Research Based Strategies to Ignite Student Memory Focus, and Motivation with RAD Strategies

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Books by Dr. Judy Willis

Research-Based Strategies To Ignite Student Learning: Insights from a Neurologist/Classroom Teacher, ASCD 2006

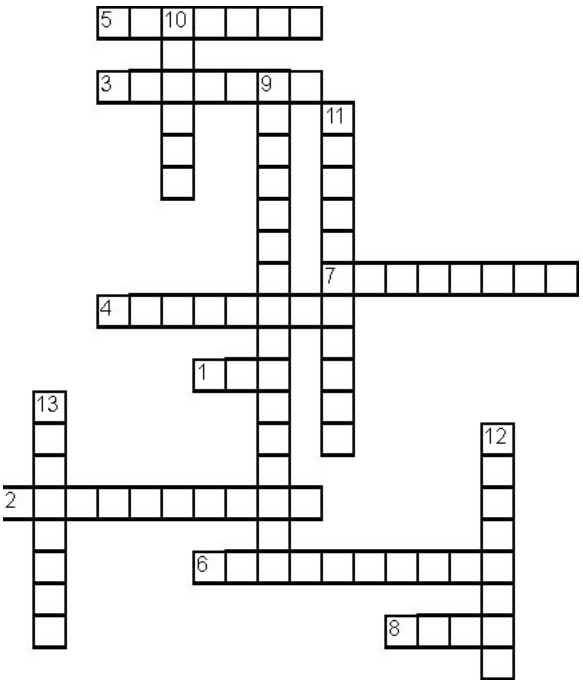
Brain-Friendly Strategies for the Inclusion Classroom, ASCD 2007

Teaching the Brain to Read: Strategies for Improving Fluency, Vocabulary, and Comprehension ASCD August 2008.

Sourcebooks released Dr. Willis' first book for parents, How Your Child Learns Best, September 2008.

Check **website RADTeach.com** for links to Dr. Willis's articles

Brain Puzzle by Judy Willis: Anytime you are have time for a filler or sponge activity, complete this puzzle using the clues shown below. Feel free to collaborate with your neighbors.



QuickTime™ and a
decompressor
are needed to see this picture.

ACROSS

1. Reticular activating system
2. Capacity of brain to change
3. Eliminates unused neurons
4. Emotional memory
5. Space between neurons
6. Coordination and memory
7. Mediates conscious activity
8. Extension of neuron

DOWN

9. Chemical info carrier
10. Brain cell body
11. Memory consolidation
12. Pleasure neurotransmitter
13. Integrates sensory input

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Goals for This Presentation

Brain research-based strategies that help students with learning and behavioral challenges that are effective for ALL students.

Classroom ready tools to help all students achieve their maximal potential in school and life.

RAD Strategies for Student Success Including How To:

Sustain attention & control focus

Connect new information input to working memory

Consolidate working memory to strong long-term memory: *goal motivation* and *patterning*

Develop higher-level executive function thinking

BRIDGING THE RESEARCH TO THE STRATEGIES

Brain imaging has succeeded in correlating successful cognitive psychology theories with visible evidence of how the brain processes information - learning. Functional imaging (PET scans, fMRI) has been able to document the brain's metabolic and biochemical responses to strategies suggested by cognitive and educational researchers.

RAD LEARNING = **R**eticular Activating System + **A**mygdala (Affective Filter) + **D**opamine

Reticular activating system: how to use changes in the environment, surprise, teachable moments, multisensory lessons to turn on the brain's attention via this filter that alerts the brain to changes and gets it primed to interact with new information and experiences.

Amygdala: how to keep filter from blocking information entering the brain due to stress. How to use some stimulation such as building curiosity, positive emotional associations and prior experience to actually expedite passage through the amygdala's affective filter

Dopamine: this neurotransmitter's release is associated with pleasurable experiences and in expectation of pleasurable experiences. Its release also increases focus and executive function in the frontal lobes. Strategies to make lessons that coincide with the Dopamine-Reward Theory.

Reticular Activating System

Novelty alerts the brain to changes and gets it ready to pay attention. Examples of building novelty into learning new information: changes in voice, appearance, color, size, hat, changes in seating to standing, music, dance, picture, photo, radish!!!

Attention and Focus

- Students are criticized for not paying attention; they may just not paying attention to what their teachers think in important.
- **Emotional Charging of Memory Connections** - Conscious memory of personally meaningful and emotional experiences increases memory storage.

Emotional Significance- Increased retention occurs when learning is linked to emotional experiences. Enthusiasm is generated when children are presented with novelty and find creative ways to explore or connect with the new material and are inspired by it. Whenever you can generate this awe and sense of wonder, your children will be pulled into the school lessons they bring home and they will be motivated to connect with the information in a meaningful way.

Strategies

- Help students remember important information by connecting the critical information to positive emotional experiences in the classroom.
- Start with global concept, prompt interest, invite engagement through prediction, KWL or KTWL
- Avoid Attention Divided: trying to listen and take notes can interfere with getting the big picture and making the connections that become memories. One brain activity at a time. If students need to take notes, stop and let them take notes. During the stop time you can answer questions.
- Focus: Students are most focused when they know they will have to do something with the information. (PET scan and reading study-the greatest brain activation when the students were told they would have to retell the story). Knowing a *think-pair-share* follows will increase active focus. Pairs write down and share one or two of their items with the whole class to validate.

Strategies to Maintain Attention and Focus

1. Color: marking key points in color results in increased recall. Write most important fact of the lesson in another color. **Color for novelty and Differentiate**

Keep students' attention and ability to keep content organized by varying the color of the paper, font, spacing, content, presentation and graphic organization. It also helps you differentiate, because you are able to identify by color when students who work more quickly are working on homework, how much progress individual students are making (and at what level of difficulty) on a portion of the lesson, and who in the room needs my help.

2. Graphic organizers as preview and overview of each lesson.

3. Physical activity every 15 minutes: Sing a song with associated movements, teach from a different part of the room so students turn their chairs.

4. Physically alter the arrangement of your classroom. Make the classroom come alive-vary bulletin boards, plants, animals, and changes in seating arrangements. One teacher followed this suggestion and wrote, "At least twice a week by varying seating arrangements, groupings and orientation, I physically

alter the arrangement of my classroom. On one of the first snowy days, I had all the students pick up their desks and turn them to face the windows to watch the snow while they worked. The principal agreed to install a new white board, so that I can have the students face a completely different direction in the classroom and have more room for students to work on the board. Students know that if desks are in rows, they can expect to work independently for the period. If the room is divided into halves, they will be having a contest working with their teams. I have been so pleased with how much they enjoy it, and how smoothly it runs itself."

5. Novelty and surprise with music, costumes, speak in a different voice, hang a dollar bill, overhead optical illusions or bizarre factoids.

Personalize for RAS: by connecting topics with students' interest (interest survey at beginning of the year) and using their names in sample problems. As another wrote, "I have made an effort to re-word math problems so that all of their names are included in the problems, and, to introduce novelty and surprise, have made the problems purposefully ridiculous. One problem this week involved cookie-eating (solution: Joe only got 3 cookies, Mac ate 28) and was been the topic of conversation and bonding in the hallway for the last few days."

How could you build novelty and therefore focus attention on a study or review session about action verbs or the science concept of friction?

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Amygdala

If students are stressed information won't pass through the ***affective filter*** in the ***amygdala*.**

Threat, fear, or high stress can activate excessive metabolic activity in the amygdala that interferes with information entering the brain's processing, patterning, and memory circuits.

Risk factors for amygdala blocking of learning: learning and behavioral challenges substance use, trauma, environment, violence, poverty, language differences,

Set the Emotional Climate: be the solid force that keeps students feeling safe and the classroom community strong.

