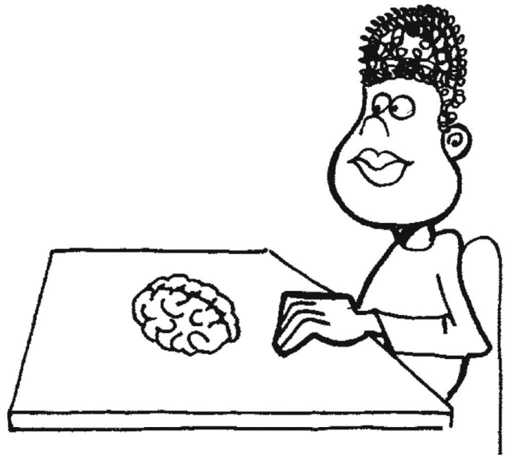


1

Begin With the Brain

Interpreting Neuroscience Research

> *It is often popularly argued that advances in the understanding of brain development and mechanisms of learning have substantial implications for education and the learning sciences. . . . Neuroscience has advanced to the point where it is time to think critically about the form in which research information is made available to educators so that it is interpreted appropriately for practice.*
>
> —Bransford, et al., *How People Learn*

In the early 1980s I heard Dr. Marian Diamond, a neuroscientist from the University of California at Berkeley, give a keynote address at the annual conference for the California Association for the Gifted. After she had amazed the audience of primarily educators with her findings about "enriched environments," brain "plasticity," and the implications for students, she asked the most profound question, to which I still have not discovered a reasonable answer:

> *"If the brain is the organ for learning, then why aren't teachers brain experts?"*

Twenty-five years ago, I suppose we could put our naïve heads in the sand and profess that the latest brain research, including Dr. Diamond's, was most often based on studies done on rats, sea slugs, and primates. The research didn't yet prove anything about human brains. Now, we can't ignore the incredible discoveries of the last three decades about the brain mechanisms that influence learning and memory:

- Advancements in neuroimaging techniques have allowed researchers to get a glimpse of the brain's activity as people perform tasks.
- Neurobiologists are helping us understanding the brain's chemistry and the influences of genetics and the environment—nature *and* nurture.
- Cognitive neuroscience research sheds light on the impact of emotions on learning and socialization.
- Neurophysiology studies demonstrate the importance of movement, exercise, and nutrition.

As the research surfaced during the 1990s, known as the Decade of the Brain, many noteworthy folks stepped up to the plate to help interpret the findings for the education community. Geoffrey and Renate Nummela Caine, Leslie Hart, Robert Sylwester, Eric Jensen, David Sousa, Susan Kovalik, Robin Fogarty, and Kay Burke were some of the first to refer to brain-compatible learning: the purposeful planning of classrooms, climate, and curriculum around what we knew about how the brain works best.

With the advent of neuroimaging devices in the 1970s (such as PET scans), we began a new journey—one that

> took scientists for the first time into the inner sanctum of the human brain *during* the process of learning. . . . Finally, some of what we have known intuitively all along can now be substantiated. Some teaching methods *discourage* quality learning, just as some clearly *encourage* it. (Jensen & Dabney, 2000, p. xi)

In pursuing the answer to Dr. Diamond's important question, I've found out from direct experience that some teachers, while not brain experts in any formal sense, do teach in a way that supports what I will call a *brain-compatible* classroom. In this chapter, I'll begin to show you what they're doing right—usually without even realizing it. We've all run into teachers we admire and want to emulate, teachers who get truly extraordinary results from their students. What I've learned is that these great teachers are, very often, teaching in accordance with some of the most advanced findings on the workings of the human brain.

One of the best original summaries for brain-compatible learning (also referred to as *brain-based* learning) is by Geoffrey and Renate Caine (1994) in their book *Making Connections: Teaching and the Human Brain.* In one of their more recent books, coauthored with Carol McClintic and Karl Klimek (2005), *12 Brain/Mind Principles in Action,* they state that,

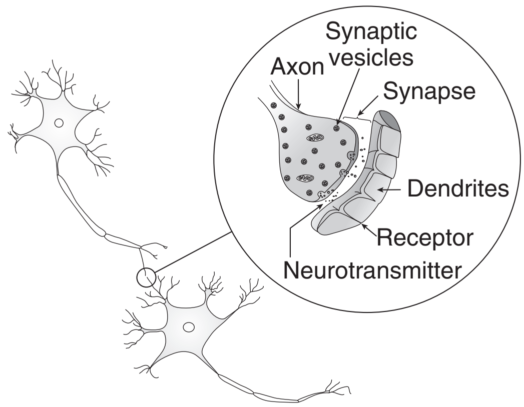
> We argue that on the basis of research and experience that meaningful learning occurs when three elements are intertwined: A state of mind in learners that we call relaxed alertness, the orchestrated immersion of the learner in experiences in which the standards are imbedded, and the active processing of that experience." (p. xiii)

For the last 12 years, I have adapted these three elements, first referred to by the Caines, and developed them into three basic categories of brain research that can influence educational practices. These big ideas about how we can optimize learning based on neuroscience research are what the rest of this

BEGIN WITH THE BRAIN BASICS

Brain Basics

The human brain consists of over 100 billion neurons and about a trillion much smaller glial support cells. The two types of cells split the mass of our brain. Glial cells are not directly involved in information transmission but provide the support and maintenance of the neurons and their trillions of synapses: the points where each connection is made.



