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FURTHER READING

THE DANA WEB SITE, **www.dana.org,** offers free resources and publications, accessible information and news about the brain, links to many other brain-related organizations, and special sections for kids and seniors.

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For more brain-related books, CDs, Web sites and other resources for educators and students, visit our Web site at **www.wiredtowinthemovie.com**

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SURVIVING THE TOUR DE FRANCE

EDUCATOR BROCHURE

OPPOSITE: **fMRI images show how the Brain changes from early childhood through late adolescence—5, 10, 15, and 20 year-old brains.** PHOTO: Greg Sorensen and Ellen Grant

This Educator Brochure draws on contemporary brain science to explore three aspects of the brain:

❶ **THE SENSES**

❷ **METACOGNITION**

❸ **EMOTIONS**

In each section, you'll find information about the **Brain Science** behind each topic, related **Educational Theory**, a **Classroom Practice Story**, and a **Tool for Teachers** to help you think about how this topic relates to your students.

Whether your students are in fourth grade or about to graduate high school, their brains, like all our brains, are changing and growing every day.

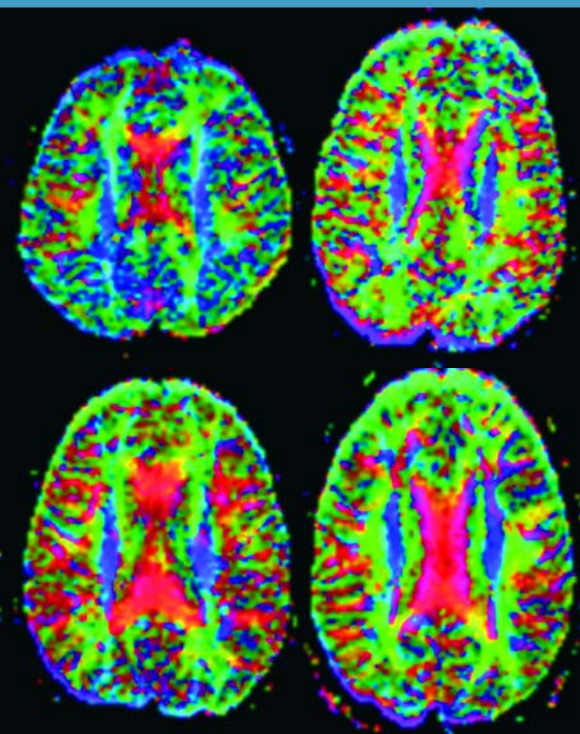
Through innovative technologies, we're learning more about the structure of the brain and how it works. While this information gives us new insight into how the brain functions, we're still a long way from understanding how the brain relates to behavior. Neuroscience doesn't yet connect directly to everyday educational and classroom practice. However, it can shed light on student behavior and learning, and offers guidance for educators.

www.wiredtowinthemovie.com

HOW DO WE KNOW WHAT WE KNOW?

When we engage our various senses, we're using different parts of our brain. How do we know this? One way is through functional Magnetic Resonance Imaging (fMRI) scans (see image below). This technology allows us to see areas of increased blood flow in the brain. Because more blood flows to the busiest parts of the brain, scientists can identify the parts of the brain most active during specific tasks.

To read more about fMRI and other brain scanning technology, visit our Web site at **www.wiredtowinthemovie.com**



In the theory of MULTIPLE INTELLIGENCES developed by the research psychologist Howard Gardner, there are eight main kinds of intelligence:

Bodily/Kinesthetic
Interpersonal
Intrapersonal
Logical/Mathematical
Musical
Naturalist
Verbal/Linguistic
Visual/Spatial

THE SENSES

Our senses are our windows to the world. They are constantly sending messages to our brains, helping us interpret the world around us. A cyclist depends on her senses to make decisions during a race, and she makes her best decisions when she's using a variety of senses. In the same way, a student's ability to learn is enhanced by engaging many senses through an array of learning environments and materials.

BRAIN SCIENCE

ENGAGING MULTIPLE SENSES may do more than help us learn—it may actually help the brain grow. Some studies show that rich learning environments contribute to the development of the **cerebral cortex**, the brain's area for complex thinking.

In these studies, scientists compared rats living in a "rich" environment with those in an" impoverished" environment. The first group lived in a large cage with other rats and several objects to investigate, such as wheels, ladders, and mazes. Those in the second group did not have the opportunity to interact with others or explore new challenges. Scientists found that the first set developed much thicker cortices than those in the second. What accounts for a thicker cortex? The neurons increased in *size*, not in number. The experiment created new and longer dendrites—the "branches" of each neuron that collect information from other neurons.