Keep stress down to prevent blocking the flow of information into the thinking parts of the brain. Common stressors in the classroom: fear of being wrong, embarrassed about reading aloud, test-taking anxiety, physical differences, language limitations, negative peer relationships, cliques, unpredictability, frustration with difficult material, boredom from lack of interest.

What classroom community builders and/or confidence building activities can you use or have you used to reduce stress from one of these classroom stressors that interferes with learning?

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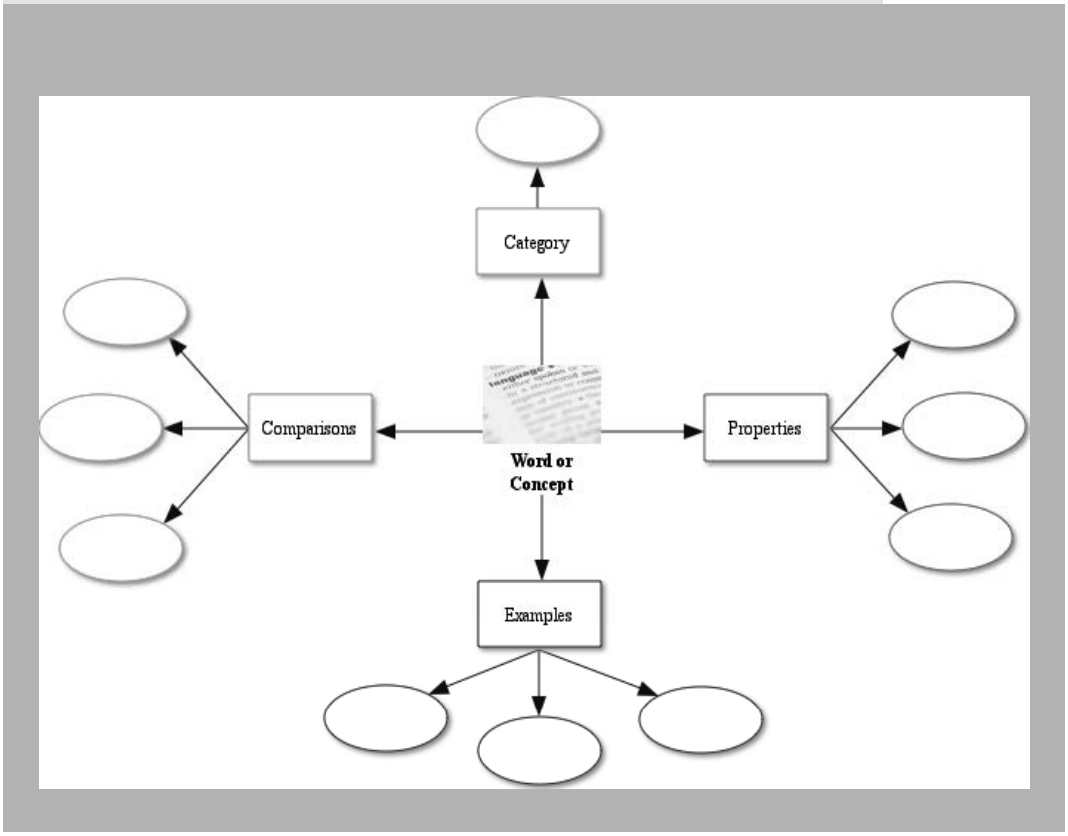
Teachers Set the Emotional Climate: The frontal lobes, where much of the ability to manage and control emotions is programmed, are the last part of the brain last to mature. This usually happens sometimes during adolescence, so teachers need to be the solid force that keeps students feeling safe and the classroom community strong.

- **Personalize** the information by relating it to their lives, current events, their interests, talents, or learning styles. "What does our town's debates over the building of a skateboard park have in common with the causes of the American Revolution?" e.g. Regulation (taxation) without representation.
- **Open-ended discussion strategies:** Ask a question of interest related to the topic of study that has more than one answer. Give wait time before any responses are permitted so all students have a chance to think. Invite multiple students to voice opinions without indicating if their opinions are right or wrong. It is fine to ask them for reasons to support their opinions.

CREATE A GRAPHIC ORGANIZER ABOUT THE AMYGDALA



1. In center write Amygdala
2. For Comparisons: What can you compare to the amygdala (can be an analogy)?
3. For Properties: What does the amygdala do?
4. For Examples: What can you do in your lessons to help promote information through the amygdala's affective filter?

Dopamine

This neurotransmitter's release is associated with pleasurable experiences. Dopamine release also increases focus and executive function in the frontal lobes.

Things known to increase brain levels of dopamine: movement, being read to, specific positive feedback or intrinsic satisfaction such as achievement of meaningful goals, humor, laughing, interpersonal activities

Strategies to make learning release dopamine:

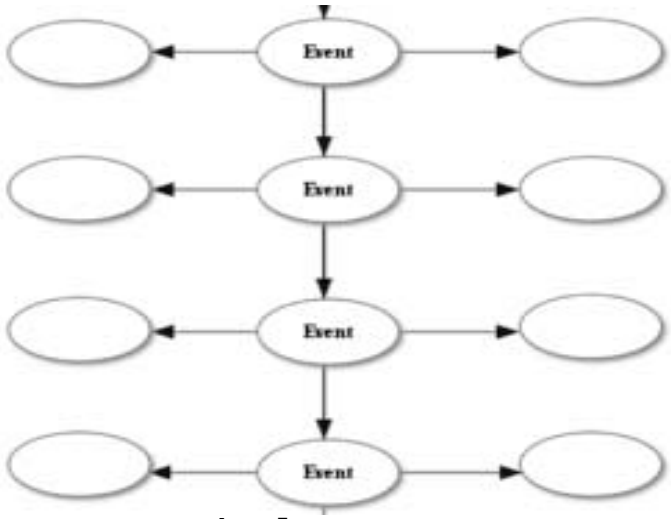
- Pantomime vocabulary words
- Word Gallery: Vocabulary review for language arts, foreign language, or subject specific terms can incorporate movement, positive peer interactions, even music. If students have a list of vocabulary words they can walk around the room and write the number of the poster that has a verbal or pictorial representation of each vocabulary word. This can vary from actual definitions to the word used in sentences. Subsequently students can add their own sentences or drawings to the wall charts. Scaffold by allowing some students have a one-word definition or work with a partner as they boogie the vocabulary walls to music.
- Put post it notes with the parts of a flowering plant on similar parts of the body e.g. head is flower, feet are roots, arms are leaves
- Ball-toss to review high points of a lesson (only if hands are turned up and eye contact is made)
- **Avoid Brain Burnout** with ***Syn-naps*** (brain breaks) needed to avoid depletion of neurotransmitters in the synapses. In this "burnout" state focus can't be maintained and new memories can't be created. Identify these overload times BEFORE they occur and have a break before that point.

Create a Graphic Organizer About Dopamine

1. In middle column write something that causes the release of dopamine
2. In the oval pointed to by the arrow, on your left next to that event, write an activity you could do using that type of event as dopamine-reward strategy
3. When possible add a comment in the oval to the left of what the potential benefit could be

DOPAMINE

Benefits **Strategy or Activity to Increase Dopamine**



RAD Preschools

Quality Preschool

Play is Brain Food During It's Growth Spurt

Create experiential and engaging activities for students. During the brain's early years, neural connections are made at a rapid rate. Much of what young children do as play—singing, dancing, painting, drawing, acting—are natural forms of experiential learning.

The Bill and Melinda Gates Foundation
March 20, 2007 Remarks By **William H. Gates Sr.**
"Why do kids go awry? Why do they wind up unemployed or in jail? Why do they quit school? We traced these problems all the way back to the years before a child's fifth birthday.