Each neuron has a *cell body;* multiple *dendrites* that branch out and grow with stimulation, forming the gray matter; and a single *axon* that typically develops *myelin,* a white fatty insulation, ending with a collection of *synaptic terminals.* Neurons communicate through an intricate network of electrochemical interactions. An electrical charge called the *action potential* is generated within the cell running from the dendrites through the axon to the *synapse,* the point of contact with another neuron. The myelin sheath acts as an insulator and assures that the charge reaches its goal.

The actual communication between neurons is a biochemical interaction. A variety of *neurotransmitters* are stored in vesicles at the base of each axon terminal, and with the arrival of the action potential, they are released to travel across the gap to attach to receptor sites on the other side of the *synaptic cleft* (gap). As the postsynaptic receptors are stimulated, another action potential is generated within that neuron, starting a chain reaction of firing.

Neurons create columns of connections, complex pathways, and form intricate networks and brain systems (see Neuroplasticity, page 13, and Use It or Lose It, pages 14–15). These circuits transport sensory and motor signals to all areas of the body. Specialized regions and lobes are dedicated to movement, sensory input, language, hearing and vision, and so on. The prefrontal lobe, largest in humans, is considered the executive area as it coordinates and integrates the work of all the other regions.

The average adult brain weighs about three pounds. The consistency is like a cube of unrefrigerated butter or cream cheese. It consumes about 20% of the body's energy when at rest. The internal layers of the brain are surrounded by cerebral spinal fluid that acts as a watery cushion.

Research: *The Executive Brain* by Elkonon Goldberg, Oxford Univ. Press, 2001.

Practical Application: *Magic Trees of the Mind* by Marian Diamond & Janet Hopson, Penguin Books, 1998.

Web Site: The Lundbeck Institute: http://www.brainexplorer.org/brain_atlas/Brainatlas_index.shtml book is based on. The strategies included in the following chapters can all be clustered within at least one of these *three key elements.*

Three Key Elements of Brain-Compatible Teaching and Learning

1. Less Stress: Create a Safe and Secure Climate and Environment to Reduce Perceived Threat and Danger

The main task here is to create a climate and environment that are conducive to learning by creating a balance of "low threat" and "high challenge" (the Caines use the term *Relaxed Alertness*).

To create a state of mind that is optimal for meaningful learning, the most important factors are

- Maintaining an atmosphere of trust and respect, where perceived threat is low and balanced with high challenge (i.e., a sense of safety and security that encompasses the mental, emotional, and physical levels);
- Keeping learning joyful and yet rigorous;
- Making sure students know the agenda, purpose, and game plan to reduce anticipatory anxiety;
- Creating a physically healthy and safe environment (sound, light, temperature, basic needs, etc.);
- Orchestrating a socially safe atmosphere where a sense of inclusion is fostered and conflict resolution strategies are demonstrated and utilized;
- Allowing time for reflection, contemplation, and expansion to process new information; and
- Teaching coping strategies for dealing with everyday stress, including stressors from home and outside of school.

If the stress response is activated, it can minimize the brain's capabilities to learn and remember. The best curriculum and instructional strategies will be useless if the student is in the *reflex response.* Later in this chapter, I will explain how this physiological reaction takes place and how to orchestrate strategies to avoid it.

2. Do the Real Thing! Provide Meaningful Multisensory Experiences in an Enriched Environment

According to *Making Connections* (Caine & Caine, 1994), the thrust here is to "take information off the page and the blackboard and bring it to life in the minds of students" (p. 115). The focus is on how students are exposed to content (the Caines refer to this as *Orchestrated Immersion*). A strong emphasis should be on creating themes and real-world connections around which fragmented curriculum topics can be organized. Students must then have opportunities to do their learning through multisensory, complex, real projects. Classrooms must be environments that combine the planning of key experiences for students and, at the same time, with the opportunity for spontaneity. Experiences must be aligned with students' developmental stages and prior knowledge. Multisensory, real-world experiences actually promote brain growth and development. Teachers need to

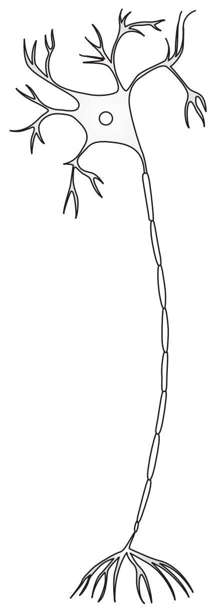
- Pre-assess students' prior experiences and background knowledge;
- Determine if the content and concept is developmentally appropriate;
- Provide complex, interactive, first-hand learning experiences;
- Make sure content is meaningful and relevant (hook concepts to prior knowledge);
- Provide a wide variety of input and resources; and
- Allow adequate time!

Research on brain plasticity is profound. When exposed to stimulation, the neurons in our brains are prompted to grow dendritic branches that reach out and connect with other neurons. Simply put, this neural network that develops is where our thoughts and memories are "stored."

BEGIN WITH THE BRAIN BASICS

Neuro "Plasticity"

When the brain is exposed to multisensory stimulation in an enriched environment, neurons are prompted to grow dendritic branches and form new synaptic connections with other neurons. The "father" of the biology of learning and memory, Eric Kandel, was awarded a Nobel Prize in Medicine in 2000 for his early discoveries about neuroplasticity and memory. He discovered that when people learn something, the wiring in their brain changes. Dr. Marian Diamond's (UC Berkeley) pioneering research proved that environmental enrichment could influence and change the structure of the brain by increasing the cerebral cortex. Her work indicated that being exposed to enriched environments and stimulation could enrich brains at any age.



