A dozen important brain based learning concepts

Creating a brain based classroom

A dozen important concepts and teaching strategies every teacher (and parent) should know about how the brain learns best

This page is dedicated to a dozen specific concepts from the most recent literature on brain based learning (educational neuroscience). The following list was compiled from those concepts **most** recommended by my graduate students as important for teachers to know, understand, and put into practice. These students are also practicing teachers from all levels, from many different content areas, and at different levels of experience. The concepts discussed here were chosen for one or more of the following reasons – because they:

- Are in direct contradiction to traditional or historic teaching practices;
- Are currently missing from many schools or classrooms;
- Are important accommodations to students' cognitive processing;
- Could radically change teachers' presentation methods and the ways in which instruction is designed or delivered;
- Have the potential to help children be better students, as well as help them remember and retain information.

After each idea I have included a segment entitled – **What needs to change?** This area contains ideas that either explain the concept in more detail, and/or offer suggestions for implementation. In some cases the concept comes with additional online resources for readers to investigate. Over time I may update and add to these resources.

Please, if you find this information useful, pass it on to other educators, and to parents. In some cases the information may also help older students gain a better understanding of their own metacognitive processes. Key word here – SHARE! There are links to some outstanding related resources throughout, please explore these too.

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1. Windows of Opportunity – All teachers are taught about *developmental ages and stages*. They know that teaching a skill beyond a students' developmental stage often means risking learner frustration, or is usually a waste of instructional effort and time because the student is not physically, emotionally, or mentally ready to attempt the skill or understand the information presented.

However, within each level of development there also exist "***Windows of Opportunity***." These refer to specific periods in brain development whereby certain skills can be learned **best or optimally**. These too are age-specific periods in relation to the development of the brain that allow for creating and consolidating neural networks.

If this "window of opportunity" tapers off without learning a specific skill, the chances of learning that skill optimally are reduced. While **neuroplasticity** (the ability of the brain to reorganize itself based on need) allows humans to learn continually, missing the optimal "window of opportunity" means the learner may not have the same degree of success or ease of learning as during the optimal time in brain development. More specifically, missing an age specific window of opportunity can impose long-term consequences in regards to learning or practicing certain types of motor development; emotional control; spoken language; math and logical thinking; instrumental music; etc.

What needs to change? Curriculum and instructional planning.

There needs to be a critical curricular alignment of skills and concepts not only to developmental stages, but also to ***windows of opportunity*** in brain development. As Americans are suffering from a national blight of "let's test our kids to death" crazies, and in this frenzy we seem to be forgetting why taking developmental stages, and progressions in brain development are so crucial in designing good instruction. The first reason, we cannot teach what children are not developmentally ready to learn, and second, if we miss the "window of opportunity," they don't get it back!

For instance, the critical period for learning grammatical structure of one's first or primary language ends around the onset of puberty. This means that children need to be exposed to rules of grammar and correct grammatical models and prototypes **before** they reach puberty for optimal understanding to take place.

Additionally, between birth-5 the brain is hard-wired to learn **multiple languages** and this window of opportunity gradually closes ending at about age 10. Obviously this doesn't mean that one cannot learn a foreign language after that age as the brain retains its ability to decode, find patterns and learn vocabulary. But the ability to speak another language or to reproduce the unique phonological sounds like a native speaker begins to shut down at the beginning of puberty. And yet American schools generally first offer elective foreign language classes in middle or junior high, or even later in high school. How come? If we know from neuroscience that the optimal window for best learning another language begins to change at 10 years old, shouldn't we begin foreign language instruction early in elementary school instead of later?

More information -

- PDF of **Developmental ages and stages overview and brain development**
- New Zealand – Wonderful short PDF file **on the social, emotional, visual, reading, thinking, and motor windows of opportunity from birth-4**. In my mind this publication should be given to ALL parents.
- **YourVoice** – A video interview with 3 experts on children and learning foreign languages.

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2. Reading is not innate – Author David Sousa states that "there are no areas in the brain that specialize in reading (193)." Apparently our genes were not encoded with reading into their structure as it was not a survival skill.