Low-quality child care/preschools—The teachers aren't properly trained—it's our fault as a society for not valuing the work they do—so they don't know how to engage the children. Often the rooms are ill-equipped, without stimulating toys or a safe space for playing. Few families have the luxury to decide that mom or dad will stay home from work. They need childcare, and they don't have affordable, high-quality options.

By the time many of these children get to the first day of school, they're already behind. And chances are they won't ever catch up. Let me be clear: I'm talking about the basic building blocks of making sure a child is ready to learn. Can she stand still in line? Can he recognize colors? Can she follow simple rules and instructions? Can he cooperate with other children? David Elkind cites the ability to work cooperatively with other children, take turns, and stand in line as among the skills necessary to success in formal schooling. Says Elkind: "If a child has these...social abilities, learning the academic skills is much easier than it is without them."

Imagine what it must be like for a child who isn't ready for the first day of kindergarten. On one side of her is a girl writing her ABC's. On the other side is a boy who can tell time. And yet she doesn't recognize a single letter. Right away, school is a place where she feels like a failure, where she feels overwhelmed.

It is not just that she doesn't have the same skills as other students in her class. It is that she's lost confidence in herself, and formed a negative—attitude about school."

What it takes for children to grow up confident and secure.

Affection from the people who take care of them. Without that sense of intimacy young children get stressed. They have a hard time forming a sense of belonging. Children with fewer intimate attachments have higher levels of cortisol, a stress hormone, in their blood. Four-year-olds attend quality preschool improve their pre-literacy skills—things like being able to recognize letters—by almost twice as much as four-year-olds who don't go.

Imaginative play, a feeling of security in today's often frightening world, and strong, meaningful relationships with both adults and other children Teachers who work together with parents, and keep children engaged in an enriched environment in which children are loved, talked to, and given ample opportunity to move, play, and explore. As old-fashioned and simple as it sounds, peek-a-boo, pattycake, and "This Little Piggy" will offer young children more than any two-dimensional materials such as computer software.

You can tell that they are learning—and having fun while they're at it.

How I will incorporate RAD?

R (reticular activating system)
A (Affective filter in Amygdala)
D (Dopamine-Pleasure Response)

Research Brain-Compatible Memory Strategies

- Advances in memory research
- Strategies to increase memory retrieval
- Creating Long-Term Memories by mental manipulation in the prefrontal cortex with executive function strategies
- Strategies for test success

Types of Memory

Types of Memory: awareness, working memory, episodic memory, rote (item or semantic memory), and relational.
Awareness: attention of the moment subconscious e.g. billboards seen while driving.
Rote Memory *(item or semantic memory)*

- Rote memory is the type of memory most frequently required in traditional classrooms and tested on most standardized tests.
- When we ask students to learn lists of unrelated facts, memorize grammar rules, historical dates, biologic genus and species, or other details of specific content with no great personal relevance, and to take most standardized tests, success is often dependent on rote memory.
- Unlike relational memory, rote memory is independent of context. When students remember information in rote memory, they do not remember the time, place, and events surrounding the learning of the information. They recall the information itself.

Working memory (procedural memory): memory of what you think you need now- the mind looks for patterns.
Fades in less than minute.
Limited capacity, approx 5-9 items so as new comes in, others go out
Chunking: Help students remember information more effectively because it is related into chunks. E.g. We chunk phone numbers and social security numbers into chunks of 3 or 4.

Working Memory to Relational Memory

Relational Memory: When new input connects with a previously stored memory the dendrites connect in new pattern sequences and the new relational memory is integrated into neuronal memory networks with previously stored memories. When either fact is later recalled or prompted, the patterned integration or association that was created will efficiently activate the related memory.

Piaget: the developing child builds cognitive structures known as mental maps or schemas for understanding and responding to physical experiences.

PFC=Prefrontal Cortex

Patterning and PFC Children (and adults) who sustain damage to their prefrontal cortex can become oblivious to the consequences of their actions, insensitive to others ' emotions, and unable to learn from their mistakes. Even when these patients had no loss of knowledge or lowering of IQ they had disturbances in emotional-neuroprocessing as a consequence of damage to their prefrontal lobes that resulted in poor decision making. This may be attributable to both the loss of PFC cortex and part to decreased ability to encode new sensory input into patterns of neural networks. If they cannot

categorize and interpret new input their information analysis, feedback, and abilities to self-correct are impaired.

Increasing prefrontal cortex executive practice can, through neuroplasticity strengthen prefrontal executive function. Practice helps children build their information processing skills they may also be increasing the networks for emotional processing and decision-making skills. Inquiry and discussions that involve opinion development, analysis, judgment, and decision-making may strengthen information and emotional processing. Children learn how to rapidly process information and distinguish between what's reliable and what's not.

Activities to stimulate the executive functions include exploring and discussing current or historical events through films, books, Internet, primary sources, or the daily newspapers from multiple perspectives. How would the French Revolution have changed your life if you were in the royal family? How would the end of slavery and the loss of population due to Civil War deaths changed your life if you had no one to work your farm for a full growing season? Students can select the position they want to defend in a class debate or report and they be asked to switch or write a dissenting opinion on a Supreme Court decision they disagree with. Pair up with someone in different corner of the room after students go to the corner depending on their opinion about a topic. Try to convince each other. Do something with the analysis such as write a letter to a government official or to the editor of the local paper.

Keep communication safe and open so students are comfortable discussing their concerns, confusion, frustration, and failures with your without fear of negative consequences.

STRESS `withers` *brain cells:* Animal research stress sometimes negatively affects the brain. In one example, researchers gave rats excess stress by restraining them daily. Dendrites withered in the hippocampus and there was less replacement of brain cells in the hippocampus, one of the few brain regions that can produce new cells throughout life.

Strategies to Increase Memory Storage and Retrieval

- Memory retrieval increases with multiple and varied modes of instruction of the same material.
- Avoid one lesson fits all. Differentiated instruction: use different learning style focuses each time you teach review the material.
- Retrieval is better when students know how information is organized e.g. categories, and best when they create these categories or graphic organizers themselves
- Visual imagery: Students visualize the history event then note it using words or sketches.
- Produce a product, make models
- Role play, skits, pantomime
- Link item to be learned with positive emotional events: flash bulb memory. (We remember the song playing during our first kiss.)

Personal involvement in learning experience - hands on and discovery learning, prediction, write on overhead projection paper to share with class, cooperative group work.

Mental Manipulation in PFC

Students experience a greater level of understanding of concepts and ideas when they talked, explained, and argued about them with their group, instead of just passively listening to a lecture or reading a text.

- The person who does the work (thinks) LEARNS. Each time students participate in any endeavor the specific pathway of neurons is activated and neurons and their connections in this

pathway are stimulated again. The more times they repeat the thought process or action, the more efficient, stronger, and less susceptible to *pruning* these brain pathways become. Eventually, only triggering the beginning of the sequence of an action or recalling first part of a set of data, will result in the remaining pieces following in sequence. Examples: Tying shoes, touch-typing.

- **Multisensory learning**: Stimulate multiple brain processing regions and cross-connections through multisensory lessons. When there are multiple pathways (cross-brain referencing) connecting to the learned material, there are several neuronal circuits connecting to the information so retrieval can occur from a variety of cues. The building of these multiple pathways by which students can access and recall the information is the reason multisensory learning and review (rehearsal) makes memories permanent and actions automatic.
- **Connect With Past Knowledge**: Help students relate the new information with data they have already acquired through personal experience or real world associations. The ***hippocampus*** takes sensory inputs and integrates them with relational or associational patterns. This binds the new information with already stored and patterned information and builds long-term relational memories.