When babies are born, many neural connections are already in place. By the time children are 10 years old, there will have been a tremendous growth period where some regions of the brain create three times as many connections as they will have later as adults. The brain then goes through a period of intense pruning (arborization). With the onset of puberty, there is another growth surge and subsequent pruning period. While there are basic developmental tendencies and time frames for growth, each brain becomes uniquely wired and shaped. There are some connections that are "experience independent," which means that you are hard wired at birth or have a genetic predisposition (*nature*). Then there is "experience dependent" brain wiring that will occur only when we are exposed to experiences that prompt the new dendritic growth and synaptic connections *(nurture).* No two brains are wired in exactly the same way. Every brain is uniquely formed.

Research: *In Search of Memory* by Eric R. Kandel, W.W. Norton & Co., 2006.

Practical Application: *How the Brain Learns* by David Sousa, Corwin, 2005.

Web Site: The Brain Connection http://www.brainconnection.positscience.com

When we have stimulating experiences that are appropriate for our level of development, our brains can grow rapidly. In classrooms, I call this the "Aha! moment." Marcia Tate's (2003) popular book, *Worksheets Don't Grow Dendrites!*, puts forth the theory that active learning will develop brains and thinking more effectively than a more passive, paper-pencil, worksheet approach.

3. Use It or Lose It! Actively Process New Concepts in a Variety of Ways to Assure Long-Term Retention

In order for students to make sense of an experience, they must have some opportunities to do active processing. "To fully capitalize on experience, there should be 'in the moment,' ongoing consolidation that solidifies and expands knowledge" (Caine, Caine, McClintic, & Klimek, 2005, p. 6). This process can encourage students to develop and express creative insights as it allows them to take charge of their own learning. By reflecting and extending a learning experience, the student strengthens the initial brain connections and builds long-term retention.

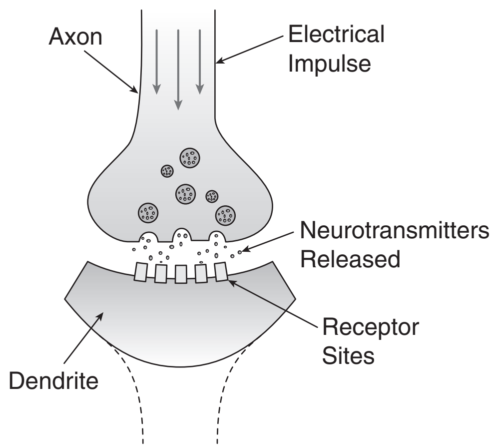
An environment that promotes the Use It or Lose It principle

- Structures frequent opportunities for students to *reflect* on the product and process of their learning. In a brain-compatible learning environment, students are provided opportunities to learn not only about the subject in question but also about themselves as people. Learners need time to contemplate and to get feedback from others as they process the learning experiences in a variety of ways so that they might adequately grasp the implications.
- Provides daily activities that allow students personal *choice* in how they process and store new knowledge. You become automatically *engaged* if you have to make a choice of any kind. In a brain-compatible learning environment, students should have multiple opportunities to discover and process information based on their preferred learning styles. There should be inquiries, activities, and projects that address a variety of critical thinking levels and the students' multiple intelligences. Choice activities should facilitate students' understanding of key concepts and can also be used as authentic assessment tools. Students can be guided to make activity choices that are challenging for them. Providing choice opportunities demands active processing and builds self-esteem and confidence.

BEGIN WITH THE BRAIN BASICS

Use It or Lose It

Multisensory input stimulates neurons to fire, starting a chain reaction within a neural network. Learning enhances and builds the synaptic connections by requiring more activity. With increased activity at the synapse, the greater the attraction, and the electrochemical signals begin to fire more quickly and easily. This developing quick response is called long term potentiation (LTP). The more a neuron is called on to be involved, the chemical and electrical responses grow more likely to fire with less stimulation. Like neuroscientists say, "Neurons that fire together, wire together."



Newly formed synapses are fragile. Learning requires strengthening the affinity between the neurons. The more activity, the stronger the attraction becomes. With more stimulation, glutamate (a neurotransmitter) is produced in the axon and triggers a connection at the synapse. New research has identified proteins called brain-derived neurotrophic factors (BDNF) that build and maintain the cell circuitry and health. Dr. John Ratey (2008) refers to BDNF as the Miracle-Gro® for your neurons. Exercise and improved circulation has been discovered as the best way to elevate the levels of BDNF in one's brain.

During several early developmental stages of brain growth, there is an overproduction of synapses. It is estimated that at age 12, there may be 125% of the synaptic connections that will be present at adulthood. As the brain begins to specialize, it prunes and limits the number of successful synapses that will remain. The arborization process happens naturally throughout life and is part of normal development.

