored in the brain" (Caine, Caine, McClintic & Klimek, 2005, p. 5). For example, if a student learns a list of new vocabulary words through only definitions on a page, that information might be stored (or have neurological connections) in only two or three areas of the brain. But if we supply the student with pictures of the vocabulary, we can add visual and spacial connections. Add to that a song that uses the new vocabulary and we now have musical connections. Have the student put the new vocabulary in a meaningful context, perhaps a personal story that carries emotion for him, and we have formed even more connections. Thus, the student will have a wide variety of interconnected areas in the brain to search through the next time he needs to access the new vocabulary word. His brain has rearranged itself; in fact it has actually grown to accommodate the new words. It will be much easier for him to recall and use the vocabulary based on multiple connections than it would have been if he had had only two or three connections to help him recall that word.

In addition to the creation of multiple connections, consistent use of them is important. The more we use the connections, the more myelinated they become. This information enlightens teachers as to the importance of providing ample processing time for students. Plenty of practice activities are crucial. Teachers should repeat and build upon material throughout the course so that students have opportunities to encounter information again and again. Over time, this will give students' brains the chance to use the newly-formed connections often enough to myelinate the axons for easy retrieval.

In sum, modular brain theory tells us that we must be creative teachers. We need to plan activities that involve all of the intelligences. We also need to present material in several different ways so that students can form many neurological connections to "store" the information for easy access later. Finally, we should provide ample practice time in order for mylienation to occur, thereby fixing the knowledge more firmly in students' minds.

Meaning: Emotion, Relevance and Novelty

When does something have meaning? What exactly are emotions and how do they affect students? These are questions that teachers have been struggling with for decades. Scientists have finally begun to unravel these questions and have discovered an instrinic link between meaning and emotion. In fact, emotional importance is the main criteria for determining whether something is meaningful to us or not. Rosenfield asserts that "memory is impossible without emotion of some kind because emotion energizes memory" (as cited in Caine & Caine, 1991, p. 57).

Meaning, then, is very closely linked with the chemical reactions in the body that we call emotions. Interestingly enough, the amygdala and the cortex are closely linked. Remember that the cortex is the area of our brain responsible for what is regarded as "rational" thinking -- decision making, planning, etc. The amygdala is primarily responsible for emotions. Jensen (1998) says, "The amygdala exerts a tremendous influence on our cortex... The design of feedback circuits ensures that the impact of emotions will usually be greater [than the impact from the cortex upon the amygdala]. It [emotional input] becomes the weight to all our thoughts, biases, ideas and arguments" (p. 74).

Emotions are generally considered by researchers to be chemical "mind-body states" (Jensen, 1998). The way that we feel directly impacts the kind of decisions we make. Chemicals like serotonin and noradrenaline have been linked to emotions such as fear, aggression, depression and others. These chemicals move throughout our bodies and our brain via "carriers" called peptides. We all know that we tend to "look at the good side of things" when we are happy and to focus on the bad when we are having a hard day. These are physiological manifestations of the amygdala's influence over the cortex in response to the level of chemicals in our body. Emotions send more signals to our brain and send them more quickly than any other stimulus our bodies may encounter.

So, as you can see, emotions are critical to our brain's "meaning- making" job. But, there are good emotions and bad emotions. Researchers assert that for learners there is good stress and bad stress. Hans Selye distinguishes between the two types by saying:

> We must, however, differentiate within the general concept of stress between the unpleasant or harmful variety, called "distress" (from the Latin "dis" =bad, as in dissonance, disagreement), and "eustress" (from the Greek "eu"=good, as in euphoria) (as cited in Caine & Caine, 1991, p.65).

Good stress can be motivating. It is perhaps better described as "challenge" than as stress. Eustress, or challenge, can cause the brain to release neurotransmitters of pleasure: endorphins and dopamine. This means that we enjoy our work more and get more from it. When we are challenged and in a safe environment, our brain is able to function and to overcome problems. Recent research also shows that dopamine actually leads to the production of yet another neurotransmitter called acetylcholine that "directly stimulates the hippocampus, the major center for new learning" (Ashby as cited in Caine et all, 2005, p. 88). Caine and Caine have coined the term "Relaxed Alertness" to describe this optimal state for learning that is affected and moderated by the fear and pleasure centers in the brain (2005, p. 4). In order to help our students reach this state of "Relaxed Alertness," we should know, as research has shown, that students distinguish between challenge and stress based mainly on whether they feel they are in control or not. If the student sees the task as an obstacle that she can conquer with effort, then eustress and motivation ensue. If the task, however, seems insurmountable or out of her control, distress sets in (Caine & Caine, 1991).

When we are distressed our brain begins to "downshift." When we downshift, the blood in our brain actually rushes to the reptilian brain (instinct) and the amygdala (emotion), robbing the cortex of proper blood flow and therefore inhibiting rational thought. We, in consequence, turn to automatic and instinctual responses such as anger, aggressiveness and fear. Learning is obviously seriously hampered.

Not only is learning at the moment hampered, but because these "emotional chemicals" circulate throughout the body, the negative emotional reaction can last for a prolonged amount of time. The same process holds true for a positive emotional reaction. Thus, if a student has a good learning experience at the beginning of class, it can last throughout the class hour, making that student "primed" for learning the entire class. In contrast, if the student has a negative experience on the first question of a test, we now know that he or she will probably experience prolonged stress and do poorly on the rest of the exam, even if the student has previously done well on similar exams.

