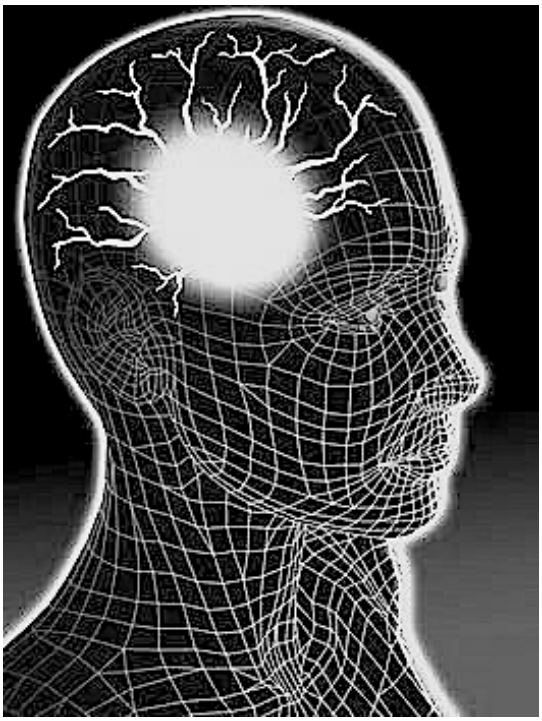
Neuroscience for Optimal Learning:

Strategies for Developing Students' Attention, Emotional Strengths, Memory, and Executive Functions



Learning and the Brain Summer Institute

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How the Brain Pays Attention

Big Ideas from Neuroscience

- The brain functions to promote survival of the animal and the species.
- To do so, the human brain has evolved to seek patterns and pleasure.

RAD Learning and Teaching

The first step in understanding how the brain learns is to explore the three main concepts of *RAD learning and teaching*. Each letter in the acronym RAD stands for both a physical feature of the brain and a corresponding word that represents how that brain feature connects to learning and teaching.

R + A + D

Reticular Activating System + Amygdala + Dopamine

Reach + Attitude + Develop

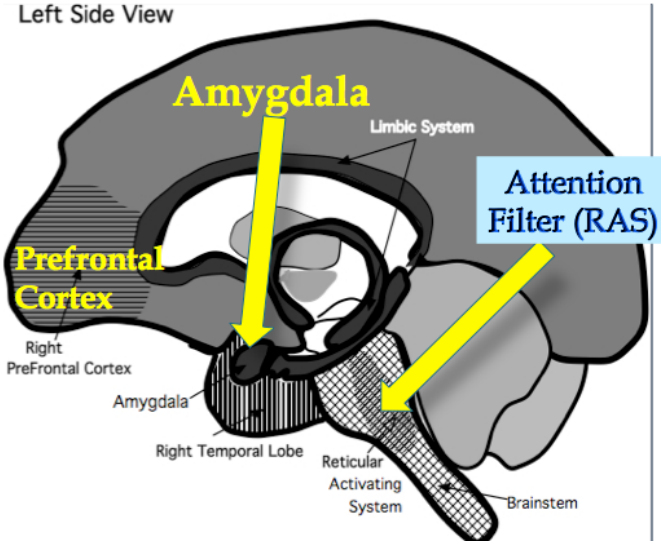
R = REACH students' attention (Reticular Activating System)

A = Cultivate a positive ATTITUDE and reduce stress (Amygdala)

D = DEVELOP memory (Dopamine)

The Reticular Activating System

Information constantly bombards the brain from the body's many sensory receptors. At any given moment, we are experiencing sights, sounds, smells, tastes, and tactile input. It is impossible for us to be consciously aware of all this sensory information. Therefore the brain has a filter—the reticular activating system (RAS)—that selects the sensory information we consciously attend to. Residing in the lower part of the posterior brain, the RAS filters all incoming stimuli and "decides" what people attend to or ignore.



To reach students, make sure the information they need to learn passes through the RAS.

How does the RAS select which information gains access to the conscious brain?

The RAS first prioritizes *novel* stimuli. If there is a *change in the environment*, the related sensory input will likely pass through the RAS. For example, if a fox looks out of his den in the morning and sees an unfamiliar fox walk by, that information will rise above other sensory input—the taste of his food, the sound of birds, the sensation of the breeze on his fur.

Threat receives the highest priority. If the RAS senses that the change in the environment is a source of threat, the related sensory input will pass through the RAS at the expense of other stimuli. For example, if the fox hears the howl of a wolf (a dangerous enemy), the related sensory input (the wolf's howling) will likely take precedence over all other stimuli, including the sight of the unfamiliar fox. Therefore, information (sensory stimuli) will most likely be selected by the RAS if there is no threat in the environment and the stimuli are novel.

How can educators influence what the RAS selects?

- Reduce perceived threat.
- Present information in a novel or curiosity-provoking manner so that the RAS selects the educator's input over all other competing stimuli.

Sustaining Attention and Engagement

What strategies can provoke curiosity and prediction to promote attention and sustain focus?

- Speaking in a different voice (cadence, volume) can catch students by surprise.
- Moving in a different way can be unexpected. For example, a teacher walking backward before a lecture could relate to topics such as flashbacks in literature, "backward" analysis or hindsight about events leading up to discoveries, historical events, or negative numbers.
- Pausing significantly before saying something important builds suspenseful anticipation as the students wonder what you will say or do next.
- Alterations in the classroom, such as a new display on a bulletin board, promote curiosity.

How can the principles of advertising support educators in capturing students' curiosity?

Advertisers hope to gain the attention, curiosity, and interest of their audience. For example, the trailers at a movie theater are usually edited in a way that is dramatic and attention grabbing. They create suspense by providing some indication of what the film is about but leaving out the majority of the details. The viewer, now enticed, wants to see the full-length movie to find out how everything resolves.

To similarly provoke curiosity, educators can advertise upcoming lessons using a variety of high- and low-tech techniques available online at Animoto. This site offers teachers a free Animoto Plus account to create your own "promotional" videos by incorporating attention filter "openers" with images, video clips, music and text. The first such video I made was to ignite curiosity about neuroplasticity, the way the brain constructs memory networks.

Using the links below, you can also see some of the advertisements made by participants in my workshops:

Funky Fractions

Fractions: Yes we can!

(*Note: All links, here and following, were correct as of the date of publication*.)

Allowing students to use your access account to create animotos provides a powerful way to build concept understanding and memory of their new learning by symbolizing it in these videos.

How can predictions be used in the classroom?

After their curiosity has been provoked, students will sustain attention if they are asked to predict what the curiosity-stimulating sight, sound, object, statement, picture, question, etc. has to do with the lesson. It is important that all students make predictions. To make their predictions powerful, students need to "bet" on their predictions. Options include:

- Writing the prediction on an individual white board or "magic pad" or using an electronic student response clicker

- Digital responses systems that allow students to respond to polls or quizzes, whole class poll data display, and reports on student performance

The Dopamine-Reward System: Why Prediction Is So Powerful

Neurotransmitters are chemicals in the brain that transmit signals between neurons (nerve cells). Neurotransmitters allow information to travel from neuron to neuron throughout the brain. Dopamine is usually thought of as a neurotransmitter.

When released in amounts that exceed what is needed for carrying signals across synapses, dopamine travels throughout the brain. The extra dopamine now acts as a neurochemical with more widespread impact. Increased dopamine both increases and is increased by pleasurable experiences and the anticipation of pleasurable experiences. Its release also increases focus, memory, and executive function.