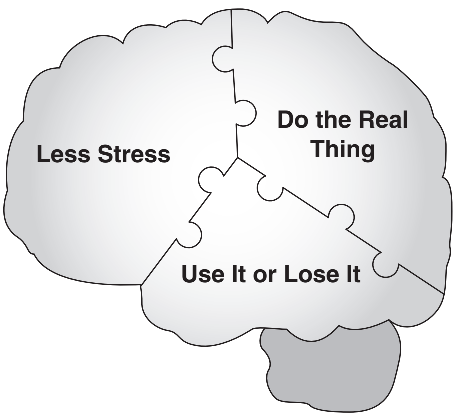
With purposeful stimulation the connections are strengthened and are less likely to experience apoptosis (natural cell "suicide" due to lack of stimulation). Some research on sleep indicates that during REM periods the brain restimulates the important (meaningful) connections and that other periods of sleep may be the necessary downtime for pruning to occur. Studies have shown that the brain actually recycles the underused pruned dendrites and uses the material as building blocks for new dendrite growth.

Research: *SPARK: The Revolutionary New Science of Exercise and the Brain* by John Ratey, MD, Little, Brown, 2008.

Practical Application: *Enriching the Brain* by Eric Jensen, Jossey-Bass, 2006.

Web Site: Bio-Medicine: http://www.bio-medicine.org/Biology-Definition/Synapse

- Orchestrates a variety of *collaboration* opportunities. In a brain-compatible learning environment, students have multiple opportunities to acquire and practice communication and social skills. Working together on projects builds a sense of community and encourages meaningful conversations and reflections. Students begin to have successful experiences in working together toward a common goal. The sharing of knowledge and experiences among students is an essential element of brain-compatible learning.



As a result, brain-compatible learning must involve:

- Designing and orchestrating lifelike, enriching, and appropriate experiences for learning in a safe and secure environment.
- Ensuring that students process in such a way as to increase the extraction of meaning.

I now recognize that in my early days of teaching many of my lessons and strategies were actually quite "brain-antagonistic!" For lack of a better plan or rationale, I had students seated in rows of desks, forbidden to speak to each other, as I asked them to memorize pages of facts that were more about the "long ago and far away" than the "here and now" of their worlds. I depended on the textbook to make connections and trudged through it all in an effort to "cover the curriculum." My first glimpse of students in a natural learning mode was when I took my sixth graders to a weeklong outdoor education camp. There, my students were exposed to real-world experiences in a safe and secure enriched environment that brought out the joy of learning! I was challenged! How could I bring this engagement and excitement back to a classroom environment? I knew there had to be a way!

For many educators, brain-compatible learning means a major paradigm shift in their teaching methods and styles. They need to go beyond providing information and requiring the memorization of isolated facts and skills. In a brain-compatible learning environment, educators must orchestrate the experiences for the students so they can extract understanding and meaningfulness for themselves. The most important aspect for educators to consider is that the brain is constantly searching for how things make sense, based on what the learner already knows and values. The brain is always looking to detect patterns and relationships and, in essence, seeking order out of chaos. Meaningfulness and building on students' prior experiences should become central issues for teachers as they rethink how learning takes place.

> Knowledge about the brain alone cannot provide a blueprint for how to educate. Information about brain development can assist only in educational design, which is no less a creative act than is the design of a bridge or a new factory. (Posner & Rothbart, 2007, p. 3)

From Fear to Flow: Maximizing the Brain's Capabilities

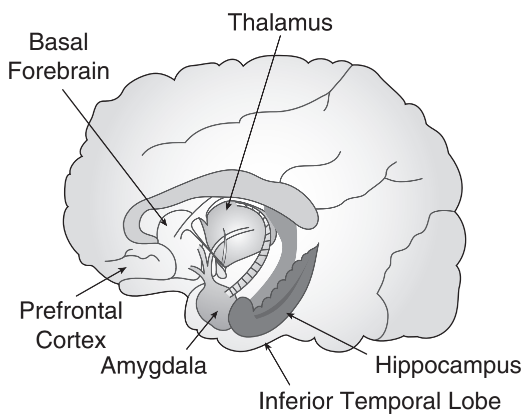
The most recent brain research confirms that encountering perceived threat and stress in the environment inhibits the brain and minimizes its capabilities. If the brain must deal with frustration, fear, or confusion, its performance is inhibited, which results in students' feeling helpless. Conversely, appropriate challenges and some degree of pressure enhance the brain's potential. Each individual is unique and will respond to challenge or threat in a unique way, but generally, humans are able to engage in optimal experiences in environments where there is a balance between challenge and low threat.

The classroom climate and environment must be designed with learning in mind. A classroom that is physically uncomfortable or maintains a threatening atmosphere or tone will minimize students' brains' abilities to function at their highest potential. Understanding some of the latest research about how our brain reacts to stress and fear can help teachers know what *not* to do and begin to know what *to* do.

BEGIN WITH THE BRAIN BASICS

Stress and Learning

When we experience a dangerous or stressful situation, or we *perceive* that we are being threatened, our brain's default system for emergencies kicks into high gear. The amygdala, two almond-shaped structures located in the mid-brain or limbic area, trigger the brain and body to react with the appropriate "fight-flight-freeze" response to a crisis with the release of high levels of stress hormones such as adrenaline and cortisol. When this reflexive automatic action takes over, the executive reflective functions of the brain's prefrontal lobes are temporarily bypassed as we respond to the danger or threat at hand. Once the immediacy of the situation has been taken care of, higher-level thinking strategies can be considered. Thoughtful solutions and a plan of action can be implemented.



Under chronic stress and perceived threat, the flood of adrenaline can begin to cause long-term cardiovascular and other immune-system problems, and high levels of cortisol can eventually damage cells in the hippocampus, affecting learning and memory. Prolonged stress can lead to learned helplessness and eventually chronic depression.