Often this prolonged emotional state is perceived by teachers as motivation or the lack thereof. It is true that students report being more motivated when they are challenged. It is also true that we create more neurological connections when something "truly matters" to us -- or in other words when we have some kind of emotional reaction to the subject at hand. It is essential to clarify at this point that researchers often distinguish between "surface knowledge and deep knowledge" (Caine & Caine, 1991). When we speak of meaning in this paper we are referring to deep meaning since that is the stage at which the most neurological connections are made and the stage at which students not only "know how" but "know why."

As we have seen, emotions lead our brain's quest for knowledge. Without an emotional factor, we seem to skim over the information as not important enough for long-term storage in our brain. There are two other qualities, however, that work simultaneously with emotions to tell us whether we should care about the information at hand or not. The first is relevance. In scientific terms, relevance is defined as a topic that has a significant amount of neurological connections already established in the brain. Thus, if I say to my students, "Today we are going to talk about modals," it is unlikely that very many neurons in students' brains will begin to fire or connect. If, however, I say "How many of you think students *should* have to pay for their own school tuition?" the question may provoke strong emotions in some students. In others, it may simply open up the neurological connections of school, parents, money, etc. Although these students may not seem overly emotional about it, they do connect to the subject because it is relevant to their lives. On some level the students must have emotions about the subject, but they may not be the "full-blown" emotions that we normally think of. Thus, it is helpful to think of relevance as another important criterion for forming meaning.

The last area that we should consider in our effort to make information meaningful for students may at first seem to contradict the last category of relevance. Our brains seek novelty. "Wait a minute," you may be thinking. "First we want relevance and then we want totally new or 'novel' things in our classroom -- how can we have both?" The brain tells us that there is a fine line between relevance and novelty. Think back to our discussion of challenge versus distress. The same type of thinking applies to relevance versus novelty -- balance. If something has no relevance then students' schemata will never be activated and their neurons will not begin to fire. On the other hand, if the lesson contains nothing new, students will "turn off" and decide that they don't need to review things they already know about. Novelty is key in keeping students' attention.

Implications for teaching

The tradition in academia of separating feeling from learning must come to an end. Emotion has always been viewed as something "less" than rational thought. We have sought to repress emotion in the classroom rather than capitalize upon it. This can no longer be accepted. "Perhaps the single greatest gift the neurosciences are giving educators is confirmation that emotions and learning cannot be separated" (Caine et all, 2005, p. 85). The proven connection between emotion and meaning forces teachers to think about how to incorporate emotions into a positive environment so that students look past the surface meaning and want to internalize new knowledge.

Emotion can be used in a variety of ways to stimulate deep meaning for students. First, make sure the content you present is relevant. It is difficult to get students emotionally involved with a topic that seems to have no relation to their everyday lives. Remember that according to the scientific definition, something is relevant if it relates to neurological connections already formed in the brain. Instead of teaching a lesson on "Family" with pictures and stories out of a book, start with students' own experiences growing up. Have them write a journal entry or tell a story about an experience they have had that relates to the theme of family. This activates their schemata (or, in brain-based terms, causes their neurological connections about families to begin firing). Importantly, it is also likely that the story will contain an emotional element for the student.

Obviously, brain-based research proves that theme-based teaching is amazingly beneficial. In fact, all of our teaching should be theme-based and chosen appropriately for our students' goals, life circumstances, and personalities so that they can see some personal relevance. We learn languages in order to talk about "things." Give your students content to work with. For example, to return to the example of modals in English grammar, don't just teach modals -- teach modals in the context in which they are used in everyday language. Instead of giving students a random list of modals and sentences to practice with, try teaching modals within a theme of dating and marriage. Students can talk about their worst dating experiences and then give each other advice on what they *should* do next time. This way modals are used extensively in student discourse and students care about the topic.

Next, try using controversial topics in class. Encourage organized debates. Act out plays that portray two sides of an issue. When the two sides are contrasted, emotion about the issue is bound to pop up through discussion. If you really want to talk about issues that create emotions, let your students choose the topics. In addition, theories such as critical pedagogy, which serves to make students more aware of the world around them and how they can change it, engage the learner in conflict and as a result open dialogues ripe with emotion. Use your students' lives as the curriculum. By respecting students' stories, we can find incredible resources for topics our students care about. Listen to them. Use their stories and you will never have to worry about "motivating" your students again. The facts are clear. Students learn more when they care.

Emotions not only need to be used to stimulate student involvement and meaning-making, but we also need to monitor emotions in the classroom so that we can prevent distress. The key here is to remember that students feel distressed when they feel that they have no control. Try giving students an option in the choice of topics, or in the way they approach classwork (group work/individual study). Students who can choose what they work on will often feel challenged rather than stressed. This applies to evaluation as well. Let students tell you what they can handle and what they can't. Adult students are very aware of what their abilities and boundaries are at any given time. Let them tell you where they are and where they want to go. Trust your students' self evaluations.

We also know that in order to avoid distress, we need to make our classrooms safe-havens with no tolerance of abusive or derogatory behavior. Thus, correct student errors in public only when you feel it will not embarrass or intimidate the student. Provide ample group work so that students can work with peers in small numbers, thereby reducing pressure. Laugh! Tell stories and laugh with one another. A teacher who can laugh at him or herself sends students the message that it is OK to make mistakes and therefore challenges rather than distresses them.

In sum, we can use emotions positively in our classroom if we know how. Using relevant and novel information can start us on the right pathways because both are deeply connected with emotions. We can also reduce stress by giving students control over their own learning and showing them that we truly care. It is time to embrace emotion as another tool that the successful teacher can employ.

Conclusion

Today it is important that we teachers learn about the machine we work with -- the brain. The implications of brain-based research on teaching are wide-spread. We can use that knowledge to defend our current practices and to improve our daily teaching.

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