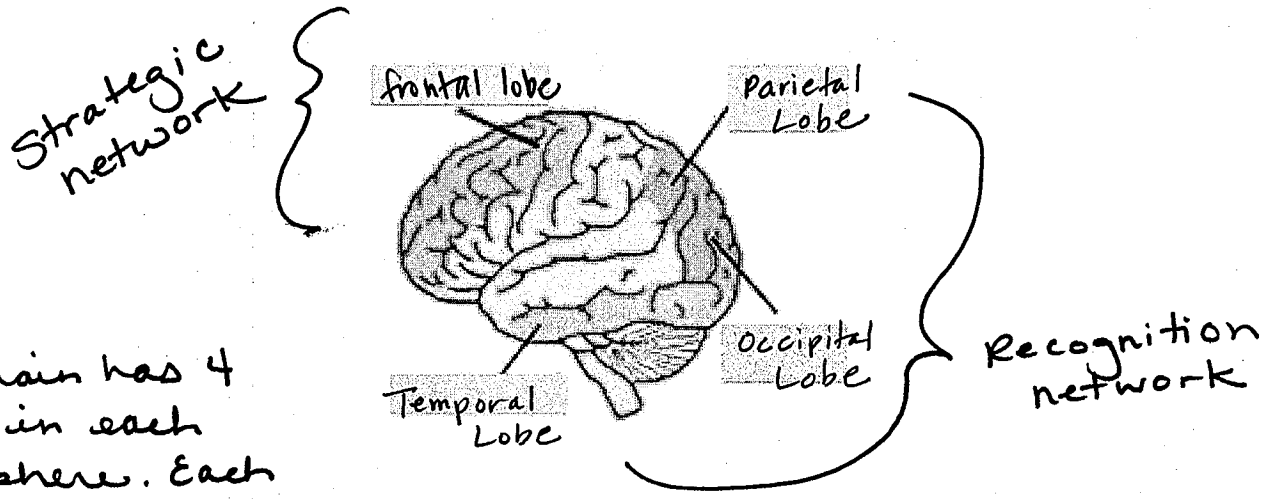
Cognitive Neuroscience Factors in Teaching & Learning
How the Mind Works and What it Means for the Classroom

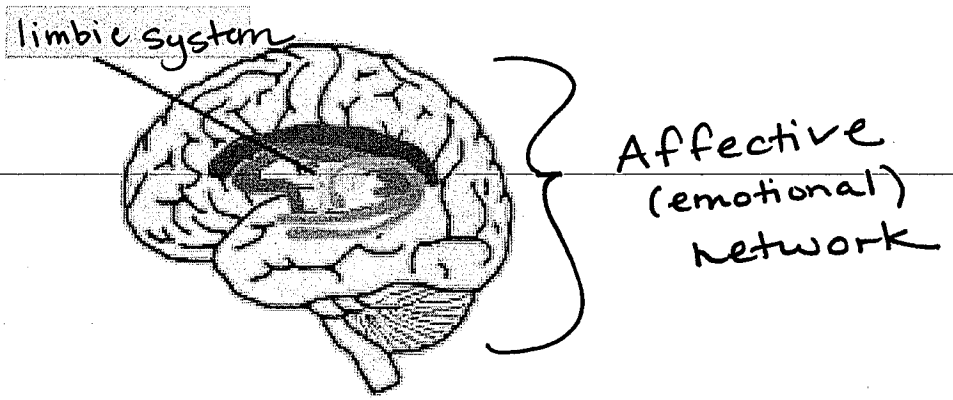
Related Course Objectives-
Upon completion of this course, students will:

- Understand the outcome of neurodevelopmental profiling with brain-based research.
- Understand the basic philosophical tenets of differentiated instruction.
- Understand the impact of teaching to the whole child.

Brain Basics – Anatomy of the Human Brain



The brain has 4 lobes in each hemisphere. Each lobe tends to specialize for certain functions. The 4 lobes make up what is known as the cerebrum.



Right cerebral hemisphere: simultaneous; specializes in context; analyzes the details; creative and empathic; controls left side of the body

Left cerebral hemisphere: sequential; specializes in text (language); sythesizes the big picture; controls the right side of the body

Frontal lobe: controls many functions including movement, memory, language, social behavior, problem-solving, making decisions and also controls our emotions & directs personality → executive functioning

Occipital lobe: controls visual perception & processes visual information, including color recognition, and then sends the information to the parietal & temporal lobes

Temporal lobe: controls auditory perception, speech, language comprehension, and also involved w/ visual recognition

Parietal lobe: interprets sensory information such as touch, pressure, temperature, and pain, and is also involved w/ language comprehension

Corpus callosum: connects the left and right side of the brain and is responsible for the communication between the two sides

Limbic system: plays an important role in emotional behavior; major structures include the amygdala, hippocampus, cingulated cortex, fornix, septum, and mammilliary bodies - generation of emotions & processing emotional memories

Neurons, or nerve cells, transmit impulses along an axon and across the synapse to the dendrites of the neighboring cell. The impulse is carried across the synapse to receptor sites by chemicals called neurotransmitters that lie within the synaptic vesicles. Exercise increases neurons' creation

Brain Rules

How do we learn? What exactly do sleep and stress do to our brains? Why is multi-tasking a myth? What can science tell us about raising smart, happy children?