When dopamine levels rise, these behaviors are more prominent:

- Pleasure
- Creativity
- Motivation
- Curiosity
- Persistence and perseverance

These activities increase dopamine levels:

- Positive interactions with peers
- Enjoying music
- Being read to, or told a story or anecdote
- Acting kindly
- Expressing gratitude
- Humor
- Optimism
- Choice
- Movement
- Feeling the intrinsic satisfaction of accurate predictions and challenges achieved

Emphasizing Key Points Throughout a Lesson

The strategies presented earlier can be used at the outset of a lesson to alert students' attention to the fact that something new and important is being introduced. Throughout a lesson, however the teacher is usually presenting information that represents varying degrees of importance. For example, in describing human anatomy a teacher might want students to understand the parts of the digestive system. Some anatomical structures are more important for understanding how the digestive system works than others. How can the teacher alert students to the most important information?

- *Color*
  Use a set of colored markers when writing notes on the board. Green could represent

that a piece of information is important, yellow could represent even more importance, and red could represent the most important "take-home message." The students will also use colored pens or pencils to write their notes. This system also helps students when reviewing information later.

- *Hat*
  During an oral presentation, when notes are not being used, wear a hat and turn its bill in different directions to indicate levels of importance.

Attention Summary

1. Until executive functions, such as inhibitory control, long-term goal-motivated behavior, judgment/prioritizing about which sensory input is important, and the ability to delay immediate gratification mature, attention is largely involuntary.

2. Novelty (pattern change) correlates with attention.

3. Perceived threat gets highest attention priority and must be reduced before attention will alert to other positive pattern changes you provide.

4. Prediction (possibility of reward-pleasure) sustains attention, effort, and memory.

5. Dopamine is the powerful neurotransmitter that holds the key to the intrinsic gratification response that fuels sustained attention and effort.

6. Dopamine release sustains interest and perseverance.

7. Instruction planned with inquiry and discovery can stand alone to captivate and sustain attentive learning.

What to consider when planning a lesson geared toward reaching and sustaining student attention and engagement:

- Will your information get through the students' RAS filters?
- Might the RAS input signal danger?
- What will arouse curiosity?
- How will all students predict the links between the cause of their curiosity and the topics of the lesson? How will they "bet" on their predictions?

Promoting Transfer of Input through the Emotional Filter

Big Ideas from Neuroscience

- The brain functions to promote survival of the animal and the species.
- The brain has a limited supply of the oxygen and nutrients critical to its survival.
- The brain's survival is supported by its programming to resist effort (use of its limited resources) when it does not expect success achieving desired goals.

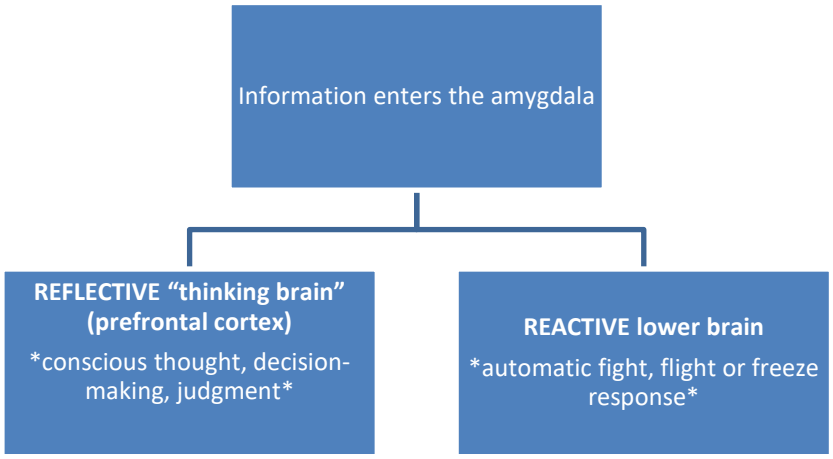
- To motivate the brain to expend its limited resources, a system drives the brain to apply effort when there is expectation of pleasure.

Teachers often ask what they can do about students who act out or zone out in class. They question what to do for students who do not "get it" and for those who already "have it." The next sections address these concerns with information about the amygdala, stress reduction, and achievable challenge.

The Emotional Filter

The *amygdala* is a part of the limbic system found in the temporal lobe of the brain. The amygdala can be thought of as a fork in the road or a switching station on the way to the prefrontal cortex (the reflective "thinking brain"). Linguist and researcher Stephen Krashen has described the amygdala as an "affective filter."

- After information passes through the RAS, it enters the amygdala, which then directs the information to one of two places: the lower reactive brain or the prefrontal cortex.
- In the reactive lower brain, information triggers an automatic fight, flight, or freeze response.
- In the prefrontal cortex, conscious thought, logic, and judgment enter to respond to new information.



What determines if the amygdala directs information to the reflective "thinking brain" or the reactive lower brain?

When a person is in a state of high or sustained stress or fear, new information coming through the sensory intake areas of the brain cannot pass through the amygdala's filter to gain access to the prefrontal cortex. Instead, this incoming information is conducted to the reactive lower brain.

The reactive lower brain has a limited set of behavior outputs: fight, flight, or freeze in animals; acting out or zoning out in students. Be aware of students who act engaged but are actually bored or fearful of failing to achieve highest goals.

Stress

Until the prefrontal cortex matures, students are more reactive than they are reflective, especially when they perceive stress. Stress can reduce the ability of the prefrontal cortex to promote efficient working memory, emotional self-control, and attentive focus.

Stress comes in many forms for students:

- The boredom of already having mastery of the information being taught
- Insufficient interest in a topic
- Lack of awareness of how the topic relates to a student's own interests or prior knowledge
- Frustration resulting from previous failures, being confused, and falling behind (This is equally stressful for both students who get failing grades and those who repeatedly fail to achieve the goals they, or their parents, set, such as being #1 in the class or getting all As.)
- Fear of being wrong if asked to speak in class, answer questions, or present their work orally

Participating in new learning requires students to take risks that are often beyond their comfort zones. Steps should be taken to reduce stress during these times. Reduced stress promotes a relaxed and alert state in which information can pass through the amygdala and on to the prefrontal cortex for long-term memory and executive function processing.

Students can learn how to become aware of their own stress and invoke strategies for relaxing and refocusing, and build skills that allow the prefrontal cortex to override the lower brain's reactive impulses.

Teaching Students About Their Brains

Learning how the brain processes input helps students develop more reflective prefrontal cortex control over their reactive lower brains. By teaching students about their brains, you can guide them to

- monitor and control their emotions;
- reflect before acting on emotions;
- experience control over sensory responsiveness (for example, hearing a sound longer);
- visualize (for example, an imaginary bubble to deflect hurtful actions and words);
- self-calm (by deep breathing or observing themselves from "above")

These articles and websites can help:

How to Teach Students About the Brain

What You Should Know About Your Brain

Animated depiction of neuron network

Neuroscience concepts and activities organized by grade level

Neuroscience for Kids: Activities and Interactive Learning About the Brain

Promoting Growth Mind-Sets

People with fixed mind-sets believe they are born with a certain amount of intelligence and skill, and that is all they will ever have. They believe that once they fail, there is no point in trying again because they have reached their limit.

Those with growth mind-sets believe that people are given a certain amount of intelligence and skill, just as they have a certain body type, but that they have the potential to grow their intelligence and skill with hard work, just like a muscle. (Carol Dweck)

The Video Game Model for Mind-Set, Engagement, and Perseverance

Big Ideas from Neuroscience

- The brain seeks patterns.
- The brain seeks pleasure.

Video and computer games are compelling because they offer *individualized* achievable challenges and frequent feedback of incremental progress that are physiologically rewarded with the intrinsic satisfaction produced by the brain chemical dopamine.

At the outset, players are presented with a goal. They begin at level one and, through trial and error (feedback), build enough skills to ultimately pass level one.

The next level challenges and may exceed players' newly developed skills, but ultimately, through sustained effort, practice, and persistence, they succeed and continue to progress through the levels.

Players receive ongoing feedback and the dopamine-boosting pleasure of incremental goal progress—reaching the next level. They feel the pride of knowing that their effort caused their success (intrinsic reinforcement). They then seek the greater challenge of the next level so they can continue to experience the ongoing pleasure of dopamine reward.