Strategies of Engagement

- Teaching is not just the dispersing of facts. Students need to develop cognitive skills of thinking, learning, and reasoning because only then will they find personal or relevant meaning in what they are taught.
- Help students make higher-level frontal lobe connections to stimulate ***executive processing*** through metaphors (discovering relationships), graphic organizers, predictions, judgment, pair-share, and open-ended questions.
- **Open-ended, child-centered discussion strategies:** Ask questions related to the topic of study that connect the new information to things he or she is already interested in. These discussions start with questions you frame that have more than one answer and ask for opinions so there is little risk of being wrong. Give wait time before any response is permitted to build judgment and communication skills. Encourage more than one opinion (problem-solving skills, patience, creative problem solving) and ask for reasons to support the opinion.

Math: Ask how adding a row of numbers is like finding the total score using the runs scored in each baseball inning?

Grammar: Read a paragraph alone or together from which you have eliminated punctuation. Read it again with the punctuation marks in place. Discuss how the commas, periods, question marks, and exclamation points made it easier to read and understand.

Other open-ended discussion topics:

Any subject: Why might this information be useful to you someday? What people, doing what jobs might use this information? How could you use this information to build a better skateboard, advertise a product you invent, plan a party with a budget, write a book for a younger child about this topic. How might you explain this new information to a child from another country who has never seen a (fill in the lesson word here).

History: How does learning about history help people in the present?

Your example of an open-ended history question here:

_____

_____

Science: What is your favorite modern invention and how do you think it came to be invented – what did the inventor need to know or have on hand to create the final product?

Your example an open-ended science question here:

_____

_____

Literature: How are you like the character in the book? What would you do if you had his problem? Why do you think he did _____?

Your example an open-ended literature question here:

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_____

Mentally manipulate

- **Graphic Organizers:** Graphic organizers with visual, diagrammatic, pictorial, or graphical ways to organize information and ideas for understanding, remembering, or before writing a paper. For the most part, the information on a graphic organizer could be written as a list or outline, but graphic organizers give students another way to see and mentally, as well as visually and kinesthetically, manipulate the information.

  Graphic organizers allow students to create visual pictures of information in which their brains discover patterns and relationships. When the brain can find and interpret information as a pattern, such as in a graphic organizer it receives the information as meaningful input for memory storage.

  Samples of graphic organizers can be found at these websites:
  Inspiration.com
  http://www.ncrel.org/sdrs/areas/issues/students/learning/lr1grorg.htmand
  http://www.teach-nology.com/web_tools/graphic_org/
  http://www.inspiration.com/freetrial/index.cfm
  http://www.ncrel.org/sdrs/areas/issues/students/learning/lr1grorg.htm

  - **Analogies** for relational memory: White is to Snow as Blue is to Sky
    Your examples here:
    Capillaries are to arteries as _____are to _____.
    Past tense is to yesterday as _____is to _____.

QuickTime™ and a
decompressor
are needed to see this picture.

- **Similes**: Photosynthesis for plants is like breathing and eating for people. Exercising my muscles makes me stronger like reading makes me smarter.
- **Puzzlemaker.com**
- **Mnemonics:** like HOMES for names of the Great Lakes (Huron, Ontario, Michigan, Erie, Superior) or ROYGBIV for the colors of the rainbow (red, orange, yellow, green, blue, indigo, violet).
- Mnemonic sentence for the first five US Presidents: Washington, Adams, Jefferson, Madison, Monroe. "**W**ill **a**ll **j**obs **m**ake **m**oney?"

Make up a mnemonic sentence for the five senses (see, hear, touch, smell, taste)

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Memory Cement

Multiple exposures to the same or similar information over time can serve as "memory cement". From one of my readers, "Rather than use the pre-made drill sheets, I have created daily practice sheets that combine content learned earlier, reinforcement of new concepts, and word problems that use the skills we are developing, or past knowledge. This is called "the blue sheet". Students complete this lesson summary alone or with one or two other students. The blue sheet is at most two sides of a single sheet of blue paper and varies in length, content, and format, depending upon my plan for the rest of the day. Some blue sheets are booklets, so have four "pages". On other days, the problems are widely spaced and very "easy". Sometimes, exactly the same kind of problem will appear on the first 3 pages of a booklet. Before a test, or when the class is not ready to move on, the blue sheet may be the lesson of the day."

- Students See Value of the Information: If students don't sense the information is important to them, it won't go through the *hippocampus*, become patterned into new synaptic connections ***(relational memories),*** and become long-term memory. Memories that are associated with emotional or personal meaning are most likely to become relational memories and be stored.
- Achieve maximal memory storage conditions with teaching strategies that connect with students as individual learners through their strengths and promote positive emotional states.
- Avoid Summer Slide: Summer Slide in Memory: (Ron Fairchild, executive director of the Center for Summer Learning at Johns Hopkins) Poor children fall further behind every year, and most of the loss comes in summer, when the economics results in unequal summer learning experiences during the elementary school years. By the end of elementary school, researchers have found, poor children trail middle-income children by at least two grade levels. For low-income children, the slide in reading is particularly harmful: They fall behind an average of two months in reading while their middle-income peers tend to make slight gains. By fifth grade, low-income children can be as much as 2-1/2 years behind in reading. Summer programs at public libraries, book clubs, museum classes, books on tape, read aloud, and less television and video games. Suggestions for fun word games for family fun can be sent home before summer.

Prefrontal Cortex for Highest Cognition and Executive Function

When you consider the processing and decision making that goes into deciding what, how, when, and how often to study, it turns out that that the frontal lobe executive functions of organizing, judging, analyzing, prioritizing, and making strategic adaptations are the essence of efficient studying. When students receive instruction geared to their learning strengths and then practice the strategies most compatible with their intelligence types, they are most successful at developing the executive functions needed to process and store the important information in such a way that it will be retrievable for tests and future consideration.

Some of these executive function study strategies to consider for each student and reinforce through metacognition and practice opportunities include:

- **Prioritize:** Practice separating low relevance details from the main ideas. This represents the executive function of prioritizing skills to help students practice the cognitive strategy that will help them make the most efficient use of study time.
- **Judgment:** This executive function includes self-checking strategies such as self-editing, estimating or checking math accuracy, time planning, looking for clues for questions in subsequent questions, and checking in with themselves to monitor their focus.
- **Analysis:** Self-monitoring is a form of the executive functions of analysis joined together with metacognition to help students develop their abilities to become aware of the types of mistakes they most commonly make. If they list these near their study areas and review them while studying they can work toward avoiding mistake patterns such as: errors in copying problems correctly, failing to analyze if their answers make sense, forgetting to read the entire question and answer all parts of it, missing important words of instruction such as "Which answer is *not* correct."

The last part of the brain to mature (through plasticity and pruning is the prefrontal cortex. Children and many teenagers do not have fully developed delayed gratification skills during their school years. The prefrontal regions are major participants in the executive function networks of judgment, prioritizing, and delayed gratification processing. This is one reason students from kindergarten through high school continue to need support and encouragement from their teachers to keep their efforts directed on long-term goal achievement.

Risk-Taking and Adolescents

In adolescence the frontal lobe has not adequately matured and the delay in their development of executive functions and emotional regulatory areas associated with planning, strategizing, judgment, attentive focus, prioritizing, critical analysis, emotional self-control, and empathy can put them at risk for risk-taking. This delay in pruning and myelination in the frontal lobes of adolescents can result in lapses in judgment and inadequate decision-making skills. 1/3 to 1/2 of adolescents with substance abuse disorders have ADHD and teenagers are three to four times more likely to die than children past infancy. This is largely attributed to the fact that they take risks and have accidents.

Neruoplastiity: (ABERDEEN project)

Today's babies are spending upward of 60 waking hours a week in things (like high chairs, car seats, and carriers). Not only does this impact their personalities (babies need to be held), but it also greatly affects their cognitive and motor development.

Greater brain region stimulation promotes the growth more connections between synapses and dendrites and more myelination there is value in **multisensory learning and repeated stimulation** of neural networks containing useful learned information through neuroplasticity. In multisensory learning more areas of the brain are stimulated as information is presented through *multiple* senses.