Brain Rules are things we know for sure, and John Medina explains what we might do with that knowledge.

Source: http://www.brainrules.net/

EXERCISE | Rule #1: Exercise boosts brain power.

Exercise increases oxygen flow into the brain, which reduces brain-bound free radicals.
Oxygen = uptick in mental sharpness

Exercise increases neuronal creation, survival, and resistance to damage & stress

SURVIVAL | Rule #2: The human brain evolved, too.

The brain is a survival tool.

- solve problems, learn from mistakes
- create alliances
- facial recognition (illusions)
- If someone does not feel safe with a teacher, he may not perform as well

Maslow - safety is a basic need

WIRING | Rule #3: Every brain is wired differently.

What YOU do and learn in life physically changes what your brain looks like (it literally rewires it)

brain plasticity → creation of new neural pathways

no 2 people have the same brains
multiple intelligence profiles are different w/ everyone

ATTENTION | Rule #4: We don't pay attention to boring things.

What we pay attention to is profoundly influenced by memory. Our previous experience predicts where we should pay attention

multi-tasking is ok for automatic activities - NOT for high level thinking

SHORT-TERM MEMORY | Rule #5: Repeat to remember.

repetition helps with memory but you risk loss of motivation

creative approaches to repetition & multiple means of representation should be considered in classroom environments

LONG-TERM MEMORY | Rule #6: Remember to repeat.

Repeated exposure to information, in specifically timed intervals, provides the most powerful way to fix memory into the brain

Teach in dumps & in layers

SLEEP | Rule #7: Sleep well, think well.

Loss of sleep hurts attention, executive functioning, working memory, quantitative skills, logical reasoning, and motor dexterity

Your brain needs to turn off for a while to rejuvinate

STRESS | Rule #8: Stressed brains don't learn the same way.

You have one brain. The same brain you have at home is the same brain you have at school. The stress you (or your students) experience at home will affect them at school. Stress damages virtually every kind of cognition that exists! Don't make your classroom a stressful environment

SENSORY INTEGRATION | Rule #9: Stimulate more of the senses.

Our senses work together so it is important to stimulate them. Those in multisensory environments always do better than those in unisensory environments.

VAKT - multiple means of representation

VISION | Rule #10: Vision trumps all other senses.

- We are incredible at remembering pictures
- support text-based information with pictures
- But remember - the eyes/brain can play tricks on some people & need sensory integration

GENDER | Rule #11: Male and female brains are different.

Warning these are generalizations (but they are supported w/ research)

Girls: tend to be excessively critical in evaluating academic performance, stronger language skills, prefer story & relation to others

Boys: tend to have unrealistically high estimates of their own academic abilities, prefer a direct approach, tend to prefer informational text

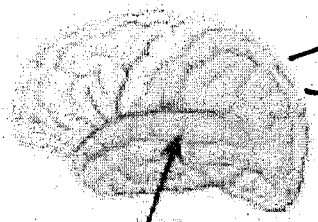
EXPLORATION | Rule #12: We are powerful and natural explorers.

We are curious about the world

Inquiry-based education → Dewey

Let students ask questions & explore their interests nurture their curiousity

Recognition, Affective, and Strategic Networks in the Brain & What it Means for Universal Design for Learning and Differentiated Instruction

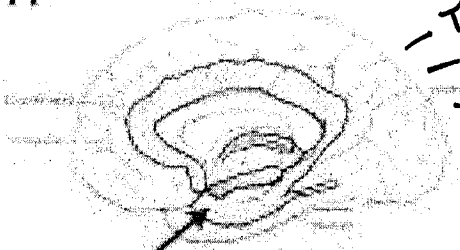


- temporal lobe
- occipital Lobe
- parietal lobe

Recognition

Limbic System
- Thalamus
- hypothalamus
- hippocampus } long term memory
- amygdala

Thinking about individual differences in light of the three brain networks can help us understand the ways in which curriculum must be flexible to reach all learners



Affective

Strategic - frontal lobe
↳ working memory & focus

Strategic network = frontal lobe (planning & thinking), continues to mature into early adulthood (connection to Piaget ~ qualitative change in the way children think) - the How of learning