In the classroom, the video game model includes:

- goal buy-in
- individualized achievable challenges
- frequent feedback or awareness of incremental goal progress

Goal Buy-In—Personal Relevance

With goals designed to connect with students' interests and authentic performance tasks they consider relevant, students want the knowledge tools they need to succeed. Students are then

in the ideal state for motivated, attentive learning because they want to know what they have to learn.

Following are several examples of boosting personal goal relevance:

- Show students how what they are about to study relates to their lives or the world around them. Watch a relevant video, such as those relating to math and science found at the Futures Channel site.
- Connect a unit with current events.
- Read aloud something curious that relates to the topic at hand.
- Before a lesson or unit, tell a narrative about the life of the author, scientist, historical figure, or mathematician at about the age of your students.
- Personalize information by connecting the topic to a person or place relevant to students (for example, share an anecdote about a book's author).
- Discuss the "So what?" factor—how the topic connects to the real world or to their lives.
- Relate how they are going to use the new information after you've taught it to them (for example, project, performance task, teach it to younger students).

To assess how well you promote buy-in, ask yourself:

- How will I gather and use knowledge about my students to inspire their interests in new learning?
- How will I relate the value of the learning beyond the classroom?
- Do I use the power of questions and "I wonder…" statements to engage students' attention and thinking?
- Do I pursue learning myself so that I model the endless nature of mastering new concepts and abilities?

Achievable Challenge

An *achievable challenge* is one in which a student has the capacity (or skills to develop the capacity) to meet an ambitious goal. As Goldilocks would say, the challenge is "not too hard, not too easy, but just right!" An achievable challenge exists within psychologist Lev Vygotsky's zone of proximal development.

The idea is to lower the barrier, not the bar. If a challenge is too easy, a student will become bored, which leads to stress, and ultimate disengagement from learning. If a challenge is too difficult, a student will experience frustration and hopelessness, which, if sustained or frequent, also leads to excessive stress. However, when facing an achievable challenge that is just within their reach, students avoid the detrimental states of stress, and the amygdala is able to pass information to and from the prefrontal cortex.

Reducing Boredom and Frustration Through Achievable Challenge

One way of helping students to develop growth mind-sets is to provide them with achievable challenges and alert them to their progress to sustain motivation, perseverance, and effort.

Students are most motivated by the expectation of a dopamine reward when they learn at their individualized levels of achievable challenge. Providing students with achievable challenges reduces the reactive states resulting from the stress of boredom or frustration and promotes the intrinsic motivation of the video game model.

In the video game model, players progress at their personal zones of achievable challenge at all times. Frequent and ongoing assessments would guide the setting and resetting of instruction and skill practice throughout learning with the individual support needed to sustain a student's efforts to overcome setbacks and obstacles.

Although this individualization is not possible for all students, options will increase as technology provides resources for online learning "games," lectures (flipped classroom), and enrichment opportunities for students already at mastery. While some students build basic math facts within their personal zone of achievable challenge with well-designed, interactive online learning programs, their teacher can concurrently guide others on inquiry projects and collaborations.

What can teachers do to enable students to work within their achievable challenge level?

To lower the barriers but not the bar, communicate high expectations for all students and provide differentiation and support so students can achieve their goals. At the start of a unit, clearly define the learning goals, success criteria, and types of assessments. Take time to provide examples of how students' interests will be incorporated into their learning and how their strengths will be included in the assessments.

- Use preassessments.
- Activate prior knowledge.
- Offer flexible groups.
- Use scaffolding and enrichment.
    - Key vocabulary lists with pictures and definitions, vocabulary pantomime
    - Manipulatives for addressing misunderstandings in math
    - Reading comprehension strategies to help all levels of readers read appropriately challenging texts (These strategies are explained in more detail below.)
    - Provide students opportunities to discuss what the read or their ideas (in pairs or small groups) before offering responses to questions. This is especially useful for students with low confidence, those developing mastery of English as a new language, and in foreign language classes when they respond orally in the foreign language.

Reading Comprehension Strategies

Talking Back to the Text

This interactive strategy helps students become personally engaged with what they read. Students begin by writing questions and prompts on post-it notes or other small papers that they can insert into their text.

Before reading, students write and answer prediction questions:

- I think you'll be telling me …
- I already know things about you, so I predict …

During reading, students can complete the following questions or prompts:

- You are similar to what I have learned before, because you remind me of …
- I would have preferred a picture of … (or sketch/download their own)
- I didn't know that and I find it interesting because …
- I disagree because …
- This is not what I expected, which was …
- This gives me an idea for …
- I want to know more about this than you have to offer. I'll find out by …
- I have a different way of interpreting this information, which is …
- I won't let you get away with this statement, so I'll check your source by …
- This could be a clue to help me answer the "big question" because …
- I think this will be on the test because …

Highlighting with Three Colors

Highlighting helps students understand complex texts with the use of a three-color system. They'll need a book they can write in, an online book/article, or if they can't write in it, a copy of the pages they need to read.

If the text is very complex, instruct them to highlight the phrases they understand the first time in one color. They don't need to go back to reread confusing sentences or look anything up; just highlight the phrases they understand—and that may be very little the first time. After that, have them change marker colors and go through the text again, highlighting any newly understood phrases with the second color. Repeat with the third color for the third reading.

The highlighters can be any three colors, as long as you keep track of the order you use them in, such as:

- First reading: yellow
- Second reading: blue
- Third reading: green

The "Think-Aloud" Strategy

At home, students should say out loud what they are thinking while reading, solving a problem, or answering questions. You can model this when reading a text in the classroom. Pause to illustrate to your students what you are thinking as you are reading the text.

Redacted Notes

Create an exemplary outline, or use student notes from previous years that are inclusive with clear designation of prioritized main topics and lesser subtopics.

After making your initial copy, create three different versions of the notes. The first version is complete. For students beginning to build note-taking skills, white out only a small amount of the content. For more advanced students, remove more text. For example, if you have an outline about types of clouds and the scaffolded outline lists three different types of clouds, you might white out one of those types of clouds for the student who is just building note-taking skills.

Flipped Classrooms

The flip in "flipped classrooms" means that students are assigned an instructional video to watch before the teacher presents the topic in class. Students learn through a variety of instructional methods, such as videos created by their classroom teachers, Khan Academy videos, or other online activities suited to their levels. They come to class with a knowledge that they can then apply to classroom activities and projects.

In the classroom, students can then work in flexible small groups with teachers or on collaborative group projects where students' unique strengths are highlighted. Core skills can also be learned at an individualized pace, especially using computer programs that adjust to the needs of the individual student, or through tailored videos that allow teachers to make a greater impact on student learning.

With those adaptations, teachers can

- be creative with less rigidly prescribed whole class instruction;
- demonstrate why subjects are meaningful and exciting;
- provide more mentoring and guiding;
- accumulate insight about where students are so they can teach at skill levels.

Class time becomes available for

- development of concept-level understanding;
- remediation and enrichment;
- inquiry, discussions, and projects.

Online Learning Games for Scaffolding and Enrichment

These resources can be used for skill practice and feedback at the student's individual level of readiness:

- At Edutopia's site, you'll find links to my blogs about online learning games for foundational knowledge and practice.
- Graphite is a free service from Common Sense Media. They list many apps, games, websites, and digital curricula.
  Newsela.com offers an archive of more than 500 articles each at four reading levels, organized by category and reading standard. Students can take quizzes and view their progress.