These pathways interconnect and the stimulation of one appears to activate related ones as a part of the brain's patterning system. Multisensory presentations of the information stimulate the growth of more brain connections. Then with mental manipulation through open-ended discussions, creative problem solving, deduction, and extensions of topics individualized based on interest to pull students into the subject can increase electrical activity of these networks and can promote the laying down of more myelin resulting in more efficient accessibility and transportation of information into and out of memory storage.

ENRICHED ENVIRONMENTS

Neuroimaging research reveals that brain plasticity can be stimulated beyond infancy into adolescents, and even some adults, such that input, experience, and practice with techniques such as innovative teaching, computer programs, music and art, and manipulation of information (thinking/processing) in brain areas of highest cognition in the prefrontal lobes. In students this brain rewiring may enhance potential (and strengthen weaknesses) when enriched environments build more dendrite connections between neurons, more synapses per neuron, and more myelination to increase speed and quantity of neural activity transit. These increasing dendrites, synapses, myelin, and neural networks increase in brain tissue volume not only due to the increase in connecting fibers (dendrites), but also with the capillaries, oligodendrocytes, and *glial* fiber cells that grow to support them.

Pruning

Brain regions not activated by neural stimulation receive less oxygen and glucose. The result can be a release of neuron-destructive chemicals that breakdown the unused neurons. This can be a useful phenomenon to increase brain efficiency when truly unneeded neurons and connections are eliminated. For example, once children can automatically tie their shoes without going through the memory prompt about a bunny running around the tree and into a hole, the brain network with that memory device can be pruned away so the shoe-tying neural network is smaller and faster when the activity is needed. The efficiency of pruning has also been demonstrated in accomplished pianists as practice leads to more automatic playing so less of the brain's motor cortex needs to be used to modulate the activity of moving the fingers on the keys.

When planning lessons consider the strongest memory motivators and include those that suit the material and learning strengths of the students.

- Choice
- Task variation
- Developmentally appropriate lessons with achievable challenge
- Reinforcement and feedback
- Personal relevance
- Real world connections (e.g. Use ratio and proportion to change a recipe so the correct amount of ingredients are brought in to make cookies in class; use real coins to calculate money problems)
- Intrinsic reward (self acknowledgment of progress as a result of one's practice and effort).

Syn- NAPS & Sleep

RECESS: children in schools where recess is withheld as punishment -- or as a way to catch up on school- or homework website of the American Association for the Child's Right to Play (www.ipausa.org) for information on how to become a recess advocate. They also offer a brochure called "The Case for Elementary School Recess," which outlines the contributions recess makes to the

child's social/emotional, cognitive/intellectual, and physical needs. Dr. Olga Jarrett and her colleagues conducted a study that determined 15 minutes of recess resulted in the children being 5% more on-task and 9% less fidgety, which translated into 20 minutes saved during the day.

Syn- NAPS Change activity every 10 minutes so neurotransmitters can rebuild and stress is reduced in amygdala.

Ucla sleep disorders center Dr Yan-Go reports 100,000 auto accidents are attributed to drowsy drivers

"Dend-write Food" Notes for Memory Consolidation …and More

Build relational memories with "Dendrite Food"

Personalization

Connection to prior knowledge

Mental manipulation through executive function

In the last 5-10 minutes of a class or at completion of a lesson students write "Dendrite Food" (exit cards) in their notebooks in response to one or more of these prompts. (choice=dopamine, amygdala)

- Draw a picture, diagram, or graphic organizer of what you learned
- Create an analogy, write what it reminded you of, or how it fits with what you already know
- A reaction or a reflection of how something you learned relates to something in your life
- Something that made you wonder or surprised you; a new insight or discovery
- What do you predict will come next?
- How could you (or someone in a profession) use this knowledge?
- Something you are confused about or found difficult
- What you understood today that you haven't understood before
- The part of lesson that was most difficult for you and the part you enjoyed the most
- What strategy did you use to solve a problem today?
- The *"So What"* or the one thing you'll remember about today's lesson

More Uses of Dend-write Cards

- Feedback - how accurately the lesson was understood
- Next class, correct any misperceptions you discover
- Check one or two responses on the best cards
- Students with checks share those insights with the class as review or to promote discussion *(Lower affective filter – increased participation because confident about what they will say to the class)*
- Students listen and can add to their own notes based on their classmates' card reading
- Cards (notebook writing) become study aides
- Post on bulletin board cards that cover important information for students who were absent or for all to review.

I n d i v i d u A l i z a T i o N

IS KEY TO ADDRESSING These PROBLEMS

Tell me, I'll forget
Show me, I'll remember
Involve me, I'll understand
~ Chinese Proverb

We learn 40% of what you hear,
60% of what you hear and see,
and 80% of what you hear, see, and do.

This is sound educational philosophy, because the more senses that are involved in learning (duplication of neural pathways through each individual sense), the more significant and memorable the educational experience.

There is nothing more unequal than the equal treatment of the unequal.

Henry Winkler, actor, director, and children's book author, who played the memorable Fonzie on *Happy Days*, has dyslexia, yet earned a master's degree from Yale. "Whether we learn differently or not, that does not mean you don't have greatness inside of you."

Why Do Students Drop Out Of School…..*boring*
What Is The Greatest Fear Students Have In School…..*saying the wrong answer.*

Hippocratic Oath: First, Do No Harm

So many children have already been harmed, gifted to LD children have been alienated from the joy of learning, are bored, frustrated, or anxious.

If they have gotten to your classroom unscathed, they probably won't get the attention you'd like to give them because of the extra needs of their classmates.

Empower students and their parents with brain knowledge, especially their ability to modify their brains through neuroplasticity. This can be especially motivating when students have been marginalized by learning differences.

Differentiated lowers risk
All students learn differently. Most of us know this intuitively. We learn best through different methods, with different styles, and at different paces. We remember being in school and struggling to master a concept while a friend of ours grasped it immediately. When a parent or a teacher would explain the same concept in a different way, however, we understood. We had friends who excelled in certain classes, but struggled in others.

There is far more standardization than customization in schools. When a class is ready to move on to a new concept, all students move on, regardless of how many have mastered the previous concept (even

if it is a prerequisite for learning what is next). On the other hand, if some students are able to master a course in just a few weeks, they remain in the class for the whole semester. And when a teacher teaches long division in the manner that corresponds to how she best learned and understood it, it does not matter whether a student grasps the idea and grows bored with the repeated explanations, or sinks deeper into bewilderment, unable to grasp the logic; the student sits in the class for the duration. Both the bored and the bewildered see their motivation for achievement shredded by the system.

Differentiate-needs memory and creativity

If we honor the individual student, and wish to prepare them to make their way in the world, ready to bring forth the unique gifts they have to offer by encouraging them to:
Ask questions small and large and design their own experiments to answer them and conduct their own investigations into the past, and not just memorize what the history book says. Creativity needs a strong foundation of skill and knowledge built through hard study.

"But in my mind, the student who leaves having memorized the textbook has not been truly educated, even if he has passed every exam. The problems of tomorrow are not going to be solved with the knowledge of yesterday. The problems arise fresh each day, and creativity is our best chance for success."

John Norton

Differentiation for Realistic Achievable Challenge

The objective of most of the successful strategies for constructing and sustaining memories is to provide experiences and develop student goals based on *individualized realistic challenge*. These are challenges that are motivating because of student interest and supported by clearly structured goals, frequent feedback, and positive intrinsic reinforcement geared to students' developmental levels, intelligences and learning strengths.

Individualized realistic challenge connects students to knowledge by communicating to them high expectations while insuring that they have the capacity to reach these goals. The confidence base is established when students know that they will have access to the tools and support they need to reach the high expectations differentiated for them. These are the classrooms where the bar does not need to be lowered or challenge eliminated in the name of access.