Affective network = at the core of the brain (the limbic system) lie the networks responsible for emotion, via the affective network we pursue goals, develop preferences, build confidence, persist in the face of difficulty, and care about learning - the Why of learning

Recognition network = networks in the brain that enable us to identify and understand information, ideas, and concepts; networks specialized to sense and assign meaning to patterns we see, hear, taste, touch, and smell
~specific differences in the recognition networks of individual learners range from subtle to profound

☆ Learning requires complex interactions of the recognition, strategic, and affective networks. While everyone's brain functions take place in roughly the same areas, PET scans have shown that each individual has his/her own activity "signature" - Every brain is wired differently

Willingham's Cognitive Principles

In his book *Why Don't Students Like School* (2009), Daniel T. Willingham answers questions about how the mind works and what it means for the classroom. His 'cognitive principles' come from the perspective of a cognitive scientist and, at times, contrast with what is generally accepted as true by educators. As we discuss the cognitive principles, I encourage you to think about whether or not you agree with Willingham. What makes sense? What leaves you with some doubt? Document your thoughts in the boxes below.

People are naturally curious, but they are not naturally good thinkers.

Think of to-be-learned material as answers, and take time to help students arrive at answers to the questions. Also, be sure to clearly explain the questions.

Need to know: What is just beyond what my students know and can do? → scaffolding (Vygotsky)

Respect Students' Cognitive Limits

People can be good thinkers if the cognitive conditions are right

Factual knowledge precedes skill.

It is not possible to think well on a topic in the absence of factual knowledge about the topic.

Bloom's Taxonomy - classification of learning w/i education

Remembering facts & comprehending information serves as a foundation for high levels of thinking like analysis & evaluation

Factual Knowledge precedes skill AND deep levels of thought

Memory is a residue of thought

A good barometer for a lesson plan is "Of what will it make the students think?"
Learning is influenced by many factors, but one factor trumps the others: students remember what they think about.

↳ Bloom's higher order thinking - application, evaluation, synthesis

Want to get students to think about what things MEAN for their lives & the world -- if we need them to memorize something that has no direct meaning - a mnemonic, song, or skill/drill might do the job

We understand things in the context of things we already know.

What do students already know that will be a toehold on understanding the new material you want students to learn?

Piaget = Schemas are categories of knowledge that help us interpret and understand the world. As experiences happen new information is used to modify, add to, or change previously existing schemas.

~ In short, teachers need to access & build on students' existing knowledge

Proficiency requires practice Practice → automaticity → freed up space in working memory which can then be used for comprehension & higher order thinking

How can I get students to practice without boredom?

- → practice it in the context of more advanced skills
- → multiple means of representation
- → let students work with others
- → game-like activities (immediate gratification)

Consider: which processes need to become automatic?

★ Repeated "firings" of neural pathways make successive firings easier and, eventually, automatic under certain conditions ~ thus, a memory is formed

↳ need to also consider affective networks & motivation

novice expert

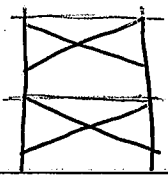
Cognition is fundamentally different early and late in training

experts = a lot of background knowledge, understands what background knowledge is & isn't important or relevant for a given situation, show better transfer to similar domains than novices do, access information rapidly & think of more ways to explain a concept, understand abstract ideas because they see the deep structure of problems

(single out important details)

Help students build their level of expertise

Scaffolding



Do they need to be experts in everything we teach?

★ **Children are more alike than different in terms of learning**

Intelligence can be changed through sustained hard work

- Talk about successes and failures in terms of effort, not ability ~ hardwork pays off
- Acknowledge that intelligence comes from both nature & a nurture

Neural plasticity = the brain can create new neural pathways, nerves continually rearrange themselves throughout the course of life, these changes are a result of one's experiences in a given environment

Teaching, like any complex cognitive skill, must be practiced to be improved

Improvement requires more than experience; it also requires conscious effort and feedback.

- Seek out feedback on the effectiveness of your teaching / practice
- Consciously try to improve by reflecting on your work

↳ When are you most reflective? What environment?

What does this mean for teaching and learning?