On the other hand, a healthy level of released cortisol energizes our brain for engagement. When we notice something that piques our interest or challenges our abilities, our motivation increases and we focus our attention. Mild stress and pressure can therefore enhance learning and memory. The challenge is finding the "sweet spot," as Daniel Goleman (2006) refers to the peak of "optimal cognitive efficiency," for each individual.

Research: *Synaptic Self* by Joseph LeDoux, Penguin Group, 2002.

Practical Applications: *Social Intelligence* by Daniel Goleman, Bantam Dell, 2006.

Web Resource: The Whalen Lab—Department of Psychology and Brain Sciences at Dartmouth College: http://www.whalenlab.info/Links.html

Identifying Triggers of Defensive Behaviors

The brain responds to fear with defensive behaviors to maximize the possibility of surviving dangerous situations in the most beneficial way. The brain's attentional system is wired to be alert to patterns and signs in the environment that may indicate danger and threat. Not only does the brain respond to dangers that our ancestors experienced, such as quick movements, loud sounds, bright lights, and predators, but each brain also has a unique set of past experiences. These personal memories of traumatic circumstances sometimes intrude into our everyday life. We filter our present situations through such memories, which often biases our interpretation. In our classrooms, we often see students react to situations based on their prior experiences. If we look, act, or speak like an adult with whom a student has had a fearful experience, then he might assume we will mistreat him as did that individual. If a student has had problems with the writing process, she may confuse new writing tasks with prior failures. Of course, the difficulty here is that every human has a unique set of experiences, so a situation that one person might perceive as threatening will not necessarily threaten another.

When the brain perceives threat in the environment, or feels stressed, anxious, or out of control, it sends messages through the nervous system to the body and regulates the various organs to try to match the demands of the situation at hand. This adrenaline surge can occur whether our body faces physical, environmental, or emotional danger, or academic confusion and frustration. An upset stomach, a racing heart, high blood pressure, clammy hands, and a dry mouth are all signs of fear in humans.

Reflexive and Reflective

For more than two decades, this phenomenon was referred to as *downshifting.* This term grew out of Paul MacLean's (see Caine & Caine, 1994, ch. 5, p. 57) triune brain theory and is meant to suggest that when under a perceived threat the human brain gears down to the brain stem to react to the danger at the expense of other areas of the brain. However, more recent neurological research has proved that the triune brain theory is simplistic at best and erroneous at worst. Robert Sylwester (1998), a well-known author, university professor, and synthesizer of brain research, suggests that this metaphor doesn't fully represent how our brain's complex response systems really work. Sylwester proposes that we use the terms *reflexive* and *reflective* to describe the two separate response systems in the brain.

As information from our senses comes into the brain, it does an instantaneous and crude evaluation of the input. It quickly compares what is being perceived in the context of prior memories and experiences that it has on file. Our body responds *reflexively* to the possible alarm, whether it is a physical threat, emotional stress, environmental danger, or academic confusion and frustration. If the sensory input either matches a negative memory or is an unknown and does not compute with any prior experiences, then the brain sounds off the 911 alert. This alert sparks the brain to produce a survival response and triggers an immediate adrenaline reaction. The brain gets the body ready to execute a possible defense: heart rhythms and blood pressure increase, stress hormones are released into the bloodstream, and perspiration begins.

The sensory information about the perceived danger or threat also travels, often simultaneously, to the cortex for a more rational evaluation. When the cortex considers the situation, it might confirm that the situation is threatening, that indeed, there is a reason to react. But if this more thoughtful *reflection* suggests that we have overreacted, the brain may send out a message to counteract the reflexive message. It can turn off the adrenaline push and call off the drill. It releases the appropriate hormones to counteract the adrenal surge.

Shifting From Reaction to Action

The *reaction* phenomenon often narrows our focus to survival only, what I refer to as "going into 911 mode." This fast, stress-driven system activates early-programmed methods of dealing with danger or perceived threats: hitting, screaming, running, crying, hiding, and so on. But as Sylwester (1998) points out, the reflexive behaviors should not be viewed as necessarily negative. We have reflexive behaviors that are positive responses. When we react quickly—reaching to catch the glass as it tips over, slamming on the brakes for the animal in the road, getting pumped up to run a race—we are using primitive responses and programmed behaviors as appropriate responses to the conditions.


Fight or Flight

When facing a perceived threat, our brain sets aside creativity, mental rehearsal, and complex thinking and puts in place predictable, easy-to-implement survival behaviors. Don't think—just do it! When a reflexive response occurs because of exposure to a perceived threat, true danger, or stress, most human brains are less capable of doing any of the following:

- Being creative
- Seeing or hearing environmental clues
- Remembering and accessing prior learning
- Engaging in complex tasks, open-ended thinking, and questioning
- Sorting to filter out unimportant data
- Planning and mentally rehearsing
- Detecting patterns
- Communicating effectively
- Engaging in complex intellectual tasks

I recall that as I used my old computer, I would often run out of accessible memory (RAM). I would get a message on the screen that said I needed to close some applications or windows before I could open new applications. I simply could not do everything at once, and my computer demanded that I use and keep open only the windows that were absolutely necessary. Today's computers have changed the screen messages, but the same basic process still plays out. If you try to do too many things at once with the computer, it may limit or delay your ability to start something new. (Now on my Macintosh computer I might see the spinning "beach ball of death" as the system processes my many demands.) In effect, the same thing often goes on in the brain when it reacts to a perceived threat; other windows and applications will be temporarily closed so that the available RAM can be devoted to the defense reflex.