Ongoing Formative Assessments

Assessments like these can be used to evaluate and promote understanding and mastery:

- Expository writing: Describe the responsibilities and qualities of Supreme Court justices.
- Computer/Technology: Redesign educational websites about the Supreme Court targeting younger students; include duties and qualifications.
- Analytical task: Create a flow chart, web, or other diagram to illustrate and explain the relationships among a justice's duties, term length, and qualifications.
- Creative task: Write a script for a scene involving senators questioning a nominee for the Supreme Court. During this hearing, one senator's questions reveal misconceptions about the duties, term length, and qualifications of a justice. Another senator skillfully questions the nominee to correct the first one's misconceptions.

Awareness of Incremental Progress

In general, we experience an intrinsic reward when we realize that we are making progress due to our practice and effort. Students who are provided opportunities for ongoing formative assessments with feedback, reteaching, opportunities for self-corrections, and metacognition will experience the intrinsic pleasure of incremental progress. With this exposure, they can build understanding and progress at achievable challenge levels of success. Even noticing small changes can be helpful. For example, having students keep a graph of how their reading fluency improves based on how much they practice can be very motivating.

In addition, the recognition from repeated experiences of incremental goal progress awareness in response to their effort builds their recognition of the cause and effect relationship of expending effort towards practice and review as something they can control as they move progressively closer to their goals.

The video game model gives students the opportunity to recognize both the intrinsic pleasure of incremental progress and that the cause-and-effect relationship of expending effort toward practice and review brings them progressively closer to their goals.

Students who feel alienated in school need additional support to regain their confidence and motivation toward reaching a challenging goal. If academic struggles have always been a source of disappointment, help students recall when they have been previously successful in reaching other goals (for example, music, sports, art, making friends, cooking something new).

Exit Slips for Formative Feedback

Before the lesson ends, students can respond briefly in writing to a selected prompt:

- "One thing I learned today is …"
- "One thing that surprised me today was …"
- "Something I'd like to find out more about is …"
- AND: "Something that confused me is …"
- OR: "A question I have is …"

Frequent Feedback: Look for Patterns of Error in Student Work

Students' misconceptions tend to be shared and produce a consistent pattern of errors. Identify these misconceptions from previous years, class discussions, and students' errors on homework and quizzes.

For example, one common misunderstanding without concept understanding (Grant Wiggins) is that multiplication is just repeated addition: "To multiply by 10, add a zero." But what about 23.7 x 10, 0.35 x 10, or 2/3 x 10?

This list of misconception references from AAAS Science Assessment website can be helpful.

Developing Awareness That Effort Increases Goal Progress in the Video Game Model

To help students recognize how their efforts are yielding progress towards their goal you can use strategies such as these:

- Conferences
- Portfolios
- Metacognition/class discussion
- Student-led conferences
- Analytic rubrics with examples of different levels (for example, benchmark examples)
- Effort = Progress to Goal graphs

Analytic Rubrics for Incremental Progress Awareness

Analytic rubrics follow the benefits of the video game model of achievable challenge and incremental progress. Rubrics allow students to

- understand what is expected and how they can achieve steps of incremental progress along the way toward overall goal;
- experience the choice (a dopamine booster) of achievable challenge—where they will focus effort;
- develop metacognitive awareness so they can self-motivate (dopamine from intrinsic gratification).

These websites offer rubric generators:

- TeacherVision
- Teachnology
- Rubistar
- Recipes4Success Rubric Maker

Effort = Progress to Goal Graphs

Have your students use graphs to see the connection between their work, practice, effort, and progress. Goals can range from the time spent preparing for tests or number of answers correct on spelling tests to progressing up rubric levels of proficiency in any subject. Help students build their own goal-directed behavior patterns by selecting the progress points they want to achieve en route to the final goal. They can use small post-its or write in pencil when they believe they

can reach each goal subdivision. As they progress, they examine the accuracy of their projections and revise subsequent goal achievement dates and strategies accordingly. You'll find sample graphs at www.onlinecharttool.com.

Your Challenges and Opportunities Start with One Student

Teaching isn't brain surgery; it's harder. You need the validation of success to keep your dopamine-effort up, so start with your own achievable challenge. Select one student where your efforts to "individualize" will have evident impact. Be alert for improvements: less ambient classroom noise, less tardiness, more participation in discussions, more perceptive questions, less disruptive classroom behavior.

Emotion Summary

1. Emotions influence where new information is processed in the brain. For learning to become memory, it must be directed through the amygdala to the prefrontal cortex.

2. High stress reduces information flow through the amygdala (emotional filter) to and from the prefrontal cortex (the cognitive/reflective brain).

3. During high stress, the survival instinct takes reactive control and responses are directed by the involuntary lower brain with output limited to fight, flight, or freeze responses (acting out/zoning out).

4. The mammalian brain is wired to withhold effort when experience predicts a low probability of success.

5. The human brain can be "rewired" to reverse effort withholding when instruction follows the video game model: buy-in, achievable challenge, and frequent feedback of incremental goal progress.

6. The power behind the video game model's impact on motivation and perseverance is the intrinsic reinforcement of the dopamine-reward response to accurate predictions and feedback of challenges achieved.

7. Goals that are clear, personally relevant, and believed to be achievable are needed to promote brain buy-in and effort when previous efforts have not yielded goal success.

8. In an amygdala-positive learning environment we see evidence of active learning and participating:

- Students observing and noticing with focused attention (without acting out/zoning out)
- Students discovering, thinking, and questioning
- Students who are engaged, motivated, interested, self-sustained learners

To promote a positive attitude so that information gets to the prefrontal cortex

- use curiosity-promoting questions/demonstrations and make learning personalized for buy-in;
- have students work in their zone of achievable challenge;

- teach students how to recognize their progress toward a goal.

What to consider in planning units and instruction in the video game model:

- How will interest and relevance help students buy into their learning?
- What hooks will connect them from the beginning?
- What will sustain their interest in learning and understanding (predictions, audience relevance)?
- How will I sustain awareness of big ideas and revisit them throughout (headlines, mind maps)?
- How will I use formative assessments to gain feedback about students developing understanding and emotional comfort? About my success?
- How will I provide incremental progress feedback for students?

Web Link

KWL Charts at readwritethink
These free downloadable charts track what a student knows (K), wants to know (W), and has learned (L) about a topic, and can be used before, during, and after units of study or research projects.

Memory: Patterning and Neuroplasticity

The process that directs connection of new to existing memory lies in the brain's pattern seeking, extending, and storing system.

Big Ideas from Neuroscience

- To survive successfully, animals need to understand their environments and make meaning of what they see, hear, smell, touch, and taste all around them.
- The brain is designed to perceive and generate patterns and uses these patterns to predict the correct response to new information.
- Through our brain's process of patterning, we are able to make predictions, anticipate what might happen next, and respond appropriately.

For new input to "stick," it must link to a similar pattern:

- If the brain recognizes anything familiar or related to memories already stored in the cortex as new information enters the hippocampus, these existing memory storage networks are activated.
- These related memories are stored in multiple parts of the cerebral cortex depending on which sensory receptors initially responded to the input. For example, the memory of ducks quacking is stored in the area of the cortex related to auditory input. If you were subsequently listening to a lecture about mallard ducks, the new information you were

hearing would enter your hippocampus. Related past memories about ducks (for example, the sound of ducks quacking, the image of ducks you saw in a pond, a fact you once heard about the properties of feathers) would "meet" the new information about mallard ducks in your hippocampus.

- The consolidation of the preexisting related memories and the new information is the process of encoding short-term memory.
- If no prior memory is stimulated and there is nothing to meet the new input in the hippocampus, the new input, with nothing to link to, may likely be lost.
- Short-term memories are temporary and will be converted to long-term memories only if they are mentally manipulated in the prefrontal cortex.
- Once the information has been converted to long-term memory, when someone mentions something about a duck, your network of relational memories will be triggered and available to you.