Of course, it's impossible to analyze humans in the same kind of controlled study. However, studies of human brain tissues seem to confirm this connection between learning and brain development.

EDUCATIONAL THEORY

HOW CAN YOU CREATE a rich learning environment for your students? Consider **the theory of multiple intelligences** as a guide.

The theory suggests that the educator should provide students with an array of opportunities to enable them to learn through various intelligences. Students explore a topic in many different ways, such as by studying music, constructing models, participating in group projects, exploring nature, keeping reflective journals, and taking part in social interaction. Students engage more of their senses than if they were listening to a teacher lecture or performing a pen-and-paper exercise. At the same time, they're overcoming new challenges and engaging socially with others in the learning process.

CLASSROOM PRACTICE STORY

WALTER MCKENZIE SAYS he had always talked a good game. "I had talked about teaching the whole child and teaching to multiple intelligences," he remembers. "It matched what I saw in my students, in any given classroom. It worked with students regardless of ability levels and background."

What advice would you give to teachers who would like to incorporate a Multiple Intelligences approach in their classroom?

“Start with one of the other areas of intelligence that you may not regularly use in your teaching, like maybe ‘visual’ or ‘kinesthetic.’ [See chart.] Identify a few strategies you can use to present the concepts you are studying in a visual or kinesthetic way, in addition to your regular activities. **Start slowly, and build up your repertoire of different approaches over time.**”

Walter McKenzie was a classroom teacher for 14 years. Today he is the Director for Information Services in the Salem, Massachusetts School district.

Walter had an opportunity to test this theory as a fourth-grade teacher in Virginia. One year a new set of stringent state standards was released. Fourth-graders were expected to master the history of Virginia from 1585 to the present, including the state's important historical events, economics, civics, geography, and current events.

While most of his colleagues concentrated on preparing students by teaching to the pen-and-paper tests, Walter, along with one other teacher, used a Multiple Intelligences (M.I.) approach. Walter sums up this approach as "teaching something in a variety of different ways to accommodate a variety of learning styles."

Walter's students read the Virginia history textbook, took assessment quizzes, practiced on sample standardized tests, and discussed test-taking strategies. But he combined this with a creative approach that led to exciting learning opportunities for his students. He rewrote some of the songs to the Broadway musical *1776* to teach about Virginia's role in colonial history. The students learned the songs, took different roles, and performed relevant scenes. The results were inspiring, especially for the students who didn't usually do well in traditional classroom settings. They gained a solid understanding of important themes and events. "So many of these kids . . . never would have gotten the material if I'd sat there and drilled them to death," says McKenzie. "But because we sang it and acted it out . . . they got really into it. The learning was incidental to the fun they were having putting on the musical and acting out the play. But the learning happened."

IN ANOTHER UNIT, students learned Civil War campfire songs, visited battlefields near their school, and even camped out. They marched, sang, learned drum cadences, ate hard-tack, salted ham, and biscuits, and drank black coffee.

Walter's approach succeeded because it tapped into the different learning styles of individual students, engaging their senses in new and different ways. Students moved beyond merely reading and writing—they explored the sights, sounds, smells, and tastes of different periods in history. Our senses and memory are closely connected—a single smell or a sound can recall a vivid memory. Engaging more senses increases the likelihood that we'll remember.

Only two of the five fourth-grade classes in the school passed the standardized tests—Walter's class and that of his colleague who also followed the M.I. approach. Walter describes the success of one low-achieving student who blossomed during the year's projects. Walter previously predicted that the student would score 50 percent but was delighted when he scored in the 99th percentile—outscoring almost every other student in the class.

Walter is convinced that it was the singing, performing, dancing, camping—all the activities that helped them *experience* Virginia history—that most contributed to his students' success. "It is my conviction that those are the kinds of learning experiences that stay with them."

TOOL FOR TEACHERS

How can you recognize, encourage, and develop multiple intelligences in your classroom? This chart describes the characteristics of the different intelligences, along with ways to exercise them.