Common reflex triggers are

- Survival issues, dangerous situations
- Perceived threat and stress
- Old memories of danger or stressful situations
- Unfamiliar circumstances or unknown agenda
- Chaos, confusion, sensory overload

Common physiological responses are

- Surge of stress hormones
- Startle reflex
- Increased blood pressure and rapid, shallow breathing
- Upset stomach, dry mouth
- The neck and shoulders (the hackles) and large muscle groups stimulated

Although these useful automatic reactions are meant for survival, the physiological responses to perceived threats and the necessity of reacting to them over time might also create a sense of lethargy and fatigue. Studies show chronic stress can result in a depressed immune system, which can cause students to get sick more frequently. James E. Zull (2002), in his book *The Art of Changing the Brain*, describes how intense feelings and stress can begin to damage long-term memory. Extreme stress can permanently damage our memory centers, as in cases of PTSD (post-traumatic stress disorder) and childhood abuse.

> Stress damages the hippocampus, leading to a shrinkage of dendrites and ultimately cell death. Not surprisingly, functions that depend on the hippocampus, like explicit or

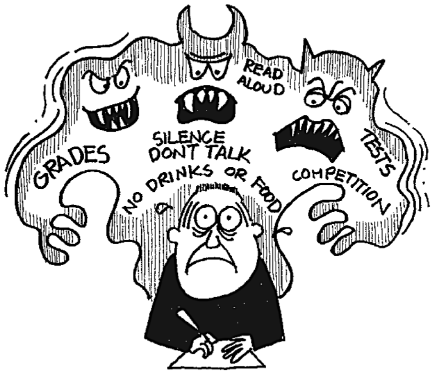
> declarative memory, become severely compromised . . . and make [neurons] less capable of performing their job in the face of stringent demands. (LeDoux, 2002, p. 278)

Even as we defensively react to stress or threat, we size up the situation and create a plan. The brain shifts from reaction to action. As Joseph LeDoux (1996) explains, "In responding first with its most-likely-to-succeed behavior, the brain buys time" (p. 175). An instantaneous survival response such as *fight, flight*, or *freeze* doesn't demand any careful consideration or choices to be made. You simply *react*.

> Eventually you take control. You make a plan and carry it out. This requires that your cognitive resources be directed to the emotional problem. You have to stop thinking about whatever you were thinking about before the danger occurred and start thinking about the danger you are facing (and already responding to automatically). (p. 176)

We quickly review various options and recall previous successes. We predict possible outcomes and prioritize the steps that we want to take. We thoughtfully plan the voluntary action that we want to take to replace the involuntary reaction that saved us initially and bought us some time.

As teachers, we work to reduce the conditions in our students' environments that induce the reflex response. At the same time, we must help students acquire personal strategies to deal with stress. Teaching students strategies that might help them when they are exposed to perceived threat or true danger should be incorporated into daily lessons. I have taught a series of lessons to students called "The Stress Mess." I ask them to reflect on the types of things that might cause them to go into a reflex response when at school. They are encouraged to illustrate these "demons." We then take time to discuss what strategies the teacher might apply to lessen the stress levels of students. We also begin categorizing the coping skills that successful students use to deal with anticipatory anxiety, test pressure, grades, performances, and so on.



The lessons can help students identify what things stress them out at school and home and what to do about it. Students can begin to identify what causes them to feel stressed or threatened and begin to build a repertoire of ways to cope with and manage that stress. Teaching students about stress and providing practice with patterns of responses will help them learn appropriate actions to take when they are stressed. The healthier the coping patterns that students store, the more possibilities from which they can choose. The following chapters will share a variety of strategies to help students:

- Manage time and schedules;
- Build communication techniques;
- Nurture healthy relationships;
- Participate in conflict resolution;
- Solve problems;
- Develop creativity and divergent thinking;
- Make thoughtful decisions and choices;
- Manage anger and emotional upsets;
- Practice self-reflection and relaxation; and
- Enhance health and nutrition.

Fear and Threat at School

What things at school might students perceive as threats, so they respond reflexively, minimizing their capabilities? We know that all students and situations are unique. Some middle and high school students may feel constantly threatened by other students who are gang members. At other campuses, the pressure of grades, awards, competitions, and social standing may cause students to feel stressed. Elementary schools may have bullies, verbally abusive students, and certain kids who dominate others. Even schools with no obvious social problems may have extremely complex schedules and rotations. Many young children may find this kind of atmosphere confusing or even threatening. Students in schools where a variety of languages are spoken in the homes or that have high migrant populations may feel threatened by communication difficulties and possible lack of long-standing relationships. Just being in an environment with hundreds of others may trigger some students to feel threatened.

As a teacher, I have witnessed students reacting defensively in the classroom. Test anxiety is a classic example. It is often marked by a physical reflex response: upset stomach, perspiration, and agitation. The brain is actually trying to react to the threat by keeping the students ready. For some students, the reflex response is so overwhelming that it keeps them from performing well on the exam. This reflex response also happens for many students when they are auditioning for a part in the school play, giving an oral report to the class, or even reading aloud. I have seen students become highly emotional or defensive when they are assigned a new book or moved to the next level in a curriculum program. These students respond reflexively to anything new because they perceive a pattern of failure.

But besides performances or evaluation situations, there are day-to-day events that seem to cause many students to have this reaction. Students may feel threatened by a parent if they don't perform well in school or receive a certain grade. This overwhelming threat may actually cause them to perform worse. Students who have an "over-scheduled" life often exhibit signs of stress.