Patterning Practice

Patterning practice builds literacy, numeracy, and efficiency of working memory. Recognizing patterns also helps students connect concepts. They can build their skills in recognizing patterns across a variety of subject areas:

- *Economics*
  Guide students to recognize patterns in story lines, or recognize trends or patterns in economic markets.
- *Biology*
  Students learning about the sensory pathways in the brain can be taught to recognize the pattern of the pathway of each sense (that is, they all travel from sensory receptors, to cranial nerves, to the thalamus, to higher cortical areas).
- *History*
  Students might pick out a pattern of civil unrest being followed by civil wars.
- *Psychology*
  Students can be assigned to watch a movie and pick out a character's pattern of behavior that is consistent with a diagnosis.
- *Music*
  Students can notice the evolving trends as styles are built upon the previous eras.

Patterning Web Resources

For all ages:

Games for the Brain

Sciencing

Early elementary pattern recognition worksheets:

KidZone

All Kids Network

Pattern recognition computer board games for upper elementary through high school:

Board Game Geek

Engineering Games

Maximizing Successful Memory Links

The brain's ability to recognize related stored memories in response to new information or decision-making is frequently an automatic process. However, if students are not aware of how their prior knowledge connects with new information, they may not activate the memory stores that relate new input.

Prior knowledge is data that students have already acquired through formal teaching, personal experience, or real-world associations. You can make memory relationships more efficient, effective, and transparent by activating this knowledge—that is, alerting students to what they already know that connects to what they are going to learn. This reflects the way the brain makes these connections through pattern recognition and pattern matching.

Use dopamine boosters that reduce stress and increase attentive focus in advance of presenting high cognitive load. Playing music, sharing a joke, or engaging in stretching movements will help working memory processing proceed more successfully.

Prior Knowledge Activation Strategies

- Display bulletin boards that preview upcoming material.
- Relate personal/cultural connections.
- Give pre-unit assessments.
- Show videos or images that remind students of prior knowledge.
- Hold class discussions starting with high-interest current events.
- Remind students about previous exposures (cross-curricular, spiraled curriculum). You'll find examples of cross-curricular topics and web links at Adventures of Cyberbee.
- Have students brainstorm what they already know and what they want to learn about a new unit. This could be done with informal class discussions or with a KWL chart. When they discuss what they learned, they can connect it back to other topics in the class and discuss similarities and differences.

Graphic Organizers

Graphic organizers are consistent with the way the brain stores information in related categories. Retrieval improves when learners know how information is organized; for example, by categories. Thus, visual maps and organizers are most effective when students have input into aspects of their design and organization. Introducing a variety of graphic organizers gradually over the grades and using similarly structured ones from year to year helps students build their comfort and appreciation for these tools.

Samples of graphic organizers can be found at these websites:

Education Place

Enchanted Learning

Neuroplasticity

Neuroplasticity is the process through which thoughts and actions change the brain. Although scientists previously believed that many parts of the brain change only during the critical stages of infancy, research now suggests that all parts of the brain are malleable throughout our lives. Specifically, when a region of the brain is stimulated repeatedly (which happens when we practice and use information), the connections between neurons (nerve cells) in that memory circuit are increased in number and durability. These strengthened connections, if used consistently, become useful long-term memories. Conversely, if a neural pathway is not used, it will be pruned (removed).

Studies That Demonstrate Neuroplastic Responses

In one study, subjects were blindfolded for one week while they received intense tactile-sensory braille instruction and practice. After the study week, the visual occipital cortex showed neural activity in new circuits that had been constructed and were quite similar to those found in people blind from birth (Merabet et al., 2008).

In another study, increased activity and density of dendrites and synapses occurred in the visual occipital cortex when subjects learned how to juggle. These regions continued to increase in metabolic activity and density of interneural connections as juggling skills improved with practice. When participants stopped practicing, the increased activity and thickness in the cortex that had formed gradually disappeared along with their skill (Draganski, B., Gaser, C., Busch, V., & Schuierer, G., 2004).

Learning from Mistakes

The *nucleus accumbens*, a small structure in the brain, constantly releases a small stream of dopamine (the neurotransmitter associated with pleasure) into the area of the prefrontal cortex where memories are formed. When we make a prediction (answer), and discover that our prediction is correct, the nucleus accumbens releases an extra dose of dopamine. While we may not consciously register the surge of pleasure caused by this dopamine boost, our brain does. The brain patterning connected to this correct prediction strengthens to increase the likelihood that the correct prediction, and corresponding surge in dopamine, will occur again.

Conversely, when we make a mistake, the nucleus accumbens diminishes the flow of dopamine. Our brain registers a decrease in dopamine, and it reacts to this displeasure by deactivating the brain patterning that led to the incorrect prediction, the goal being to avoid making the mistake again with its corresponding decrease in dopamine. When all students have opportunities to predict (write or express their answers) and receive immediate corrective feedback, stronger memories are formed.

Opportunities for Mistakes Are Necessary

As the brain develops habits geared toward rapid efficiency and single responses, it grows increasingly dedicated to accepting the first retrieved response to new stimuli or questions as the single existing response. Without broader and more enriching experiences in interpreting data and developing solutions, students will miss information that is not specifically called to their attention.

Provide opportunities for students to increase their comfort with taking more time to draw their own conclusions, adapt what they have learned in new ways, and develop their executive functions such as judgment, estimation, reasoning, and creative innovation.

To promote predictions and decrease the fear of making mistakes

- acknowledge your own mistakes;
- use example/non-example lists (where you write “example” and “non-example” on the board and record student predictions accordingly, so all their examples get placed on the board);
- repeat the correct part of their responses.

Designing Experiences for Memory and Cognition

If you were teaching about the qualities of the brain, you might mention that the brain has the consistency of Jell-O. By alerting students to this fact, you provide them a richer sensory experience of what the brain is like, rather than just showing them a picture of what the brain looks like.

Movement

These strategies involve movement for mental manipulation and multisensory input and may increase dopamine levels:

- *Pantomime* vocabulary words (English, foreign language, content specific).
- *Word gallery*
  Put up numbered posters that have a verbal or pictorial representation of a vocabulary word. Students then take a list of vocabulary words, walk around the room, and record the number of the poster that matches their words. Subsequently they can add their own sentences or drawings to the wall charts. Provide scaffolding by allowing some students to have a one-word definition or work with a partner. The activity can be even more dopamine enriching by playing music that students can enjoy as they move through the activity.
- *Ball-toss review*
  Students toss a ball to one another as each states one thing they remember from a lesson.

- *Snowball fight*
  Each student writes a question on a piece of paper. The students then stand in two lines, crumple their papers, and throw snowballs at the other team. They then select snowballs to answer.
- *Stand and write*
  As a group, students stand and, using their choice of elbow, knee, or ear as if it were a pen, spell out a particular vocabulary word. As they do, they say each letter together.
- *Four corners*
  Mark the corners of the room as A, B, C, or D. Students can answer multiple-choice questions by moving to the corner of the choice they believe to be the correct answer.

Building Durable Neural Networks of Memory

Information we learn needs to be integrated into durable long-term memory circuits of connected neurons to be sustained. This means that the learner has to "do something" with the information so the neural network activates solidly. It is the electrical current flowing through the dynamic network that promotes the neuroplastic changes to sustain the learning as memory. Activities that entail symbolizing, categorizing, summarizing, and transferring promote the building of these memory circuits.

Symbolizing

Symbolizing learning in a new way is "translating" knowledge into another mode. This cannot be done successfully without understanding the information, just as you cannot accurately convey the meaning of a sentence translated from one language to another if you don't understand the second language and only have a bilingual dictionary.

- *Create a narrative.*
  Students can write and share a story, blog, PowerPoint, website, skit, or video about the reading.
    - With iPads: Explain Everything and ShowMe are two apps that allow students to create and share information in a multisensory fashion.
    - Voki is a presentation tool students can use to create a character and enter text for the character to say. The presentations can be published and shared. Voki also includes special options for teachers.