Type of Intelligence	Characteristics	Ways to Develop Intelligence
Bodily/Kinesthetic	Physical coordination and dexterity, using fine and gross motor skills, and expressing oneself or learning through physical activities.	Playing with blocks and other construction materials, dancing, playing various active sports and games, participating in plays or make-believe, and using various kinds of manipulatives to solve problems or to learn.
Interpersonal	Understanding how to communicate with and understand other people and how to work collaboratively.	Cooperative games, group projects and discussions, multicultural books and materials, and dramatic activities or role-playing. Interviewing key people out of the classroom, setting up exchange interviews with students from other locations via the Internet.
Intrapersonal	Understanding one's inner world of emotions and thoughts, and growing in the ability to control them and work with them consciously.	Participating in independent projects, reading illuminating books, journal-writing, imaginative activities and games, and finding quiet places for reflection.
Logical/Mathematical	Number and computing skills, recognizing patterns and relationships, timeliness and order, and the ability to solve different kinds of problems through logic.	Classifying and sequencing activities, playing number and logic games, and solving various kinds of puzzles. Designing and making electronic puzzles.
Musical	Understanding and expressing oneself through music and rhythmic movements or dance, or composing, playing, or conducting music.	Listening to a variety of recordings, engaging in rhythmic games and activities, and singing, dancing, or playing various instruments.
Naturalist	Understanding the natural world of plants and animals, noticing their characteristics, and categorizing them; it generally involves keen observation and the ability to classify other things as well.	Exploring nature, making collections of objects, studying them, and grouping them. Creating models of sites, both historical and current.
Verbal/Linguistic	Reading, writing, speaking, and conversing in one's own or foreign languages.	Reading interesting books, playing word, board, or card games, listening to recordings, using various kinds of computer technology, and participating in conversation and discussions. Creating own stories and books.
Visual/Spatial	Visual perception of the environment, the ability to create and manipulate mental images, and the orientation of the body in space.	Experiences in the graphic and plastic arts, sharpening observation skills, solving, designing, and constructing mazes in 2 and 3 dimensions and other spatial tasks, and exercises in imagery and active imagination. (Document work using a digital camera.)

Courtesy of New Horizons for Learning, www.newhorizons.org

METACOGNITION

How Do We Know What We Know?

How did Dr. Giedd discover that our brains go through a growth spurt during adolescence? He used MRI technology to scan the brains of children at two-year intervals. By reviewing these scans, he found that the prefrontal cortex begins growing again just before puberty.

Rishay, a student, describes her project to (LEFT TO RIGHT) Yvonne, Leslie, and their colleague Deidre Kilkenny-Stein.

Scientists once thought that the brain stopped developing after the first few years of life. They believed that connections formed between the brain's nerve cells during an early "critical period" and then were fixed in place as we age. If connections between neurons developed only at this time, then only young brains would be "plastic," or able to change. Today we recognize that the brain continues to reorganize itself by forming new neural connections throughout our lives. This phenomenon, called **neuroplasticity**, allows the brain to compensate for injury and adjust its activity in response to new situations or changes in environment.

BRAIN SCIENCE

WHILE OUR BRAINS are changing into adulthood, they are developing faster when we are babies than at any other time in our lives. Not only are new neurons forming, but trillions of new connections between them are forming as well. After an initial growth spurt, there's a "pruning" period in which unused connections wither and die. Recent studies have shown that preteens and teens go through a second growth spurt and pruning period.

In preteens and teens, most of this activity takes place in the **prefrontal cortex**. This part of our brain controls higher-level thinking such as planning, organizing, and moderating mood, and directs our attention to ourselves, our thought processes, and actions. The growth of the prefrontal cortex is an ongoing process with "spurts" at the key developmental stages, when many new connections between neurons are formed. This growth may be supported by **metacognition**, our ability to think about our own thinking. Developing this ability may allow students to be in better control of their own thoughts and behavior.

Neuroscientist Jay Giedd studied the brains of 145 children at two-year intervals. He found that right before puberty, there is a growth spurt in the brain's prefrontal cortex. Then, during the teen years, the brain goes through another pruning process in which weak connections are removed. This process allows the prefrontal cortex to mature, helping teenagers improve how they reason, make decisions, and control their impulses.

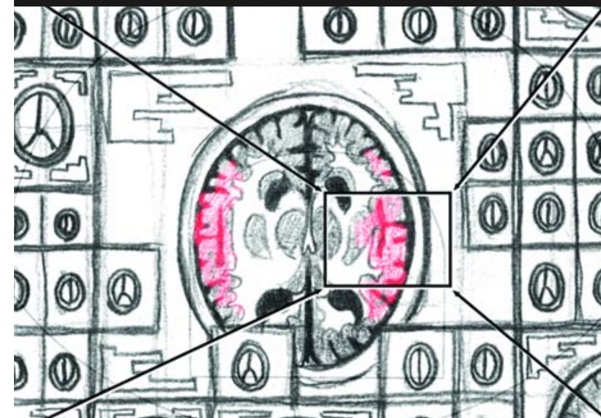
EDUCATIONAL THEORY

AS STUDENTS REACH middle school and high school, their ability for metacognition becomes stronger. Perhaps this is not surprising, since this higher-level thinking takes place in the prefrontal cortex—which is growing and developing in preteens and teens. This is an important time to teach strategies that can help students monitor and take control of their own learning.