Students' perceptions of whether or not the classroom is a safe and secure environment can influence their reactions. A long-term relationship with a teacher appears to strengthen feelings of safety and reduce anxiety. Other factors seem to relate to personality. Shy, sensitive children often react defensively to some of the most simple assignments and challenges. Students who are risk takers in general might react positively to stress or threat.

It is not difficult to generate a list of conditions under which your students are likely to respond reflexively. Although several of the circumstances listed below could challenge or pressure certain students to perform well, many students are threatened by these events; consider them carefully:

- Fear of potential physical harm from teachers or other students
- Emotional threats, embarrassment, put-downs, demonstrated disrespect for self, culture, or social group
- Inadequate time to complete a task
- Lack of time for reflection and expansion
- Predetermined correct outcomes established by an external agent
- Unfamiliar work with little support for learning
- Lack of orderliness and coherence
- Physical and social isolation
- Unknown purpose, schedule, or agenda
- Lack of information about a task, behavior expectations, or goals
- Punishments for failure, such as loss of privileges
- Competitions and contests
- Extrinsic rewards
- Perceived irrelevance and lack of personal meaning
- Restricted movement and lack of physical activity

As I noted earlier, using some of these occasionally with some situations may in fact be advantageous, depending on your students and the situation. However, you need to consider every situation carefully. Your relationship with your students will help you make the decision as to when potentially risky techniques might be effective.

Circle of Influence

Attempting to create a low-threat environment at school doesn't even address the needs of those students who arrive already functioning in survival mode. Many children today are living in stressful environments. The economics of day-to-day living and the lack of emotional familial support are signs of our times. We see more and more children brought to school by siblings, just barely making it in time for the free breakfast program, not knowing where one parent lives and unsure about the other's job or income.

Children from more stable homes may also suffer from prolonged stress and anxiety. Over-scheduled children who have enrichment classes, lessons, or athletic practice almost every day can also feel helpless and fearful. The unreasonable demands on their lives may cause them to react reflexively rather than reflectively. Fixing what's going on outside of school may be outside your circle of influence. Some teachers do get involved with home visits and family support, but that is an unrealistic expectation for most of us. What we must focus on is what we *can* do in our classrooms, in our day-to-day contact with children.

Creating Schools as Safe Havens

The thought of rethinking *everything* about our school's campus and programs that would contribute to helping kids feel safe sounds overwhelming, impossible even. But creating an environment that is conducive to learning should be our first task, even before implementing the curriculum. It must be the foundation of everything that we do in schools.

The first key brain-compatible element is called *less stress.* This should describe the *tone* the school environment should have. It should be a place where harmony exists between the learner's brain and body, anxiety level, and curiosity. The climate must be one of low threat and high challenge. Such creative balance is the challenge for educators.

Finding Flow

Our first task is to acknowledge the profound effect that stress and threat have on the brain and body. As educators, we must first envision, and then create, environments that provide a low-threat climate. We must also investigate the elements that will maximize capabilities, promote positive behavior, and encourage students to be reflective. Just as we spend time on removing threatening stimuli, we must also consciously provide opportunities for students to experience joy, success, and satisfaction.

Psychologist and author Mihaly Csikszentmihalyi (1990) proposes an easy-to-understand suggestion in *Flow.* For 30 years, his team studied states of "optimal experience"; that is, times when people report feelings of deep concentration and enjoyment. He uses the term *flow* to describe a state of concentration that is so completely focused it amounts to absolute absorption in an activity. During a flow experience, the mind and body are in complete harmony. Self-consciousness, negative feelings, worries, and anxiety disappear. The activity takes on personal meaning, is intrinsically motivating, and results in total satisfaction.

Athletes reflect such flow when they refer to being "in the zone." Musicians and artists comment on having optimal flow experiences when they are deep in a creative mode or performing. You can apply the flow theory to any situation in which you are having or trying to create a positive enjoyable experience. Flow is the antidote for stress and threat! When one is deeply concentrating on a challenging task, the worries of everyday life are forgotten.

A central condition of flow is the balance between the challenge presented and the skills of the person to meet the challenge. If the experience challenges the student beyond what he feels capable of, he might feel anxious and respond reflexively. Conversely, if a student feels her skills are much greater than the task demands, she may become bored. Students are most likely to experience flow if the challenge is balanced with their self-perceived skills.

Teachers know they have orchestrated conditions for a flow experience when they look at the clock and announce, "Ladies and Gentlemen, we have run out of time today. Please start wrapping up your work and get ready to go . . ." and the response from the students is an immediate, "Ahhhhh, no! Can't we keep working on this? Do we have to stop? When can we do this again?" Isn't that what every teacher longs to hear? When activities in the classroom are learner-centered and students have had some choice and are working at an appropriate level of challenge, students get engaged! In order to provide opportunities to get into flow, teachers must adjust the daily schedule to allow for some chunks of time. Typical timelines in a self-contained classroom are often very predetermined and somewhat fragmented. Literacy blocks and students switching classes (or being pulled out frequently) don't encourage a teacher to plan for uninterrupted project or activity time. I recommend that teachers start requesting at least 90 minutes, two times a week, of "protected time." No interruptions allowed. No students gone to resource programs, and so on. Then, they can use these blocks to orchestrate tasks that encourage flow.