- *Use humor and personalization.*
  These can be used to make even the driest of facts memorable. For example, one of my previous workshop participants told an amusing story about a lonely piece of new information that entered a brain. It felt lost and sad until it found its family among the related memories in the hippocampus. Illustrating the story adds a further level of mental manipulation.
- *Teach the new information to someone else*.
  Understanding something well enough to teach it to another person requires clarity of

thought and understanding that ultimately supports the "teacher's" long-term memory of the concept.

Categorizing

- *Similarities and differences*
  Just as survival depends on recognizing the changes in an animal's expected environment, people also respond to remembering new learning in relation to stored networks of related information. Identifying similarities and differences is an effective way of connecting new information to existing long-term memory.
- *Analogies*
  For example, "Lungs provide mammals with oxygen from the air. Gills of fish provide oxygen extracted from water."
- *Category discovery*
  Before instruction, students predict how to sort things they will study in a unit using commonalities they perceive (for example, shape, type of rock). As understanding builds, students revise categories. They continue to refine their categories as they identify the characteristics that identify "members" of that category (for example, types of graphs, math terms calling for addition, subtraction, division, area, volume, etc., different types of transformations). They then construct the characteristics by which to evaluate and identify other items that belong in the category. Try this sample activity:
    - Sort by possible commonalities.
    - Give the selected categories names.
    - Select characteristics that can be used to identify future "members" of that category.

Summarizing

- *Pair-share or collaborate to summarize*
  Students experience a greater level of understanding of concepts and ideas when they talk, explain, predict, and debate about them within a small group, instead of just passively listening to a lecture or reading a text. Students, depending on age and topic, can listen to directed lecture with focused attention for only 10–20 minutes without some type of break. Having students take a moment to summarize the information and communicate with the student next to them is an excellent dopamine-raising mini-break.
- *Twitter or text-message style writing*
  Students can write out a summary as if they were posting a tweet (limit of 280 characters) or writing a text message. These formats require brevity, and therefore encourage students to condense their thoughts to the main point. Younger children can make "phones" out of decorated cardboard. Tell them that they can call anyone they like but have only one minute remaining on their phone battery so they need to plan

what they will say in advance. (A brief summary can go a long way. Just think about how much meaning can be found in a perfectly crafted haiku!)

Transferring

- *Authentic, problem-oriented situations*
  These foster inquiry, critical thinking, and logical conclusions. They also increase the ability to access and evaluate information. Project-based, integrated learning that incorporates executive functions (such as critical analysis, judgment, reasoning, and prioritizing as students sift through data) promote cross-brain interactivity and global thinking. In these learning situations, students will
    - have opportunities to try multiple approaches;
    - discuss and evaluate verbally in groups;
    - extend pattern networks as new knowledge links to prior knowledge;
    - engage in relevant experiences to give meaning to context specific vocabulary and domain principles;
    - use executive functions to transfer learning to new applications, which builds more awareness of concept links.
- *Essential questions*
  These questions help students identify relationships and connect experiences and interests with real-world problems (McTighe & Wiggins, 2014 Essential Questions, ASCD). For example:
    - "How does the shape and size of a container influence what it can hold?"
    - "Why was slavery the greatest issue of disagreement between the North and South in provoking the Civil War?"
    - "What makes the sea the best home for some creatures and land the best for others?"

Students should be given opportunities to come back to essential questions and reflect on the big ideas they construct during a unit. These opportunities can include discussions, essays, and even stopping several times during a unit to have students write "headlines" or a news article related to the new big ideas they recognize.

Long-Term Memory Summary

1. The brain constantly changes through neuroplasticity (building, strengthening, or pruning of networks of memory).

2. The brain adapts and improves in response to the environment and results of predictions it makes.

3. When mental manipulation (categorizing, graphic organizers, analogies) or application (use) activate newly encoded short-term memory circuits, neuroplasticity establishes them into long-term memory networks. These graphic organizers or categorizations, made by the learners, promote increased strength, durability, and speed of retrieval of their memory circuits.

4. Memory circuits used together to perform novel tasks or solve new problems link into extended circuits of durable concept knowledge available for transfer to novel applications now and in the future.

Web Links

Create an Animoto video online to summarize information from class or readings.

Make Beliefs Comix includes summarizing, storytelling, and plot description activities.

With Tagxedo, students can make word clouds for "big ideas" in text.

Executive Functions: Maximizing Students' Highest Potentials

Educators are the caretakers of students' brains, especially between ages 5 and 18 when the rate of neuroplasticity (maturation and pruning) is greatest in the prefrontal cortex, where executive functions are developing. The brain constantly changes; it adapts and improves in response to the environment and experiences through the process of neuroplasticity.

Negotiating a Globalized and Digital World

Globalization and technology continue to change the knowledge and skills needed by the students who will lead us in the coming decades. Information is increasing at a logarithmic rate, and the speed of media access is simultaneously accelerating. The availability of new information, changing "facts" provided by more sophisticated tools of analysis, and technological innovations multiply. The increased availability of information is unfortunately accompanied by a lack of source accountability. To be ready for college, the workforce, and life in a technological society, students need the skills to gather, comprehend, evaluate, synthesize, and analyze a daunting volume and extensive range of media.

As technology evolves, some jobs can be automated and even replaced by computers. To be competitive in the job market, students need to do what computers cannot: for example, conduct original research, innovate, solve novel problems, communicate clearly (orally and in writing) and collaborate.

In addition to a strong base of core knowledge, well-honed executive functions are essential for success in today's world. They can be thought of as the skills that would make a corporate executive successful:

- Attention focus
- Emotional self-control
- Organization
- Prioritization
- Judgment

- Reasoning (deduction/induction)
- Critical analysis (for example, validity)
- Cognitive flexibility

Executive functions are what students need to

- be self-directed and goal-motivated;
- think critically about information, check the reliability of sources, challenge assumptions, and seek validity and contradictory evidence;
- have the understanding and cognitive flexibility to adapt to new information;
- identify the most meaningful data to use for problem solving and analysis;
- recognize relationships and concepts to use for transfer and creative innovation;
- communicate and collaborate successfully;
- anticipate consequences and outcomes, and plan and revise accordingly;
- think in creative and connective ways. (Predictions are that over 50 percent of today's grade-school children may work in jobs not yet invented.)

Preparation for Future Demands and Opportunities

The rapidly increasing quantity and availability of information, changing facts, more sophisticated tools of analysis, technological innovations, increasing subspecialization as domain knowledge exceeds that capable of mastery by generalists, and greater interdependence among political, economic, social, and technological domains are inevitable. All students need to be prepared for their futures with more than just rote, factual knowledge. They need the sophistication to evaluate, comprehend, and incorporate new input into their concept networks.

To adequately prepare for their future success, students need guided opportunities to construct strong networks of executive functions during the school years. Without this preparation, they may lack the requirements for higher education and the competitive job market, including the skill sets needed for cognitive flexibility, successful communication, collaboration, or creative innovation.

Executive Functions Across the Curriculum

Organizing

Promote student awareness of their preexisting organizational skills by asking questions such as:

- How do you sort your music on playlists?
- How do you organize your classroom desk materials?
- How do you keep track of friends? Dates? Sports?

Ask questions about things that are already organized systematically.

- How is this book chapter organized? How is the content of this book organized into chapters?
- What organization do you see in the periodic table of elements? In the division of plants and animals into classifications such as kingdoms, genus, and species?

Use graphic organizers as appropriate.

- Education Place
- Enchanted Learning

Adapt checklists to students' needs.

- Gradually decrease the specifics on checklists as you move into solely writing categories. For example, on a checklist for a report, under grammar, you might initially include categories that specify capitalization, punctuation, spelling, and sentence structure.
- As students build independence for organizing, you could list just the category of grammar but omit the specifics.
- If you use rubrics to show students how they did on the different aspects of the report, they can use that information (or information you write on their reports directly) to personalize their checklists. Here, they can add items where their organization was less successful.
- Invite them to remove from checklists areas where they feel they have become self-sufficient.