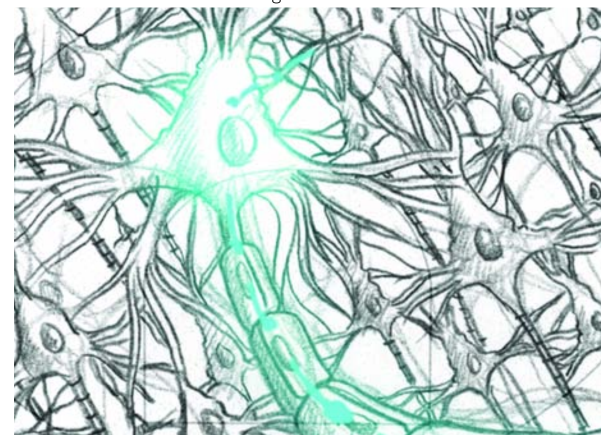
You encourage metacognition every time you have students assess their own work, predict their performance, or reflect on their learning strategies and identify which are successful and which need work. Metacognitive strategies also involve students working together in a constructive and supportive way, such as peer review or reciprocal teaching, in which one student explains or teaches a concept to another.

Many effective metacognitive strategies tend to be specific to certain subject areas. For example, in one strategy for learning Language Arts, students can make an outline or concept map to develop a plan for writing. Then students can judge their progress and their final work against the original plan as they write. In science, inquiry skills are taught to help students understand the connections between the evidence presented in an experiment and the conclusions drawn. The more students are able to talk about their process—such as why and how they followed certain steps—the better they can articulate how they arrived at a conclusion. This is a crucial skill in math and science.

This sequence of sketches for movie graphics shows a signal passing between neurons.

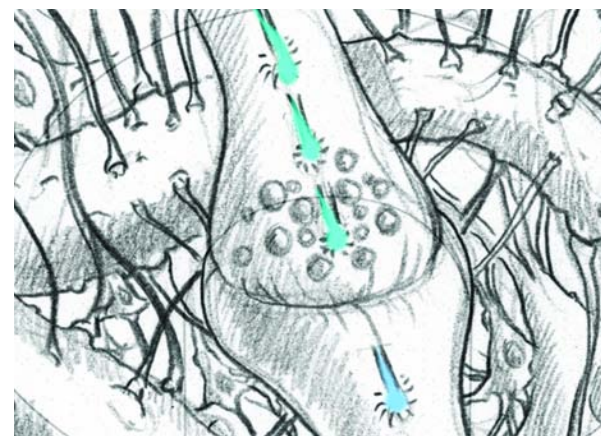


FRAME 1: MRI scan showing activated area of the brain.



FRAME 2: Electrical impulses travel along a neuron.

FRAME 3: The impulse activates chemical neurotransmitters that travel across a space called the synapse.



FRAME 4: Neurotransmitters travel across the synapse, from one neuron into the next.

CLASSROOM PRACTICE STORY

YVONNE SMITH HAS BEEN TEACHING her students metacognitive strategies for over 20 years. She is constantly asking them to think about how and why they think, learn, and make decisions. What's remarkable about Yvonne's students is that they are four and five years old. These students at Central Park East School in East Harlem, New York, are just beginning a program that will encourage them to be reflective thinkers and learners by the time they reach adolescence. When they reach her colleague Leslie Gore's fifth- and sixth-grade classes, they'll have a strong self-awareness of how they learn, their strengths and challenges, and their own unique processes as learners.

While Yvonne and Leslie teach very different ages, theirs is a school-wide philosophy of developing students who are aware of themselves as thinkers, learners, and doers. "We want the kids to be reflective about their own work and all that goes into it, including their thought process," explains Yvonne. "I try to help them think about why they made certain choices in their work, how they went about solving a problem, how they felt while experiencing something new, or how they see themselves as workers and learners throughout the process."

Creating Self-Motivated, Reflective Learners

Students are given "project time," in which they can choose what they'd like to do, study, or make. For example, Yvonne's students choose from many work areas, such as dramatic play, writing, cooking, painting, block areas, clay, and sewing. Both during and after project time, students are asked to talk about their decisions, their process, and the challenges they faced.