Reading is the process of melding three systems (visual, auditory, and understanding/comprehension) that need to work together in order for children to learn to read. Since reading isn't a natural ability, this may explain why many people have trouble with acquiring this skill. It is one of the hardest things we ask young brains to do. Therefore, teachers need to have adaptive rather than rigid approaches to teaching reading as different children learn to read in significantly different ways. Specifically reading includes the following separate skills: phonological or phonemic awareness; alphabetic principles and phonics; vocabulary; fluency; and text comprehension. Add to these the actual physical ability and coordination to visually track smoothly words across the page and we can see how complex and multidimensional this skill truly is.

In reading functions such as *fluency*, literacy at home often determines a child's success in acquiring that skill in school. **It is imperative that educators, politicians, parents, and the general public support programs that bring books and reading to children early in life no matter what their income level.**

It is also imperative at all levels of education that teachers understand if they want students to understand text, students must first be able to concentrate on chunks of text and not get caught up in the smaller, individual pieces (decoding, etc.). How many of us have seen children who when asked to read aloud are good at decoding phonemes and appear to be reading fluently, but when they are asked what they read and what it meant, they could not recall or comprehend textual meaning?

What needs to change? Instructional methods and time allocations for reading and comprehending.

In addition to continuing to support early literacy programs and parents' efforts at introducing children to books and reading early, at instructional levels time allocations need to change for students who have difficulty reading and comprehending written language. Teachers can help students move into the area of content understanding by providing pre-reading, and post-reading activities, related exercises, and support and scaffolding.

Variable time allocations need to be offered as good readers often complete assignments easily needing less time for understanding. They can be offered accelerated or enriched assignments. Those having difficulty reading and comprehending written language need additional academic support and possibly added instructional time. Reading is definitely not a one size fits all skill and educators, as well as the scheduling in schools, must become more personalized and flexible, thus meeting the needs of different types of readers. This mass one size fits all approach to education is not working very well for many of our children.

3. Complexity and Difficulty – Teachers need to be able to discern the differences in "complexity" and "difficulty" in cognition. **Complexity** describes the thought process the brain uses to deal with information. For example if you move up the steps in the revised version of **Bloom's Taxonomy**, ***analyzing*** is cognitively a more complex process than ***remembering*** and takes the learner up the scale to a higher order cognitive function.

Difficulty refers to the amount of **effort** the learner must expend within a level of complexity in order to accomplish a learning objective. Many teachers incorrectly assume that increasing the difficulty will challenge students to think in a more complex way. **Not true!** This could be because many teachers do not recognize the differences between the two concepts. Often what happens is teachers simply give students **more of the same thing** rather than increasing the complexity of the learning task.

What needs to change? Curriculum and instructional planning - Teachers need to track both the difficulty and the complexity of their assignments.

As students most of us have experienced being given endless problems in math class. Why have students do 20 arithmetic problems of the same difficulty, when they may be able to get the concept through doing 5 or 10 problems as rehearsal? To increase and challenge cognitive growth we could throw in some of the higher order thinking problems and raise the **complexity** of their thinking as they are engaged in the challenge. Change the degree of **complexity** and bump up exposure to higher level cognitive functions rather than just endlessly increasing the **difficulty** of a learning task.

Here is another paramount concept rarely displayed by American teachers, and it goes along with metacognition. Older students can learn to examine problems and match the "complexity" inherent in the problem based on **Bloom's new categories**, thus identifying and sharpening their metacognitive awareness at the same time they are solving problems.

One of the easy ways to demonstrate this is to reveal and model personal internal dialogs to students. I used to tell my classes of problems I encountered and relate how I went about solving them with internal dialogs. Or, if we had a problem in class, then I would encourage collective dialogs examining the complexity of a problem and then brainstorming possible solutions. On content related problems or in math, I frequently used pair shares whereby partners had to share how they would solve a problem before completing it. I also encouraged students to "FIND" problems and bring those to class for discussion. While these types of actions take time, by using techniques like internal dialogs and the examination and discussion of problems jointly, we are actually teaching students how to think better and at more complex and diverse levels.

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4. Brain Fuel – water, oxygen, glucose - The human brain consumes 20% of the body's calories and needs a constant supply of water, oxygen, and glucose to function at optimal levels. The lack of any one of these can significantly affect a student's learning, but when balanced properly can improve working memory, attention, and motor functions.