Checklist for an Oral Report High School

CATEGORY	RESPONSIBILITIES
Delivery	☐ I maintained eye contact most of the time. ☐ I spoke to the entire audience, not just one or two people. ☐ My pronunciation was clear and easy to understand. ☐ My rate of speech was not too fast or too slow. ☐ My voice was loud enough to be heard easily. ☐ My voice varied in pitch; it was not monotone. ☐ I did not use filler words

	(for example, “uhm,” “uh,” “ah,’ “mm,” “like”). ☐ I used meaningful gestures. ☐ I used notes sparingly; I did not read from them.
Content	☐ The information I gave was interesting or important. ☐ I used vocabulary that the audience could understand and defined unfamiliar terms. ☐ My vocabulary was strong and varied. ☐ I used logical appeals where appropriate that included reliable, factual information. ☐ I used emotional or persuasive appeals where appropriate. ☐ I added supportive detail to the main point(s).
Organization	☐ I organized ideas in a meaningful way. ☐ The information and arguments/details were easy to follow. ☐ I stayed focused and did not stray off topic. ☐ The introduction included a clear statement of the main point(s). ☐ Ideas flowed logically from one to the next.
Presentation Aids	☐ Presentation aids used were relevant to the speech.

	☐ Presentation aids were not distracting. ☐ Visual aids were easily viewed by the entire audience. ☐ Visual aids contained no spelling or grammatical errors.
Resources	☐ I used resources that reflected different perspectives. ☐ I used interviews with others as a resource. ☐ I cited my sources using the required format.

(From PBL Project Based Learning)

Prioritizing

Prioritizing involves distinguishing low-relevance details from the more critical main details. When beginning a project, students might consider how to make the most efficient use of their time. For practice you could ask students questions such as:

- How do you select your choices of which television programs to prerecord for your three hours of TV during the school week?
- How do you plan which of your favorite stuffed animals to pack for a trip when you have room for only two?
- How do you select what to write down as you take class or textbook notes?
- When you were successful on a test you studied for, how did you decide which information was most important to learn and study for that test?

Judgment

The use of judgment is necessary to successfully navigate social and emotional choices and critically evaluate academic information. This executive function, when developed, promotes students' ability to monitor the accuracy of information as well as of their understanding and work.

Judgment can be developed through guided opportunities with self-checking strategies such as estimating in math, checking grammar accuracy, planning time, looking for clues for questions in subsequent questions, self-monitoring for focus, and editing plus revising their work.

Reasoning

Reasoning represents one's ability to interpret information and think logically based on prior knowledge, new information, pattern expectations, and deviation from expected patterns. Reasoning includes the ability to recognize or construct the rules or concepts gleaned from existing information as well as applying known concepts to new problems in order to make accurate predictions, interpretations, and responses.

"That's not fair" presents a teachable moment:

- Students select rules or laws they disagree with and support their opinions with evidence.
- Students predict what the opposing responses would be and prepare to rebut these.

The Learning Catalytics app links students so they may discuss their reasoning regarding assigned topics.

Critical Analysis

Critical analysis is the capacity to recognize when a first or automatic response is, indeed, the best or complete response, or the most appropriate action to be taken. Analysis also includes evaluating situations to determine the meaning of questions, what information needs to be gathered, what resources are needed to achieve success, and where to find the most valid sources of information.

To analyze source bias or accuracy:

- Know the difference between theory and research.
- Read actual research.
- Learn the scientific method and use it to critique research.
- Ask students to support opinions with reasons, and to predict what an opposing viewpoint would be and explain how they would defend against those arguments.
- Ask students how they would solve real problems, especially related to current events and teachable moments.

To analyze websites:

- Find examples of objective and authenticated websites and contrast them to examples of websites that present opinions as facts.
- Develop criteria for website validity with students. For example: Who created the site? What are their credentials? Is information on the site properly cited?
- Apply these criteria to assess other websites and sources of information.

To evaluate media:

- Students read and analyze passages, visual images, graphs, charts, maps, cartoons, photographs, artwork, eyewitness accounts, etc. from a variety of sources. They then respond to questions requiring validity analysis and synthesis of the information (oral and/or written).

- Students analyze a topic using a variety of sources: books, graphs, charts, maps, cartoons, photographs, artwork, eyewitness accounts, etc.
- The teacher can include opportunities for different types of judgments about these multiple sources:
    - Source validity
    - Priority of source value
- Interpret reasons for the way information is presented; for example, laws regarding freedom of speech, reasons why the author chose the literary devices used (foreshadowing, first- or third-person narrator, flashbacks).

Using government decisions to practice judgment

Teachable moments can come from government rulings that students investigate when they are concerned about a local issue or policy impacting them. If students think it is unfair for city property to be used for a parking lot instead of a skateboard park, they can evaluate the records of discussions that took place in the city council and make judgments about what information was fair. They can analyze the equality of how much time was given to citizen comments versus discussions held by the council in private subcommittees. These types of analyses and uses of judgment are particularly engaging and relevant when students know they will have an opportunity to share their impressions and recommendations with the people or committees involved. They can organize a visit to the council, hold a classroom discussion with a council member, or write letters to the editor of the local paper.

Cognitive Flexibility

Developing cognitive flexibility encourages students to be receptive and open-minded to new experiences, unfamiliar customs, variations of opinions and interpretations, alternative points of view, and multiple approaches to problem solving. Cognitive flexibility allows students to predict a variety of outcomes and assess changing data or new information from multiple perspectives.

To help build cognitive flexibility, expose students to

- multiple perspectives and points of view;
- a variety of interpretations and media;
- multiple approaches to problems;
- multisensory input.

Example: “This is not a ….”

- “This is not an egg beater.”
- “It’s a kite-string winder.”
- “It’s a drill to make double holes in the sand.”
- “It’s a whiz-a-ma-jig to make awesome noise.”

To support different options

Provide (or have students create) two or more outcomes for a future event, and have students devise a defense for each option:

- Possible winners of an upcoming election
- Potential cities to host the Olympics
- The outcome of an upcoming court decision

Find more than one way of solving a problem or two different hypotheses for a phenomenon. Have students select the one that they think is the best and give reasons for their selection.

Variations

- Create variations of works of art.
- Retell stories from the point of view of another character.
- Create different endings for fictional stories or historical events.
- Describe the thoughts or behaviors of characters or historical figures in novel situations, such as Ben Franklin discussing the economics of the Wall Street bailout with President Bush or opining what Abraham Lincoln would suggest about current immigration issues.

Executive Functions Summary

1. The prefrontal cortex holds neural networks of executive functions. These networks direct almost all areas of the brain to coordinate and facilitate goal-directed behavior; for example, prioritizing, self-monitoring, self-correcting, planning, decision-making, reasoning, judgment, critical analysis, organizing, abstracting, pattern recognition and extension (connecting knowledge into transferable concepts), creative problem solving, attentive focusing, and working memory.

2. Educators are the caretakers of students' control centers of highest cognition: the prefrontal cortex. This part of the brain is especially malleable between ages 5 and 18 when the neural networks of executive functions undergo their greatest rate of maturation (neuroplasticity) and improve in response to activation.

3. Opportunities need to be provided to stimulate the developing executive functions for students to achieve their highest potentials for judgment, goal achievement, and creative cognition in the twenty-first century.

4. To strengthen executive functions, a successful unit should include opportunities for students to

- apply the executive functions (higher-order thinking);
- question initial assumptions or answer and explore them further;
- recognize relevance to their own lives and immediate future;
- find relational meaning and patterns in information;
- combine their new knowledge with what they've learned in the past;
- develop more connections and pathways of a transferrable concept knowledge.