A longitudinal noted that teachers who emphasize competitive comparisons of student ability discourage students from asking for help.

In a study of what makes computer games so captivating, variable player-ability-based challenge was interpreted to be the key element. The most popular computer games took players through increasingly challenging levels as they became more and more skillful. As skill improved, the next challenge would stimulate new mastery to just the right extent that the player could reach with practice and persistence. That incremental, responsive challenge in the classroom, at the appropriate level for students' abilities is motivating and strategically builds mastery.

Differentiated plans, that set students on appropriately challenging paths, they will have the benefit of maximum brain engagement. The extra planning time will be rewarded by students' successes, improved confidence and attitudes, as well as their achievement on standardized tests and the reduction in time that is required for basic behavior management in the class.

Engagement and Motivation from Multifaceted Lessons

Use multifaceted teaching strategies can attract students through their auditory, visual, tactile, or emotional preferences and reinforce learning and memory for all students. Once students are

engaged through their strengths, they will have the motivation to continue. To assure engagement in the initial planning of a new unit, consider using one or more of the following strategies.

1. Multisensory introduction – the more senses stimulated in the introduction, the more intelligences will be engaged.
2. Elements of surprise, novelty, or curiosity, demonstrations
3. The Big Picture: Especially for the global learners, started with some explanation of how what they are about to study relates to their lives or the world around them. When students understand the reasons for what they are expected to learn, they are more likely to be intrinsically motivated to participate actively in the lesson. Otherwise the information may be perceived as unrelated chunks of data, like memorizing a list of people's names without knowing why they are important.
4. Sequential lesson progression: When instruction is planned to progress sequentially there are frequent opportunities for assessment and feedback so students will build on knowledge and skills they have mastered. This sequential instruction uses the mastered material as a solid base upon which to add the more complex concepts or processes.
5. Destressing: For the brain to successfully admit sensory information there must not be the interference of the stress of confusion, anxiety, or frustration blocking data transit through the amygdala's affective filter. That means students must either have the background knowledge to make connections and pattern new information with relational memories, or they must know how to get the support they need to structure new patterns. This might mean some students may need to use calculators because their faulty memory tracking slows their mastery of the multiplication tables. (Later that delay is worked on with extra practice, tutoring, or computer feedback-mastery building programs). Some students may initially need partially filled in outlines upon which to write notes about what they learned about the new topic. *Through practice and more familiarity with the new topic, they will need less scaffolding, but they will not be shut out from the lesson because of the brain-blocking impact of stress.*

When planning lessons consider the strongest motivators and include those that suit the material and learning strengths of the students. The strongest motivators are:

- Choice
- Task variation
- Developmentally appropriate lessons with achievable challenge
- Reinforcement and feedback
- Personal relevance
- Real world connections (e.g. Use ratio and proportion to change a recipe so the correct amount of ingredients are brought in to make cookies in class; use real coins to calculate money problems)
- Intrinsic reward (self acknowledgment of progress as a result of one's practice and effort).

Feedback

Ongoing feedback helps students perceive their progress from an outside perspective or as compared to preset standards. Good feedback can help students see how they are progressing to their short and long-term goals.

Feedback During Lessons: Feedback is a valuable form of ongoing assessment. Ongoing assessment is necessary for keeping all students in differentiated classes actively connected to the lessons. You can provide individual assessment and feedback even during whole class activities using individual white boards on which all students write their answers and hold them up simultaneously or thumbs up or down in response to yes/no questions. Peer teaching, where students who already

understand something explain it to and then gently quiz partners who need more practice can provide feedback during independent work time, but the peer tutors should be limited to volunteers.

Ongoing feedback helps students perceive their progress from an outside perspective or as compared to preset standards. Good feedback can help students see how they are progressing to their short and long-term goals.

You can provide pre-feedback or feed-forward even before students begin a project or paper with rubrics or examples of the work of students from previous years. The latter is especially helpful if you include examples of A, B, and C level papers that match the high, medium, and low criteria included on the rubric. These rubrics and brief conferences as the unit of study advances helps students monitor their progress and adjust their strategies and actions responsively.

Homework Review Before Class

They also solve group problems and get up and move around to discuss their solutions with other students, during these contests. I've also energized the students (Fred Jones) by having them race (timed) to turn in their blue sheets, get out their notebooks and be ready for note-taking.

Rubric Feedback: In differentiated instruction, the rubrics used for all students can be the same. With differentiated goal setting, students can be guided to select the rubric level of success that will be at their achievable challenge level and work toward that rubric level. Rubric-based grading can keep the bar high in differentiated instruction by offering several categories such as quality of work, organization, following the assignment instructions, artwork/charts/graphs, cooperation in group work, grammar/punctuation, etc. so all students will find one or more that the associate with their strengths.

Sample rubrics and on-line programs to make your own rubrics can be found at:
http://rubistar.4teachers.org/index.php
http://janeconstant.tripod.com/Rubrics.htm

TEST SUCCESS

Strengthen Neuronal networks with Review Using Different Learning Strengths

How might children with different sensory learning strengths learn and remember vocabulary words in a lesson or lessons that incorporate?

Auditory (sounds)
Visual (seeing or visualizing)
Kinesthetic (movement)
Tactile (touch)
Interpersonal: such as dramatization, cooperative group activity

You can provide pre-feedback or feed-forward even before students begin a project or paper with rubrics or examples of the work of students from previous years. The latter is especially helpful if you include examples of A, B, and C level papers that match the high, medium, and low criteria included on the rubric. These rubrics and brief conferences as the unit of study advances helps students monitor their progress and adjust their strategies and actions responsively.

Test day preparations: In addition to relaxation and mindfulness techniques, reassurance, and release of anxiety students can be helped out of the basic survival mode that releases the fight/flight hormones and neurotransmitters that overwhelms their RAS and affective filters. Routines the class participates in together before tests can help to release this test anxiety. These can include:

- Laughter at a joke or a funny hat you wear. Even the deep breathing and muscle stimulation of laughter releases endorphins, acetylcholine, and increases oxygen flow. All can be positive biological factors to enhance focus and test performance.
- Confirm that all supplies are available and students have gone to the bathroom, have all needed supplies, books, calculators, notes, and have their water before the test starts. Students who need to leave their seats during the test can disrupt the concentration of classmates.
- Read aloud instructions as students follow along these same instructions in written form. Have students repeat back as you list on the board or overhead their understanding of the instructions.
- Confirm that students know what to do when they finish the test and that they understand what the times written on the board mean – such as time remaining.
- Ideally, practice sessions have taken place in which students have made their own test pacing plans. For example, students who are most challenged by the word problems in math should know to plan extra time to interpret these problems in the ways they have practiced. Remind them before starting the test to calculate how much time they should allocate to these problems and to write themselves a note about what time it will be when they should move on to the word problems.
- Similarly, students have likely had experience understanding the point value system for tests so that before starting each test they can determine and plan to devote the most time to the questions that carry the most point value. Encourage them to write these specific plans down and acknowledge them positively when they use that strategy.
- During lessons there have been key formulas, facts, mnemonics, or acronyms that students have used in the learning of the material. For students who benefit from these memory prompts, remind them to write them all down in margins or at the top of their papers before they even read the questions. In that way they will not be in a state of anxiety (from reading questions they don't think they know how to answer) when they write down their memory hints in their more relaxed and positive state, before they start answering the test questions.
- Explain the reason for the pretest strategies. When students recall that they have been more successful on previous tests and completed more answers accurately when they answer the questions the knew first and came back to the harder ones later, after marking the unanswered questions, they will be encouraged to do so on each subsequent test.