These conversations are central to encouraging self-reflective learners. They can take place individually (between a teacher and student), in small groups, or in large groups. Teachers constantly ask students to explain their thinking and their process—from how they came up with an idea to how they solved problems. "How" and "Why" questions are essential to these discussions. [See *Tool for Teachers*, page 8] "There are no right and

Tool for Teachers

How do you encourage students to be aware of how they think, learn, and do? Try asking these questions.

Before a Project

What did you choose this topic or this project?

What do you want to learn about this topic?

How will you go about this project?
What steps could you take?

Who might be a good person to help?

What kinds of resources do you think you'll need?

What do you think will be most challenging for you in this project?

During a Project

What steps did you take to get to this point?

Why did you follow those steps?
[Why did you do it that way?]

What challenges are you having?

How do you think you could solve these problems? [How did you get stuck?
How might you get unstuck?]

Who might be able to help you solve this problem? Is there someone in the class who can help you?

What are your next steps?

After a Project

What worked about the process you used?
What didn't work?

What might work better next time?

What do you plan on doing with your final project?

What was fun about this project?
Which part was hard for you?

What questions do you still have?
How could you go about finding the answers?

What do you notice about [another student's] project?

How is your work connected to something else you're learning about?

wrong ways of thinking," says Yvonne. "I want them to talk about all the ways, and to be very conscious of what they're choosing and why."

In Leslie's class, students are also asked to reflect on their work each day in writing. They record their thoughts as they are working, details to remember for the next day, questions and problems they faced, and how they did—or could—solve them.

Getting students to talk about their own and each other's work can be challenging, especially for younger kids. One way Yvonne sparks discussion is by having her students share their paintings. She'll ask: "What do you notice?" This opens up the discussion in a non-threatening and non-judgmental way. "They are encouraged to begin thinking and noticing and finding language to describe what it is they see," explains Yvonne.

Recognizing Challenges and Solutions

While Yvonne and Leslie nurture and celebrate their students' strengths, they also want them to recognize areas where they need help. In Yvonne's classroom, that might be a student who says: "I need to go sit by myself," or "I need to read more books about this." Leslie might hear a student say: "I multiplied 20 cents by 3 because the three pieces of candy each cost 20 cents. But then I got confused and didn't know what to do next."

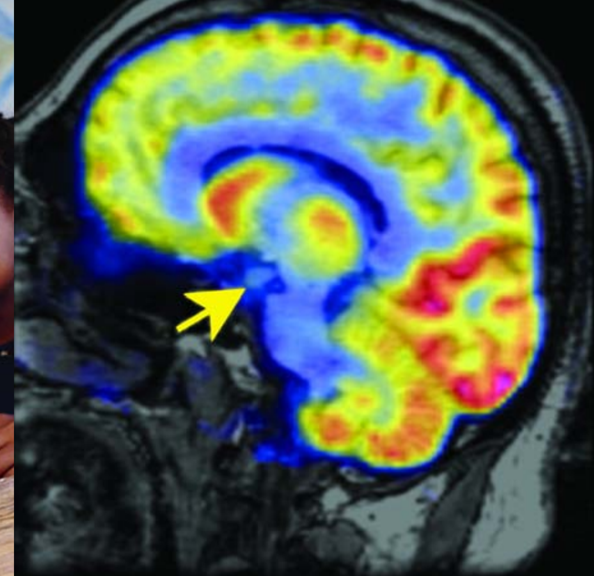
Once students acknowledge that they need help, they're then encouraged to think about how to find solutions. Support may come from their own research, adults, or other students. One student in Yvonne's class was making a space shuttle model, but got stuck trying to show how it was "powering up." After looking through many pictures in library books, he decided to talk to the art teacher. He explained he wanted to show "smoke and fire," and the art teacher helped him sort through various materials. When he saw the colored cellophane, he said, "That's it!"

Why Teach This Way?

Yvonne and Leslie believe that when students understand why and how they learn, or why they follow a certain process, they learn with a greater depth and breadth. These teachers are creating lifelong learners, independent thinkers and problem solvers, students who will become more conscious of how they work and learn.

TEACHERS CAN MODEL AND NURTURE this awareness by being conscious of how they talk with students and how they encourage students to discuss learning with one another. By constantly asking questions, you are modeling the process of metacognition. Questions need to be real—not "test" questions to which you know the answer. You should be curious to hear what the student has to say. This will help students to become the kind of people who think about what they're doing, and why they're doing it.