Because learning is a complex process carried out by one of the most complicated and nutrient-needy organs in our body, we can't expect it to happen at optimal levels if we don't feed and condition it properly. The brain consumes glucose and oxygen for fuel and requires water to move neuron signals. Exercise keeps oxygen flowing to the brain, and makes it possible for our brain to generate more neural connections. Ironically, as administrators are cutting programs, costs, and things like recesses in favor of more time spent on required tests and coverage, **what they don't seem to realize is they are cutting the very programs that might help kids perform at their best on intellectual tasks**.

What needs to change? How schools are designed and planned, and specifically we need to examine how we support children's general and neurological health.

Most schools have policies restricting eating and drinking in classrooms, but the best brains are fed and watered. Every classroom needs a water fountain or a ready source of water. Past the primary years students are expected to sit quietly in their seats. We now know that simple exercises such as running-in-place, jumping jacks, or cross body movements can work well in a school setting to get the blood pumping and oxygenated and rev up the thinking brain. Exercising for two short minutes oxygenates the blood.

Eating fresh or dried fruit provides glucose and is an essential fuel for optimal brain function. Small packages of dried fruit or raisins are convenient and relatively mess-free. Drinking an 8 ounce glass of water not only hydrates the brain, but gets glucose and oxygen in the blood to the brain faster. All of this information needs to be communicated to parents with suggestions for their children's diet and exercise.

If we want all kids at all ages to think better in schools, then we need to offer opportunities for the brain to be nourished and receive the rewards of oxygenated blood through exercise and movement.

More information-

- **Smithsonian** – Why does the brain need so much power?
- **Scientific American** – Does thinking really hard burn calories?

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5. Understanding the brain's emotional nature and connections are key to storing and unlocking memories - Through research we have found that the limbic portion of our brain (hypothalamus, thalamus, hippocampus, and amygdala) regulates our emotions and emotional memories. Deep in the center of the human brain this system is connected to all other parts of the organ. Understanding the functions of this system are key to recall and memory as it is this portion of the brain that decides what gets stored in our longterm memory. This is also the area of the brain that regulates interactions between our cerebrum and the autonomic functions of our brain stem.

The limbic portion of the human brain is closely tied to human survival instincts. When we are under stress or frightened we know that stress releases a hormone called cortisol. It is this substance when released and circulated through the body creates defensive behaviors – our fight or flight responses. It is important for us to know about this cycle because once triggered it can severely interrupt higher order thinking.

This need for safety and freedom from emotional turmoil in learning environments is reiterated time and again in the literature surrounding educational neuroscience. In the classroom the comfort level of students, as well as their levels of self-confidence, often have a lot to do with teacher-student interactions and peer-to-peer interactions. Once the brain processes an outside stimulus as threatening, a rush of adrenaline is sent to the brain. All unnecessary stimuli are put away so the brain can focus on the things at hand that pose an immediate threat.

These facts are important because in establishing positive learning environments educators must put students' safety and comfort as high priorities. Maslow was right when he created his ***Hierarchy of Needs*** as brain-friendly learning atmospheres need to be free of undo stress and threats before learners can pay attention or care about learning objectives. If students feel physically or emotionally threatened, they will never learn what teachers set forth.

The other key issues surrounding learning and emotions that need to be understood and remembered by all teachers are 1) it is emotion that directs our attention, and 2) our emotional reactions to past experiences play strongly into positive and negative transfer. Because of our rudimentary survival instincts, humans pay attention to those things that trigger strong emotional responses **far faster and with more attention** than those things that attract us through logic or reason. We need to fully understand the power of this connection and use it to help educate students.

We also need to be aware of how to use past learning experiences to explore positive transfer of new information. Due to the emotional nature of the brain, positive and negative experiences play into remembering new information. Teachers need to be aware of learners' histories and use those experiences to help students create positive emotional triggers to memories.

What needs to change? Learning environments need to be examined to assure that learners are feeling safe and secure. Educators also need to be aware of learners' histories and use those to aid memory.

It is important for teachers to create a warm and welcoming classroom built on trust and respect. In a positive learning environment the brain is more likely to release endorphins, the hormones responsible for a sense of euphoria and pleasure and which stimulate the frontal lobes of the brain – the thinking command center. The world today is such an invasive place, school environments are no longer as safe as they once seemed. Educators need to diminish both external and internal threats by monitoring classroom policies and their own behaviors toward students as well as student-to-student interactions. Teachers also need to be vigilant in preventing bullying and abuse by peers.