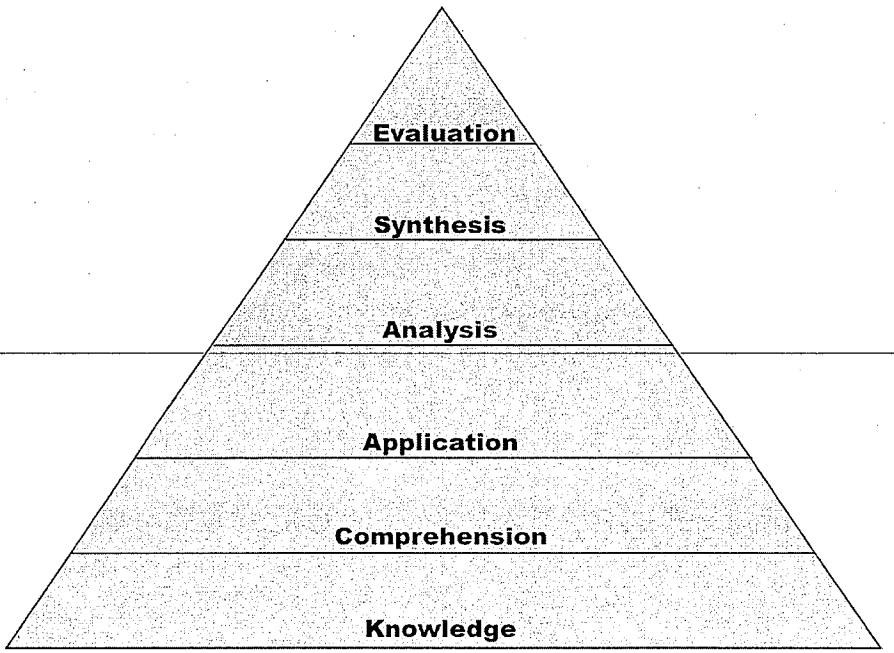
Bloom's Taxonomy

Asking students to think at higher levels, beyond simple recall, is an excellent way to stimulate students' thought processes. Different types of questions require us to use different kinds or levels of thinking.

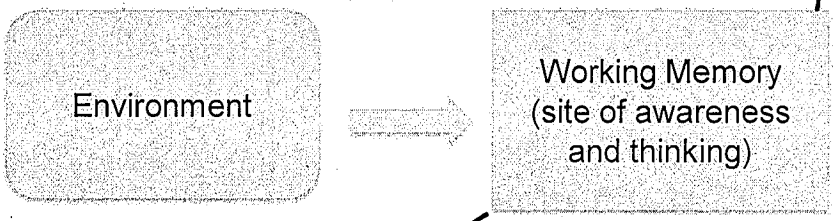
According to Bloom's Taxonomy, human thinking skills can be broken down into the following six categories.

1. **Knowledge**: remembering or recalling appropriate, previously learned information to draw out factual (usually right or wrong) answers. Use words and phrases such as: how many, when, where, list, define, tell, describe, identify, etc., to draw out factual answers, testing students' recall and recognition.
2. **Comprehension**: grasping or understanding the meaning of informational materials. Use words such as: describe, explain, estimate, predict, identify, differentiate, etc., to encourage students to translate, interpret, and extrapolate.
3. **Application**: applying previously learned information (or knowledge) to new and unfamiliar situations. Use words such as: demonstrate, apply, illustrate, show, solve, examine, classify, experiment, etc., to encourage students to apply knowledge to situations that are new and unfamiliar.
4. **Analysis**: breaking down information into parts, or examining (and trying to understand the organizational structure of) information. Use words and phrases such as: what are the differences, analyze, explain, compare, separate, classify, arrange, etc., to encourage students to break information down into parts.
5. **Synthesis**: applying prior knowledge and skills to combine elements into a pattern not clearly there before. Use words and phrases such as: combine, rearrange, substitute, create, design, invent, what if, etc., to encourage students to combine elements into a pattern that's new.
6. **Evaluation**: judging or deciding according to some set of criteria, without real right or wrong answers. Use words such as: assess, decide, measure, select, explain, conclude, compare, summarize, etc., to encourage students to make judgments according to a set of criteria.

Source: TeacherVision: http://www.teachervision.fen.com/



Simple Figure of the Mind



Your working memory is good at processing information (if cognitive conditions are right) but it can only hold so much at one time. All of your active thinking happens in your working memory.

Long-Term Memory (factual knowledge and procedural knowledge)

Storage center, holds your existing knowledge

If you load your working memory with too much information, then there's no room to process it, which makes it more difficult to recall the information later on.

baking a cake analogy - combine ingredients to make something new

Thinking: combining information in new ways; information can come from long term memory (facts you've memorized) or from the environment - not "auto pilot"

Working memory: holds the stuff you are thinking about ~ has a limited capacity and can only do so much - this is called cognitive load

Long term memory: vast storehouse in which you maintain your factual knowledge of the world (ladybugs have spots, you watched a show about candy factories yesterday) & procedural knowledge

All of the information in your long term memory resides outside of your awareness. It lies quietly until it is needed, and then enters working memory and so becomes conscious. For example, if I asked you "What color is a polar bear? You would say "white" almost immediately. That information was in long-term memory thirty seconds ago, but you weren't aware of it until I posed the question that made it relevant to ongoing thought, where upon it entered your working memory.

★ Thinking occurs when you combine information (from the environment and long-term memory) in new ways. That combining happens in working memory.