STUDENTS CAN DEVELOP METACOGNITIVE SKILLS by reflecting on their work. Questions you might use to encourage this practice are listed on the left. These questions can be used individually, or in small and large groups.

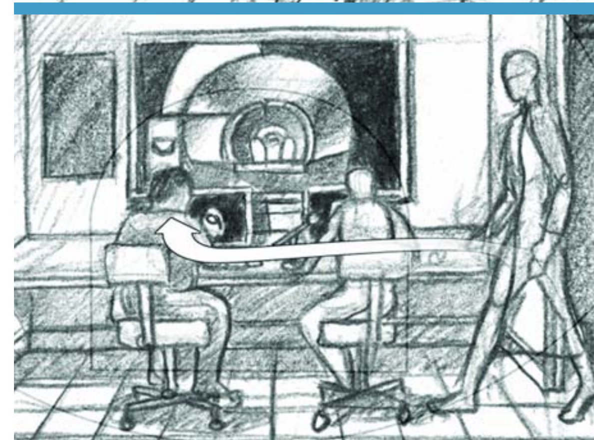


How Do We Know What We Know?

How did Dr. Yurgelun-Todd compare how teen and adult brains read emotions differently? She used fMRI technology to watch which parts of their brains were most active. Her scans show that when teens identify emotions, they rely on the amygdala. For adults, the frontal cortex was most active.

TOP: The amygdala (SEE YELLOW POINTER) is a key area in the processing of emotions.
© Keith A. Johnson, M.D., *The Whole Brain Atlas*

BELOW: Illustrations for the movie computer graphics.
FRAME 1: A cyclist entering the MRI machine on a sliding table.
FRAME 2: Medical professionals examing his brain for evidence of injury.



EMOTIONS

Our emotions play an essential role in our lives. They can work like "alarm systems" for our brain, telling it where to focus attention. Just think of a cyclist who suddenly encounters an obstacle on the road. Her fear draws attention to the obstacle and provides a rush of adrenaline that makes her react quickly to avoid danger. In the classroom, emotions have a big impact on our students' performance and their ability to learn. As teachers, it's important to understand the positive and negative effects that emotions have on learning, and to provide opportunities to help students express, understand, and manage their emotions.

Brain Science

AS TEACHERS KNOW, there is often a "disconnect" while communicating with a teenager. This is supported by current research which shows that one reason may lie in the teen's developing brain. When it comes to identifying emotions, teenagers and adults use different parts of their brains. Teens may interpret the expression of emotion differently from adults.

In a recent study, neuroscientist Deborah Yurgelun-Todd compared how the brains of teenagers and adults responded to a series of pictures showing adult faces expressing various emotions. Both groups were asked to identify the emotion in the picture, while an fMRI was used to map the areas of their brains that were responding.

The results were surprising. The brain scans revealed that the same picture of a facial expression held different meanings for adults and teens. Teens were using a different part of their brains to identify the emotions. They relied mostly on the **amygdala**, a small part of the brain involved in emotions, instincts, and impulsive reactions. On the other hand, adults used the **frontal cortex**, an area used for logical reasoning. This study may help explain some of the challenges of adult-teen communication.

Educational Theory

AS TEACHERS, IT'S IMPORTANT that we understand the different ways in which emotions affect students' ability to learn. Emotions can engage and focus our attention. Imagine what happens when you're teaching and there's a sudden disruption, such as gales of laughter. Perhaps something you said or did was enormously funny to the students. You may not understand their reaction but it's important to acknowledge it. It's difficult for students to quickly "shut off" their emotions and refocus their attention, so rather than ignoring, challenging, or correcting their emotional response, it can help to deal with or discuss the disruption before resuming your teaching.