Web Links

Preparing Your Students for the Challenges of Tomorrow

Understanding How the Brain Thinks

The Brain-Based Benefits of Writing for Math and Science Learning

Improving Executive Function: Teaching Challenges and Opportunities

Three Brain-Based Teaching Strategies to Build Executive Function in Students

Three Strategies for Using the Arts to Build Student Executive Functions

Executive Function, Arts Integration and Joyful Learning

Culminating Material

What have you learned that, if implemented, could have the most valuable impact on your students?

What resources/assistance would you need?

How will you evaluate your success?

Useful Lists from Handout and PowerPoint Presentations

Sources of Novelty

- Change of sound (voice volume, pitch, cadence, silent pause)
- Change of color
- Movement
- Placement of objects
- Your appearance (hat, clothing)
- Curious items

Causes of Stress in School

- Peer relationships

- Test-taking and oral presentations
- Physical, clothing, language differences
- Lack of personal relevance
- Frustration due to previous failure and falling behind
- Sustained or frequent boredom

Characteristics of Video Gamers

- Buying into goal
- Perseverance through challenge
- Use of immediate feedback to improve

Why the Brain Responds Positively to Video Games

- Goal buy-in
- Achievable challenge
- Timely and frequent feedback
- Acknowledgment of incremental goal progress

Why Dopamine Is a Source of Intrinsic Satisfaction

- Promotes pleasure
- Promotes sustained attention
- Promotes motivation and perseverance

Dopamine Boosters (* indicates a strong booster)

- Movement
- Enjoying music
- Being read to
- Humor
- Having choices
- Interacting with peers
- Optimism
- Kindness
- Gratitude
- Making correct predictions*
- Achieving challenges*

General Principles for Reading Comprehension

(These can be practiced using the Talking Back to the Text strategy.)

- Prediction
- Activate background knowledge
- Personal connections

- Prioritizing importance
- Synthesis

"I think you'll be telling me …"

"I already know things about you, so I predict …"

"You are similar to what I have learned before, because you remind me of …"

"I would have preferred a picture of …" (or sketch/download your own)

"I think this will be on the test because …"

Prior Knowledge Activation Strategies

- Bulletin boards that preview
- Personal/cultural connections
- Pre-unit assessments
- Showing videos or images that remind students of prior knowledge
- Reminding students about previous exposures
- KWL chart

Activities for Mental Manipulation (Strengthening Memories)

- Teaching the information to another person
- Creating narratives (telling/writing/demonstrating a "story" about the information)
- Creating a symbolic representation of the information
- Summarizing the information
- Creating analogies
- Putting the information into graphic organizers

Useful Websites

Animoto offers a free EDUCATOR "Plus" account.

Brain illustrations

BrainFacts is a public information initiative offered through the Society of Neuroscience. USE the website www.brainfacts.org

The Dana Foundation provides information for parents, students, and teachers about neurological research and has links to other resources.

Resources for Validity: Products, Research, Theory, Claims

British Education Index: Education Online

Requires research or analysis be authored by individuals with professional standing in the specific field of the research. Studies must follow the quality criteria of that professional organization. Excluded are articles or websites whose primary purpose is to advertise events, products, courses, or publications.

WhatWorksClearinghouse of the US Department of Education evaluates education research, theory, products, and claims using medical model–type criteria to analyze the validity of each research study used. They use a consistent rating scale of research validity to determine how much weight each research study has on their independent conclusions.

Glossary

Amygdala: Part of limbic system in the temporal lobe. It was first believed to function as a brain center for responding only to anxiety and fear. When the amygdala is in this state of stress, fear, or anxiety-induced overactivation, new information coming through sensory intake cannot pass through its filter to gain access to the prefrontal cortex to form long-term memory. Prefrontal cortex output cannot direct reflective responses, so the reactive brain is in control.

Axon: The single fiber that extends from a neuron and transmits messages to the dendrites of other neurons (or to body tissues).

Cerebral cortex: This outer layer of the brain, where most neurons are located, is also called gray matter due to the coloration of the neurons. The cerebral cortex is associated with the highest cognitive processes, also referred to as executive functions, including planning, decision-making, reasoning, and analysis.

Dendrites: Branched protoplasmic extensions that sprout from the arms (axons) or the cell bodies of neurons. Dendrites conduct electrical impulses toward the neighboring neurons. A single nerve may possess many dendrites. Dendrites increase in size and number in response to learned skills, experience, and information storage. New dendrites grow as branches from frequently activated neurons.

Dopamine: A neurotransmitter most associated with attention, decision-making, executive function, and reward-stimulated learning. On neuroimaging, dopamine release has been found to increase in response to rewards and positive experiences. Scans reveal greater dopamine release while subjects are playing, laughing, exercising, and receiving self-acknowledgment for achievement.

Executive function: Cognitive processing of information for higher functions such as organizing, analyzing, sorting, connecting, planning, prioritizing, sequencing, self-monitoring, self-correcting, assessment, abstractions, problem solving, attention focusing, and linking information to appropriate actions.

Hippocampus: This ridge in the floor of each lateral ventricle of the brain consists mainly of gray matter that has a major role in memory processes. The hippocampus takes sensory inputs and integrates them with relational or associational patterns, thereby binding the separate aspects of the experience into storable patterns of relational memories.

Neurons: Specialized cells in the brain and throughout the nervous system that conduct electrical impulses to, from, and within the brain. Neurons are composed of a main cell body, a single axon for outgoing electrical signals, and a varying number of dendrites for incoming signals in electrical form. There are more than 100 billion neurons in an average adult brain.

Neuronal circuits or **neuronal networks**: Neurons communicate with each other by sending coded messages along electrochemical connections. When there is repeated stimulation of specific patterns of a group of neurons, their connecting circuit becomes more developed and more accessible to efficient stimulation and response. This is where practice (repeated stimulation of grouped neuronal connections in neuronal circuits) results in more successful recall.

Neuroplasticity: Dendrite formation and dendrite and neuron destruction (pruning) allows the brain to reshape and reorganize the networks of dendrite-neuron connections in response to increased or decreased use of these pathways. Plasticity refers to the ability of synapses, neurons, or regions of the brain to change their properties in response to usage (stimulation).

Neurotransmitters: Brain proteins that are released by the electrical impulses on one side of the synapse, to then float across the synaptic gap carrying the information with them to stimulate the next nerve ending in the pathway. Once the neurotransmitter is taken up by the next nerve ending, the electric impulse is reactivated to travel along to the next nerve. Neurotransmitters in the brain include serotonin, tryptophan, acetylcholine, dopamine, and others that transport information across synapses. When neurotransmitters are depleted by too much information traveling through a nerve circuit without a break, the speed of transmission along the nerve slows down to a less efficient level.

Prefrontal cortex (front part of the frontal lobe): The prefrontal cortex responds to event and memory processing and makes conscious decisions. It is the region of the frontal lobe where the brain directs the planning of the movements to do a task.

Reticular activating system (RAS): This lower part of the posterior brain filters all incoming stimuli, making the "decision" as to what people attend or ignore. The RAS alerts the brain to sensory input that sense receptors in the body send up the spinal cord. The main categories that focus the attention of the RAS, and therefore the student, include physical needs, choice, and novelty.

Scaffolding: This is instruction based on the concept that learning always proceeds from the known to the new. Students construct their new learning on the foundations of what they already know with the help of teachers, parents, or more knowledgeable others who support them with instruction to help them build upon the abilities and knowledge they have to reach a higher level.

Synapses: These are gaps between nerve endings where neurotransmitters like dopamine carry information across the space separating the axon extensions of one neuron from the dendrite

that leads to the next neuron in the pathway. Before and after crossing the synapse, information is carried in an electrical state when it travels down the nerve.

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