After the test is returned it is time to add to the metacognition list of strategies the students found helpful and evaluate which predictions they made about the test that were correct. Unless students are given time to go over their test results and read your comments, they may never do so. To assure that process, ask students to respond to your comments in writing and remark on the patterns of their errors and then return the tests to you.

Your response to their metacognition will be an extra reminder and the process will assure their accountability for reading your comments and reviewing their tests. As with any process that might cause students to feel criticized or defensive, so you can ask them to first respond to your positive comments and write down what they did to achieve the successes in the areas you praised.

It may be helpful early on to give students suggestions for what to evaluate in their error review such as: Did they leave questions unfinished at the end? If so do they think they knew the answers to some of these and they might have skipped more difficult questions along the way so they could have gotten to the last questions (and gone back as time allowed)? In other words, did they get the most points for their time spent? Were any of their errors due to not following instructions? What could they do next time, such as underlining key words in instructions and rereading them before answering the questions? Were mistakes made because they didn't review sections of the test material, because they didn't focus on the information they were given about what the test would cover, or because they didn't ask for help understanding items they knew would be on the test, but about which they were

confused? Tests returned soon after they are completed will be especially valuable as students learn what they were confused about before going too far into the next unit that builds on the previous information.

Brain needs body exercise also

Children are watching television an average of five hours a day! By the time a child graduates from high school, she will have spent about 15,000 hours in front of a television and 12,000 hours in the classroom

Overweight children also have slightly lower school achievement, on average

Studies of about 200 overweight, inactive children ages 7-11 Medical College of Georgia showed that a regular exercise program reduces body fat and improves bone density, and
a healthier metabolism improves ability to handle life. All study participants learned about healthy nutrition and the benefits of physical activity; one-third also exercised 20 minutes after school and another third exercised for 40 minutes. Children played hard, with running games, hula hoops and jump ropes, raising their heart rates to 79 percent of maximum, which is considered vigorous.
"Aerobic exercise training showed dose-response benefits on executive function (decision-making) and possibly math achievement, in overweight children," "Regular exercise may be a simple, important method of enhancing children's cognitive and academic development. These results may persuade educators to implement vigorous physical activity curricula during a childhood obesity epidemic."

Functional magnetic resonance imaging studies, which show the brain at work, were performed on a percentage of children in each group and found those who exercised had different patterns of brain activity during an executive function task.
For this study, researchers gave the children tests that look at their decision-making processes. In the first such studies in children, the researchers found small to moderate improvements in children who exercised as well as a hint of increased math achievement.
Executive function was measured using the Cognitive Assessment System and math skills using the Woodcock Johnson Test of Achievement III.

Exercise increases the production of neurotrophic factor in the hippocampi (in rat brain research), a brain protein encourages brain cells to sprout synapses. Exercise prevents the negative effects of chronic stress on the brain at the molecular level and boosts the brain's biological battle against infection. John Ratey of Harvard Medical School "Spark: *The Revolutionary New Science of Exercise and the Brain,"* A California Department of Education study shows a correlation between the number of state physical fitness standards children meet and how well they score on reading and math tests. School running clubs many elementary school running clubs the emphasis is on fun, not competition. Some as young as kindergartners walk and mothers do laps with students sometimes while pushing strollers. At other schools, some students circle the playground in wheelchairs. Running club organizers typically keep track of laps run and motivate students with rewards such as water bottles, T-shirts easy they are to start: no equipment, no uniforms and just a few people to count laps.

Care, Food, and Watering of the Brain

Nutrition and Brain

University of Alberta, researchers surveyed around 5000 Canadian fifth grade students with an **increased fruit and vegetable intake** and less caloric intake from fat were 41% less likely to fail the literacy assessment.

ENERGY DRINKS
Wake Forest University Baptist Medical Center in Winston-Salem, N.C.
Dr. O'Brien surveyed **energy drink** and alcohol use among college students at 10 universities in North Carolina. The study, published this month in Academic Emergency Medicine, showed that students who mixed energy drinks with alcohol got drunk twice as often as those who consumed alcohol by itself and were far more likely to be injured or require medical treatment while drinking. Energy drink mixers were more likely to be victims or perpetrators of aggressive sexual behavior. The effect remained even after researchers controlled for the amount of alcohol consumed. High school students drink as many as five cans a day.

ENERGY DRINK WITHDRAWAL: Many energy drinks have the same caffeine, and some have more-manufacturers aren't required to disclose caffeine content. The popular drinks and how they can contain high amounts of sugar as well as caffeine. Children are more sensitive to caffeine than adults and already have plenty of energy. Many energy drink consumers develop caffeine dependency and withdrawal: Headache, Fatigue, Difficulty concentrating, nausea and muscle pain Withdrawal starts after 12-12 hours, peaks after 1-2 days

Did You Know?

Topics for discussion with your colleagues

Through neuroimaging studies (of the amygdala, hippocampus, and the rest of the limbic system and through measurement of dopamine and other brain chemical transmitters) we now have visible evidence that there is a profound increase in long-term memory and higher order cognition when students have trust and positive feelings for teachers, and supportive classroom and school communities.

The more dopamine students have released by positive emotional experiences (in school and out) the less likely they are to seek dopamine/pleasure surges from high risk behavior of drugs, alcohol, promiscuity, risky fast driving, overeating. More sports, music, dramatics, and enjoyable learning = less high-risk behavior and suicide in teens. This brain research demonstrates that superior learning takes place when classroom experiences are enjoyable and relevant to students' lives, interests, and experiences.

Learning connected with positive emotional significance that leads to the new information being stored in long-term memory. Learning associated with strong positive emotion is retained longer, and stress/anxiety interfere with learning, so those lessons do not sustain for end of the year testing, even if students pass unit tests.

Syn-***naps***: Any pleasurable activity (singing, walk about the room and chat with friends, listening to music, having a few pages of a class book read aloud to them, or sharing jokes) used even as a brief break can give the amygdala a chance to "cool down" and the neurotransmitters time to rebuild as the students are refreshed.

Dopamine release (and the pleasure associated with it) has been found highest in school children when they are moving, laughing, interacting, being read to, feel a sense of accomplishment, and when they have choice.

The last part of the brain to mature (through plasticity and pruning is the prefrontal lobes. Children and many teenagers do not have fully developed delayed gratification skills during their school years. The prefrontal regions are major participants in the executive function networks of judgment, prioritizing, and delayed gratification processing. This is one reason students from kindergarten through high school continue to need support and encouragement from their teachers to keep their efforts directed on long-term goal achievement.

A longitudinal study of middle schoolers noted that teachers who emphasize competitive comparisons of student ability discourage students from asking for help.

For children with attention focusing difficulties, each time they focus their attention they are activating the brain's alerting and focusing pathways. This repeated stimulation of these pathways makes the neural circuits stronger and increases their ability to actively direct their attention where it is needed.

Enthusiasm is generated when children are presented with novelty and find creative ways to explore or connect with the new material and are inspired by it. Whenever you can generate this awe and sense of wonder, your children will be pulled into the school lessons they bring home and they will be motivated to connect with the information in a meaningful way.

Students experience a greater level of understanding of concepts and ideas when they talked, explained, and argued about them with their group, instead of just passively listening to a lecture or reading a text.

Use more senses: The experiential education motto is that you learn 40% of what you hear, 60% of what you hear and see, and 80% of what you hear, see, and do.

Useful Definitions

Acetylcholine: A neurotransmitter that stimulates multiple brain centers including the hippocampus, brainstem, and forebrain where new learning takes place. Associated with attention and focus.

Affective filter: Steven Krashen, in his studies of linguistics developed a theory of language acquisition and development that included the hypothesis of an affective filter. He described higher success rate of second language acquisition in learners with low stress and slower language acquisition when stress was high. He postulated that anxiety and low self-image created a mental blockade that filtered or blocked out new learning. The term is now generalized to refer to an emotional state of stress in students during which they are not responsive to processing, learning, and storing new information. This affective filter is represented by objective physical evidence on neuroimaging of the amygdala, which becomes metabolically hyperactive during periods of high stress. In this hyperstimulated state, new information does not pass through the amygdala to reach the information processing centers of the brain.