Tool for Teachers

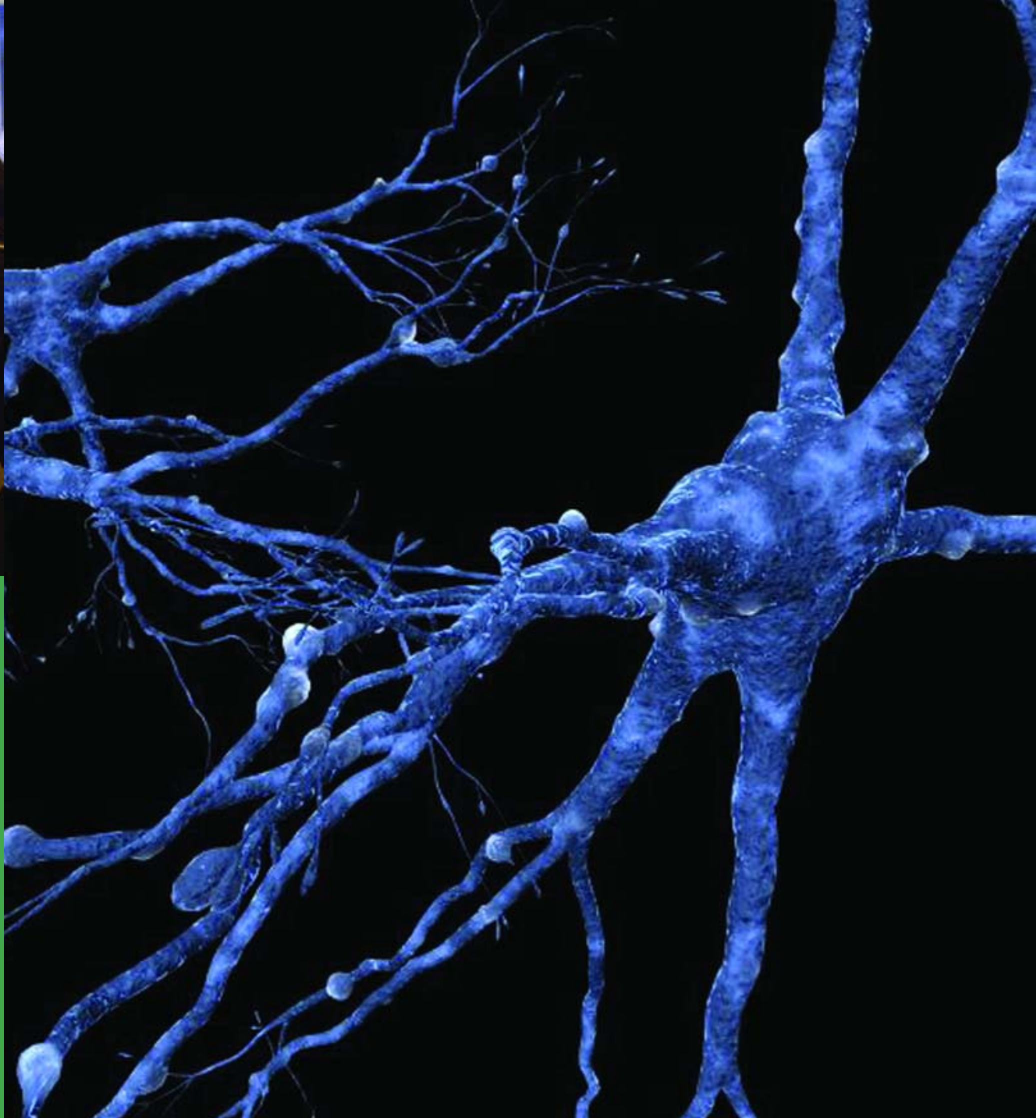
HERE'S A WAY TO FACILITATE CONSTRUCTIVE DISCUSSION when you have a disagreement with a teenage student over a particular topic or issue. Each of you should draw a vertical line down the middle of a sheet of paper. Write your positive feelings and thoughts about the topic and issue in one column and the negative feelings and thoughts about the topic or issue in the other. Be honest and include all of your opinions on the point of disagreement.

When you've both finished your lists, take turns in reading aloud. Start with the positive list and then move on to the negative one.

This method allows each party the opportunity to discover more about the underlying feelings and goals of the other in a way that puts emotional responses in a meaningful context.

Emilio De Torre with kids from Madison Square Boys & Girls Club at an event in summer 2004.

 ABOVE RIGHT: Neurons



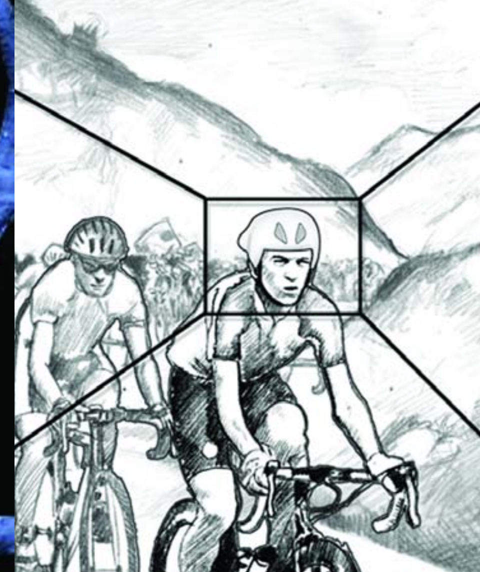
Emotions can have a positive effect on learning. For example, if students are excited by a classroom game, their excitement activates their attention, as well as other cognitive processes, helping them to learn. Positive emotions also build motivation. When students are involved in an assignment or topic, they're more likely to be focused on learning. And students are often motivated by the opportunity to direct their own course of learning.