Additionally, teachers need to pay attention to emotional triggers during teaching and presenting. If indeed attention follows emotion, then teachers need to use that knowledge in helping students remember and learn by utilizing emotional triggers. Making connections to stories, to students' interests, to things that are relevant to their lives all add emotional layers to teaching and help gain attention.

6. Chunking – The working or immediate memory has capacity limits, about 5-9 items in adolescents and adults. Chunking is a strategy to increase the capacity of the items that can be functionally held in the part of the brain known as the "immediate" memory. The brain can only process limited amounts of information sufficiently and these differ with age. By understanding this concept, teachers can deliver just the right amount of information without overwhelming their students' brains. **"Chunking"** occurs when the working memory perceives incoming data that is collective as a single item as in often used telephone numbers, the alphabet song, etc.

Remembering a phone number is a perfect example of how we naturally chunk information as we remember it as related sets of numbers instead of a single sequence of unrelated numbers – for instance 877-555-0123 rather than 8-7-7-5-5-5-0-1-2-3. Most of us break phone numbers into two groups of 3 and then one of 4 rather than an impossibly long group of 10 unrelated numbers.

What needs to change? Instructional aids and informing students of methods they can use in order to best utilize the chucking principle to increase retention.

Teachers need to pace delivery so that it reflects limitations in the working memory. Also, they can either orchestrate chunking for students, or teach them how to do it. For instance a conceptual, well-rehearsed mindmap can visually chuck lots of discreet bits of information into a single visual concept for better retention.

More information: If you or your students are interested in learning more about mindmaps, there are some commercials sites that also offer information about the concept, plus there are software programs that create learning webs and mindmaps.

- **Tony Buzan** is one of the premiere inventors of the concept and he has a number of books on the topic
- **Mindmap.com**

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7. Sense, meaning and relevance – Innately we know that brain storage is not limitless, and so the human brain allows us to discriminate as to which concepts and ideas should be placed into the working memory on its way to the longterm memory. This process takes place in about a **30 second time span**. In deciding what to remember our brains ask *"Does this make sense?" and "Does this have meaning?"* Of these two criteria, "meaning" appears to have a greater impact on the probability that information will be stored for recall, especially if it has **personal meaning**. In this process past experiences can aid or impede the determination as whether a student can process certain information.

What needs to change? Grounding the information presented in personal meaning or future relevance.

We can help our students to build or connect meaning with what they learn by relating to students' interests, creating models, or by artificial memory devices such as acronyms, humor, anecdotes, metaphors, personal stories and histories or using positive emotive experience in the classroom. It will

also help students if they have opportunities to summarize what they have learned, or by them finding interest and motivation within our topics. Humans make very quick decisions as to whether or not incoming information is usable, or needs to be remembered. **This process takes all of about 30 seconds**.

It is important for teachers to know and understand their particular constituencies so they can make meaningful connections, and provide cogent examples. It is also important for teachers to frequently review their stories, metaphors, and examples used so they are up to date and reflect the experiences and culture of their audiences. There is something that is **non-referential** teaching. This is when teachers use examples, metaphors or stories that have little or no meaning to students. Teachers need to review materials so that this does not happen.

Memories are not stored intact but in pieces. The more understanding and meaning that can be attached to information, the more likely it will be stored in different networks giving students more avenues for retrieval. One of the key elements in facilitating recall are emotions as these help students assign understanding and meaning to new information and help to solidify the information during the storage process.

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8. Retention varies with teaching method and time allocations – The length of retention is directly proportional to the model or method used. Unfortunately while still used in direct instruction and as a primary method in delivering large amounts of information, *lecture* is one of the **least effective** teaching methods, with *discussion* as mid-range method for retention, and *teaching others* the most about at about a 90% retention rate.

What needs to change? Methods of instructional delivery and focusing curricula on key concepts.