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 senses threat, it becomes overactivated (high metabolic activity as seen by greatly increased radioactive glucose and oxygen use in the amygdala region on PET and fMRI scans). In students, these neuroimaging findings are seen when they feel helpless and anxious. When the amygdala is in this state of stress, fear, or anxiety-induced overactivation, new information coming through the sensory intake areas of the brain cannot pass through the amygdala's affective filter to gain access to the memory circuits.

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

Brain Mapping: Using electrographic (EEG) response over time brain-mapping measures electrical activity representing brain activation along neural pathways. This technique allows scientists to track what parts of the brain are active when a person is processing information at various stages of information intake, patterning, storing, and retrieval. The levels of activation in particular brain regions are associated with the intensity of information processing.

Brain Stem: The brain region between the spinal cord and the rest of the brain. This is also where nerve centers essential for basic survival, such as heart rate, breathing, digestion, and sleep, are located.

Cerebellum: The lower posterior region of the brain that supervises coordinated movement, posture, and balance and adjusts actions in response to external cues, such as where your foot is in relation to the step. The greatest numbers of connecting neurons to and from the frontal lobe are in the cerebellum such that this region appears to influence higher cognitive processes such as reasoning.

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.

Computerized Tomography (CT Scan, CAT scan): This scan uses a narrow beam of x-rays to create brain images displayed as a series of brain slices. A computer program estimates how much x-ray is absorbed in small areas within cross sections of the brain to produce the image.

Dendrite: 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. Proteins called *neurotrophins*, such as nerve growth factor, stimulate this dendrite growth.

Dopamine: A neurotransmitter most associated with attention, decision-making, executive function, and reward-stimulated learning. Dopamine release on neuroimaging 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 acknowledgement (e.g. praise) for achievement.

EEG (Electroencephalogram): EEG measures the electrical activity occurring from transmissions between neurons in the cerebral cortex.

Executive Function: Cognitive processing of information that takes place in areas in the left frontal lobe and prefrontal cortex that exercise conscious control over one's emotions and thoughts. This control allows for patterned information to be used for organizing, analyzing, sorting, connecting, planning, prioritizing, sequencing, self-monitoring, self-correcting, assessment, abstractions, problem solving, attention focusing, and linking information to appropriate actions.

Frontal Lobes: With respect to learning, the frontal lobes contain the centers of executive function that organize and arrange information and coordinate the production of language and the focusing of attention.

Functional Brain Imaging (Neuroimaging): The use of techniques to directly or indirectly demonstrate the structure, function, or biochemical status of the brain. *Structural* imaging reveals the overall structure of the brain and *functional* neuroimaging provides visualization of the processing of sensory information coming

to the brain and of commands going from the brain to the body. This processing is visualized directly as areas of the brain "lit up" by increased metabolism, blood flow, oxygen use, or glucose uptake. Functional brain imaging reveals neural activity in particular brain regions as the brain performs discrete cognitive tasks.

Functional Magnetic Resonance Imaging (fMRI): This type of functional brain imaging uses the paramagnetic properties of oxygen-carrying hemoglobin in the blood to demonstrate which brain structures are activated and to what degree during various performance and cognitive activities. Most fMRI scan learning research has subjects scanned while they are exposed to visual, auditory, or tactile stimuli and then reveals the brain structures that are activated by these experiences (exposures).

Graphic organizers: Diagrams that are designed to coincide with the brain's style of patterning. For sensory information to be encoded (the initial processing of the information entering from the senses), consolidated, and stored the information must be patterned into a brain-compatible form. Graphic organizers can promote this more patterning if they guide students' brains when they participate in this creating of relevant connections to their existing memory circuitry.

Hippocampus: A ridge in the floor of each lateral ventricle of the brain that 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.

Limbic System A group of interconnected deep brain structures involved in olfaction (smell), emotion, motivation, behavior, and various autonomic functions. Included in the limbic system are the thalamus, amygdala, hippocampus, and portions of the frontal and temporal lobes. If the limbic system becomes overstimulated by stress-provoking emotion (seen as very high metabolic activity lighting up those brain areas) the information taught at that time will be poorly transmitted or stored in the long-term memory centers.

Metacognition: Knowledge about one's own information processing and strategies that influence one's learning that can optimize future learning. After a lesson or assessment, when students are prompted to recognize the successful learning strategies that they used, that reflection can reinforce the effective strategies.

Neuronal Circuits: Neurons communicate with each other by sending coded messages along electro-chemical 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.

Neuron: 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.

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 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.

Occipital Lobes (visual memory areas): These posterior lobes of the brain processes optical input among other functions.

Parietal Lobes: Parietal lobes on each side of the brain process sensory data, among other functions

Plasticity: 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).

Positron Emission Tomography (PET scans): Radioactive isotopes are injected into the blood attached to molecules of glucose. As a part of the brain is more active, its glucose and oxygen demands increase. The isotopes attached to the glucose give off measurable emissions used to produce maps of areas of brain activity. The higher the radioactivity count, the greater the activity taking place in that portion of the brain. PET scanning can show blood flow and oxygen and glucose metabolism in the tissues of the working brain that reflect the amount of brain activity in these regions while the brain is processing information or sensory input. The biggest drawback of PET scanning is that because the radioactivity decays rapidly, it is limited to monitoring short tasks. Newer fMRI technology does not have this same time limitation and has become the preferred functional imaging technique in learning research.

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

Quantitative Encephalography (qEEG; brain mapping): This brain wave monitoring provides brain-mapping data based on the very precise localization of brain wave patterns coming from the parts of the brain actively engaged in the processing of information. Quantitative EEG uses digital technology to record electrical patterns at the surface of the scalp that represents cortical electrical activity or brainwaves. "Functional" qEEG testing adds recording to evaluate the brain's responses to reading, listening, math, or other demands and provide visual summaries in topographic maps.

Reinforcement Learning Theories: Theories (such as *Dopamine Reward Learning*) based on the assumption that the brain finds some states of stimulation to be more desirable than others and makes associations between specific cues and these desirable states or goals.

Relational Memory: Learning consists of reinforcing the connections between neurons when students learn something that adds to what they have already mastered that expand on neuronal networks already present in the brain.

Reticular Activating System (RAS): This lower part of the posterior brain filters all incoming stimuli and making the “decision” as to what people attend or ignore. The Reticular Activating System 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 need, choice, and novelty.

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

Somatosensory Cortex Areas: One in each parietal brain lobe where input from each individual sense (hearing, touch, taste, vision, smell) is ultimately processed.

Survival Level of Attention: Ideally students are beyond a basic survival mode and can direct attention to more than just avoiding danger. However, too much stress can push them into this survival mode. This can occur when students feel confused and overwhelmed by a classroom experience such that they cannot connect with, focus on, and create patterns and meaning from lesson's sensory input data.

Synapse: These gaps between nerve endings are 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 as a chemical message, information is carried in an electrical state when it travels down the nerve. It is through synaptic transmission that cells in the central nervous system communicate when an axon sends a neurotransmitter across the synaptic cleft to activate the receptor on the adjacent dendrite.

Temporal Lobes: These lobes on the sides of the brain process auditory and verbal input, language and phonetic discrimination, mood stability through projection fibers leading to limbic system, and learning.

Venn Diagram: A type of graphic organizer used to compare and contrast. The outer areas are for differences and the similarities are listed in the middle area.

Working Memory (Short-term memory): This memory can hold and manipulate information for use in the immediate future. Information is only held in working memory for about a minute. The memory-working span of young adults is approximately seven for digits, six for letters, and five for words.