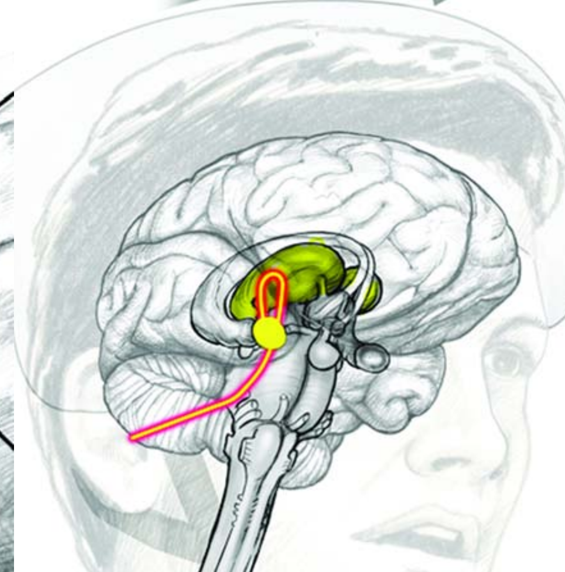
Classroom Practice Story

EVERY DAY, EMILIO DE TORRE is focused on the emotions of the young people around him. A former sixth-grade teacher, Emilio is the Educational Director of Madison Square Boys & Girls Club. This program serves over 5,000 young people in grades K–12 in New York City. At Madison, the *whole child* is nurtured and developed, and great emphasis is placed on young people's emotional needs and the role emotions play in their learning.

Emilio understands that young children can bring a host of deeper emotional issues to the classroom. "You can't ignore their emotional well-being," he says. They may be dealing with their parents' divorce, a sibling's arrest, or drug use in their neighborhood or homes. Many immigrant children are dealing with the loneliness and frustration of adjusting to a new country, a new language, and a new way of life. They may feel self-conscious about the way they look and talk. "A lot of kids are shy about this," says Emilio. "And the shy kids always get overlooked. There's a big span of kids in the middle that are not being nurtured as they could be." He stresses how important it is not to ignore these kids—those that may not be excelling or acting out.

The Belonging, Usefulness, Influence, Competencies (BUIC) philosophy reflects how Madison strives to understand and validate students' emotions, as well as encourage positive emotions. They attempt to have all their programs provide:





ABOVE **Illustrations for movie graphics show the fear pathway.**

FRAME 1: As a response to fear, external stimuli, such as sounds, are processed by the brain.

FRAME 2: Sound travels from the ear to the thalamus, then to the amygdala (indicated in bright yellow).

FRAME 3: The amygdala signals the body to release adrenaline, resulting in expanded lungs, increased heart rate and blood flow, and dilated pupils.

Belonging: Foster a sense of belonging in *all* children, regardless of race, background, and grades. "It doesn't matter if you are failing every subject or making straight As," says Emilio. "It doesn't matter what you look like. You belong in this room and you feel valued."

Usefulness: Help students feel that what they do or say is useful. Madison also wants their programs to offer useful information, whether they focus on children's emotions, academics, or health.

Influence: Help students feel they have a voice and that they have influence on what's going on around them in a positive way. "We want the children to feel that they are influencing the program, what's going on that day, and the other children around them," says Emilio.

Competencies: Help students feel they are becoming competent and learning new skills. "We have a series of outcomes we hope to achieve with every program," explains Emilio. Whether the program focuses on basketball or algebra, Madison wants children to feel they are developing important skills and becoming more competent every day.

How does Madison carry out this philosophy? The central tool is to provide student-directed experiences in which there is no right or wrong dichotomy. The program encourages young people to investigate their own interests, examine new things, and relate them to what they already know. This fosters a deeper emotional connection and a love of learning, without the fear often associated with a classroom setting. Students feel validated and in control of their learning. And finally, giving students the freedom of exploration provides the motivation to learn.

This approach supports the Madison "BUIC" philosophy. Students feel a sense of **belonging** because they don't feel the normal pressure to come up with the right answer or to feel like a failure if they don't know it. They feel **useful** because they're in charge of their own learning and have a clear role to play. They have **influence** because they get to make their own decisions. And finally, by building new skills, they develop **competencies** that will help them succeed in classroom settings, on conventional tests, and in life.