While children and adults have different attention spans, both are limited. (Yes adults out there, you have trouble with lectures longer than 20 minutes too!) Educators at all levels need to re-examine their teaching and presentation methods as retention increases with carefully orchestrated time allocations. To optimize learning, switch types of tasks during timed intervals. Teaching in limited segments within a longer teaching period increases student attention and retention. For instance, if you have older students for a 40 minute period, their retention and attention will increase if tasks are divided into 10-20 minute segments, while preadolescents need more frequent changes at 5-10 minute intervals. Even adults have difficulty focusing and need things changed up every 15-20 minutes.

More information:

While a commercial site promoting the **works and videos of Geoff Petty**, he is one of Britain's experts on teaching and his site has lots of good free links on teaching and learning. Check out the PFD downloads.

This is article is about **lecturing and alternatives for college students**. Despite that focus, the article has lots of useful information about how to institute changes into old teaching habits.

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9. Rehearsal increases retention, but there are different types of rehearsal - Simply and emphatically put, there is no long term retention of cognitive concepts without rehearsal of some kind. The continued reprocessing of information and interaction with information is called "rehearsal" and this activity is essential if information is to be embedded from the working memory into the long-term memory. Because a teacher spends longer time on selected information does not always increase retention. It is the quality of the interaction that determines if it will be remembered. There are also different types of rehearsal and each type has a different level of effectiveness in regards to retention - **rote rehearsal; elaborate rehearsal, and then within those massed practice; or sustained or distributed practice**.

Rote rehearsal (or maintenance rehearsal) is effective in storing information when the learners need to use it in the exact form that it was presented. **Elaborate rehearsal** needs to be used when learners will be required to connect information later to new learnings and with other information. This type includes organizing, thinking about and linking new material to existing memories.

Within these types of rehearsals is **massed practice**. Practicing new learning during time periods that are close together are called "massed practices" and produces fast learning. "Cramming" for a test is a form of massed practice. And while this type of rehearsal places materials in the working memory quickly, if it has no sustained meaning to the learner or more elaborate rehearsal after its immediate use, the information or knowledge is dropped and often forgotten.

Sustained practice over time is also called "distributed practice." We are more likely to place material learned from sustained practice or distributed practice in the long term memory for retrieval over a longer time period. It is therefore important to have students revisit or review concepts learned over longer periods.

What needs to change? Allocation of time in class for rehearsal, and certainly informing student about different types of rehearsal techniques, and as well as training them in effective metacognitive strategies.

Being deliberate and allowing enough time for rehearsal during class will increase students' abilities to retain information. For instance, if you have to use lecture or direct instruction as a method of delivery, stop periodically giving students a task whereby they are discussing the materials, or offer ways for them to interact with the information or concepts in a different way. **Because you said something does not mean that your students took it in or will remember it.** If you are lecturing, offer students opportunities to rehearse information. For instance, instance every 15 minutes students could be asked to compare notes with their neighbors exchanging and justifying concepts they deemed most important.

Discuss metacognition (thinking about one's thinking) offering suggestions of different techniques that students can use to rehearse information in more elaborate ways other than "cramming."

Making rehearsal an integral part of learning is key in helping students retain and remember what they have learned. This type of rehearsal creates connections between new information and prior learning. **Thus, elaborate rehearsal is far more effective than rote rehearsal in creating meaning and in facilitating enduring learning.**

Instruction that is content-based and intended to help students memorize facts that will be built upon later, whenever possible, should be reviewed and linked to other information. Teachers should provide advanced organizers or other ways to link new information to past experiences or previously studied knowledge from earlier in the course, or link it to class discussions, or to students' lives thus creating multiple linked memory links.

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10. Primacy-recency effect – This is one of those concepts that fly in the face of traditional classroom routines and structure. Apparently during a learning experience we remember best that which comes first, second best that which comes last, and least that which comes just past the middle of the timed period. This means that a teacher should teach a **new topic first** rather than doing things like giving back homework, or taking attendance, or lunch count at the start of class. We waste valuable prime time with housekeeping chores when these could be completed during the middle times of class or in ways that do not interrupt learning.

The beginning and end of a class are known as "prime-times 1 & 2". In accordance to this fact of memory and the primacy-recency effect, the time in the middle should be used as down-time or the time to practice and expand upon new material. Focusing teaching efforts at the beginning and end of class are the most important times to offer new material.

What needs to change? – Adjust instructional delivery so that you are taking advantage of the prime-recency effect using prime times 1 and 2 to the best advantage for quality learning.