At middle and high schools, the concept of getting learners into flow is a terrific point to make when considering an alternative schedule. There are dozens of possibilities; I make one suggestion: Do the students have an opportunity at least two times a week to get into flow? Are the classes arranged in such a way that a teacher could orchestrate a hands-on lesson or project-based activity and encourage students to get "into it" for at least 90 minutes or more?

Csikszentmihalyi notes that there are eight major components of flow:

1. Flow occurs when we confront tasks we have a chance of completing.
2. We must be able to concentrate on what we are doing.
3. The task has clear goals.
4. The activity provides immediate feedback.
5. Deep but effortless involvement removes from our awareness the worries and frustrations of everyday life.
6. The experience is an enjoyable one that allows us to exercise a sense of control over our actions.
7. The concern for self disappears.
8. During a *flow* experience, the sense of time is altered; hours pass by in what seems like minutes.

Source: Adapted from Csikszentmihalyi, 1990.

Implications for Educators

As we begin to understand the overwhelming effects of stress, coercion, and threat on the human brain, we must look at traditional classroom discipline and management systems. The strategy many use to control a student's behavior must not also be the very thing that sets up another defensive reaction. We must shift our thinking to creating systems that promote optimal experiences. By designing instructional strategies and orchestrating systems that are based on flow theory and common sense, we can create truly brain-compatible learning environments.

In the 1990s, educators began to rethink the structures of schools and the way in which curriculum were designed and implemented. A big influence on the restructuring efforts was the results of brain research that were currently available. We knew that students could learn more if the curriculum was connected to their world outside school. We understood the importance of experiential learning and developmental stages. With greater understanding of the multiple intelligences, we were able to design a wide variety of instructional strategies and new assessment approaches. But even when our curricula are incredibly well designed and integrated thematically, if they are implemented in a brain-antagonistic setting, they are doomed to failure.

Since the enactment of No Child Left Behind (NCLB) in 2002, schools and educators have been in turmoil about the discrepancies between the results that the government is demanding by 2014 to be determined by state-level testing, and the implementation of appropriate, useful teaching strategies. We are in a difficult time. You need only peruse the top 15 articles on What Works Clearinghouse (http://ies.ed.gov/ncee/wwc/) to see that many of the successful models being presented do have various aspects of brain-compatible theory embedded within the programs. Another example worth downloading online is "Reducing Behavior Problems in the Elementary School Classroom" (Institute of Education Science, 2008) (http://ies.ed.gov/ncee/wwc/publications/practiceguides/index.asp#be_pg). But sadly, brain-compatible teaching strategies haven't yet been credited for student success. It is incredibly difficult to document elements of brain-compatible strategies in longitudinal studies. So during this era of testing and Adequate Yearly Progress (AYP), the use of brain-compatible strategies must become part of a good teacher's tackle box of powerful tools, rather than just a suggested teaching model. Only a few schools have been willing to declare that their programs and teaching philosophy are based on brain research.

The strategies and activities outlined in this book can serve teachers, and their students, in important and relevant ways during the NCLB era. Understanding how to orchestrate a brain-compatible, learner-centered classroom will serve you and your students well in the current atmosphere of high-stakes testing. Many terrific teachers have felt coerced to set aside brain-compatible strategies to follow district and state guidelines that favor teaching to the test and often teaching to the middle. When we apply our understanding of how brains learn best in classrooms, students will benefit. Their abilities to learn will be enhanced and they will ultimately do well on tests. Courageous teachers will continue to teach with the brain in mind!

Is it possible to create an environment that has an absence of threat, as Leslie Hart (1998) suggests we shoot for? Given the wide variety of people, there really is no such thing as an absence of threat for everyone. The trick is to create a classroom and school environment in which the majority of students don't feel threatened but do feel greatly challenged. Mild stress and tension can actually promote arousal, and a curious emotional state will trigger engagement. This type of setting allows natural learning to take place. Joyful, rigorous learning should be our first goal. Creating schools that focus on simultaneously engaging the learner's intellect, emotions, creativity, and whole body must be the second goal.

I have developed the ideas I share here over the last 30 years as I have explored brain research and tried to integrate the new understandings into classroom practices. For veteran teachers, some of the ideas may be updated variations on some tried-and-true techniques, as well as an acknowledgment of the good things you are already doing. For newer teachers, suggestions at the end of each chapter give places to begin. While your intention may be to implement many brain-based strategies and learner-centered approaches eventually, your own brain can handle only so much new information before you yourself begin to have a reflexive response! I recommend using my motto: "I have every intention of doing it all, but I have the common sense to know that I can't do it all at once!"

WHERE TO BEGIN

1. I encourage you to expand your understanding of cognitive neuroscience. A terrific book to start off your investigation is: *Brain Rules: 12 Principles for Surviving and Thriving at Work, Home, and School* by John Medina (2008).

2. Whether or not you find time to read the following books from cover to cover, you will find them invaluable resources to your professional library:

Caine, R. N., Caine, G., McClintic, C., & Klimek, K. (2005). *12 brain/mind learning principles in action.* Thousand Oaks, CA: Corwin Press.

Jensen, E. (2005). *Teaching with the brain in mind* (2nd ed.). Alexandria, VA: Association for Supervision and Curriculum Development.

Sousa, D. A. (2005). *How the brain learns* (3rd ed.). Thousand Oaks, CA: Corwin Press.

Zull, J. E. (2002). *The art of changing the brain.* Sterling, VA: Stylus.