INTRODUCTION TO EDUCATIONAL NEUROSCIENCE
TRUE OR FALSE?

- We only use 10% of our brain.
- Ages zero-three years are more important than any other for learning.
- There are critical periods for learning important skills such as language.
- Some people are left-brained. Others are right-brained.
- Male/female brains are very different.
- People can learn (read) as they sleep.
- Memory as a general capacity can be improved.
- Young children can learn only one language at a time.
- There are different types of learners (auditory, kinesthetic, visual, tactile, etc.)
- There are multiple types of intelligences.
- Emotion hinders the learning process.

*All of these statements are all false and simply “neuro-myths.”*
School Accountability Movement: Schools are accountable to taxpayers for their funds. Our students must be able to compete within a global marketplace. Public education is the foundation of American society.

Prestigious colleges and universities, such as Harvard Graduate School of Education, Dartmouth College, and Cornell University, have established teacher preparation programs that link neuroscience to pedagogy.

Equitable educational experiences/outcomes: Every child deserves a world-class education and should not be limited simply because they live in the “wrong” zip code. We simply have too many children being left behind and not ready for college and careers.
EDUCATIONAL NEUROSCIENCE: WHY NOW? TEACHERS NEED TO INCORPORATE THE FOLLOWING INTO THEIR CLASSROOM INSTRUCTION

- Movement enhances learning and memory; the brain becomes more active during increased blood flow; increased blood flow helps the brain access more long-term memory areas; and increase brain mass, cell production, cognitive processing, and mood regulation.
- Emotions impact and strengthen learning experiences: Humans are emotional beings and we cannot separate emotions from cognitive processing. Learning does not occur in a static vacuum but consists of many complex social/emotional interactions.
- Brain development explains behavior: The impulsivity of adolescents is explained by their “adolescent” brain. Brain regions responsible for rational thought and emotional control mature between 22-24 years of age.
- School’s social/cultural climate affects learning.
- The brain can grow new neurons in hippocampus: This neurogenesis helps the encoding of long-term memories.
- The brain can “rewire” itself – neuroplasticity continues throughout life. Strong reading instruction can “rewire” the brains of students with dyslexia and help them read on grade-level.
- Short-term memory is not so temporary and doesn’t immediately evaporate. Novel concepts can be carried in working memory for several weeks and then discarded when no longer needed – after the test! Since the brain thrives on sense and meaning, learning should be relevant to the student if it is to be stored in permanent memory.
- Sleep is important for memory: Everyone, even teachers, need sufficient sleep. What does this say about technology in the bedrooms of adolescents who like to “sleep” with their smart phones?
Structures of the Brain: Implications for Educational Neuroscience

- View this “Brain Rap” Video

View Brain Videos by Dr. Todd Rose, Harvard Graduate School of Education

- Part 1: The Neuron
- Part 2: Lower Brain Structures
- Part 3: The Cerebrum
- Part 4: Frontal Lobes
- Part 5: Sensory Lobes
THE IMPACT OF NEUROSCIENCE ON TEACHING AND LEARNING

The goal is to create and empower “expert” life-long learners who capture the joy of learning through the development of metacognition skills.

To do this, learners need a stress/risk free and scaffolded educational environment marked by incremental and achievable challenges:

- Lev Vygotsky’s Zone of Proximal Development (the distance between the learner’s level of independent problem-solving and their level of potential development). Scaffolding is provided by teachers and peers.

- Stephen Krashen’s Comprehensible Input (the best instructional methods supply comprehensible input in low anxiety situations and contains relevant/meaningful messages).
Fear and stress influence the way the amygdala filters sensory information – sending it to the prefrontal cortex (the “thinking” brain) or the lower, reactive brain (“fight, flight, or freeze”). Information sent to the lower brain is not available for higher cognitive processing.

The Reticular Activating System (RAS) is a primitive network of cells in the lower brain stem through which all sensory inputs must pass.

- The RAS involuntary and automatically selects/process several thousand bits of sensory information out of the millions available every second. The RAS is most receptive to sensory input that is critical to survival. When a threat is perceived, the RAS automatically selects related sensory information and directs it to the lower reactive brain.
CLASSROOM IMPLICATIONS

- Teachers must reduce the threat of punishment and embarrassment to prevent the RAS from sending sensory input to the lower brain. Fear, sadness, anger hinder higher order cognitive processing.
- When no threats exist, the RAS is particularly receptive to novelty and pleasure. Environmental changes prime the RAS to pay attention to evaluate curiosity-evoking stimuli.
For learning to occur and be constructed into long-term conceptual knowledge, sensory input needs to pass through the RAS and be processed by the PFC.

The PFC regulates cognitive/executive functions such as judgment, organization, prioritization, critical analysis, concept development, and creative problem-solving.
Dopamine is a neurotransmitter that carries information across the synapses between the dendrites and axons of neurons. Learning activities that stimulate dopamine release increase pleasurable feelings, focus, motivation, and memory.

A drop in dopamine can be associated with negative emotions. Thus, when a student answers a question correctly, dopamine levels increase and so does learning by reinforcing the memory of the information.

Due to the neuroplasticity of the brain, neural circuits change in response to the levels of dopamine. The brain alters neural circuits to avoid an unpleasant drop in dopamine.
Frequent, formative assessment is the key to promote long-term memory and executive functioning by adjusting instruction so students do not succumb to the fight, flight, or freeze mode.

Instruction must be amygdala-friendly and dopamine releasing.

Practice makes permanent: neuroplasticity changes neural networks and repeated activation of a circuit makes stronger, efficient networks.
The brain perceive and generate patterns to predict responses to new stimuli. Patterning is the meaningful organization and categorization of information. When new information is added to the pattern, neural networks are extended and future predictions are more accurate. Classroom instruction needs to target and develop pattern recognition skills to increase successful learning experiences.

When sensory input reaches the hippocampus (next to the amygdala), it is available for consolidation into memory. For this to occur, prior knowledge from stored memory is activated and transferred to the hippocampus to bind with the new information. This is why new information needs to be directly linked to the prior knowledge and experiences of each student.

This is why intelligence is not a static entity ("IQ of 105") but increases since the brain builds intelligence by extending, correcting, and strengthening neural networks. For this reason, even children with disabilities can learn at high levels.
Teaching and learning is not just about transmitting the subject matter of a discipline. 21st century learning is ....

+ learning to think critically,
+ learning to communicate clearly,
+ learning to collaborate,
+ learning to make complex judgments about a rapidly changing environment, and
+ learning to adapt to that environment.