This concept means that the current structure of teaching needs to change dramatically in many classrooms. New information should be taught first and a review of older material and daily classroom tasks should take place during the down - time, not during the "prime - times" for learning. There are peak times within a 40 minute learning event when information is best delivered, received, and stored. New information is received best at the beginning and ending of the learning time period. As downtime is in the middle of the class period, this is when housekeeping chores like attendance and paper return should take place, or when tasks like rehearsal or review should take place.

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11. The brain needs novelty – I don't think there are too many folks who would dispute that there are many differences between the way that children grew up and learned in the past, compared to those kids of today. Students now are used to a fast-paced lifestyle -- overly busy schedules, expectations to perform, technology everywhere, even dominating their social interactions. All of these things keep the brain on its toes.

Gaining students' attention becomes an issue in the classroom when educators use the same style of teaching (especially the "sage on stage" model, and excessive passive learning). Frequently more traditional educators don't take into account how students' brains work or how today's learners responds to educational environments. As educators, if we know that the human brain is lured by novelty, and that which is different or unusual, then we need to use this to our advantage by surprising our students with new ways of learning and emphasizing content and processes that are both pertinent and interesting.

What needs to change? Presentation methods and types of content.

Please do not think that I am implying that classrooms need to become centers for "edutainment" or that teachers need to become clowns and magicians. But many educators and parents are crippled in their thinking by what I term "toxic nostalgia." This is where memories of what was conflict with current realities and strongly interfere with what could be better.

The existing reality of the culture in America and in other parts of the world is that children, even ones who cannot read or write, and especially ones in their teens, have access to a myriad of visual and sensory stimuli far beyond those today's adults ever imagined. Despite this reality schools and teaching have been generally slow to change their methods of presentation and teaching often opting to keep things the same – "what was good enough for me is good enough for kids" attitudes. Exploring how things might change rather than insisting that methods of teaching stay the same would improve both retention and children's willingness and hunger for interesting and novel educationally related experiences. Perhaps aligning content with different types of presentations will help assure that things are better attended to and remembered.

There is an adage that fits here – "if you want material to be remembered, than make it memorable." In a sea full of people in black clothing it is easy to remember the women wearing a bright red flower on her dress, and conversely it is easy to remember the person all in black in a group of people with overly bright and busy clothing. There are also more tools at teachers' disposals today that might help them find unusual examples to present to students. These aides might help grab attention by appealing to the human brain's need for novelty.

Here are some suggestions:

- YouTube; and some Wikipedia examples have embedded audio and video feeds; also online lectures, and podcasts;
- **TED Talks Presentations ;**
- **Media that Matters ;**
- There are many wonderful TV companion websites like those offered through resources like

    - **PBS** Org.**;**
    - **National Geographic ;**
    - **Smithsonian** ;

- Games, puzzles, contests, real life problems, quests
- Poetry, rap, music, song, sketches, humor
- Different grouping configurations

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12. Multitasking is not something that the brain is able to do - Although many people think they can do it, especially children/students these days, the brain is not able to focus on more than one thing at a time. When it does try, it ends up having to switch between the subjects, therefore causing a loss in what the brain is able to remember. An interrupted brain takes 50% longer to complete something and results in 50% more errors. This should be addressed in every classroom or learning environment in order for students to get the most of their time spent studying or learning.

What needs to change? Time allocations for tasks, and the addition of flexible scheduling.

ln essence, when students are focused on a task, they should not be distracted or given another task. Make things clear from the beginning and allow them enough time to complete the task.

More resources:

Want to learn more about brain based education/educational neuroscience? Here are some prime links

Edutopia on brain-based learning – Lots of links to varied resources and also to an array of video interviews on experts in the field, this site has it all.

Edutopia - Six tips for brain-based learning – A wonderful resource for both teachers and parents on some of the highlights of brainbased education in PDF format.

Eric Jensen on Brainbased Learning – An overview by one of the national experts and gurus of educational neuroscience.

BrainHQ – Articles by a vast array of experts in areas related to learning and the brain.

Kathy Nunley's article on the teen brain.

Dr. Daniel Amen talks about the importance of imagining in treating and diagnosing not only brain injuries but learning issues and psychological disorders.

References

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