What Do We Know About the Human Brain?

Increasingly, we are becoming aware of the need to incorporate brain-based research into our models of learning and teaching. Various models of our brain's architecture have been proposed over the years:

The Holistic Brain: The brain is a pattern-seeking, holographic organ.

Two Cerebral Hemispheres: The left hemisphere is responsible for linear thought/language; the right is responsible for creativity, holistic thinking, and intuition.

Paul MacLean's (1978) model suggests that the brain is a triune organ that evolved to process survival, emotional, and rational functions.

Howard Gardner (1983) suggests that our conscious brain functions through multiple forms of intelligence processed in different brain areas (e.g., linguistic, spatial, logical-mathematical, etc.).

Gazzaniga (1985) conceives of the brain as a vast number of interconnected, semi-autonomous networks of neurons called modules, each specializing in a limited cognitive function. Neural modules are formed to consolidate activities in order to process complex cognitive functions.

What Does Brain Research Tell Us About Learning?

1. Every brain is a uniquely-organized system.
2. The brain is a social organ.
3. The search for meaning is innate.
4. The search for meaning occurs through “patterning.”
5. Emotions are critical to patterning.
6. Every brain simultaneously perceives and creates parts and wholes.
7. Learning involves focused and peripheral perception.
8. Learning always involves conscious and unconscious processes.
9. We have at least two ways of organizing memory.
10. Learning is developmental.
11. Complex learning is enhanced by challenge and inhibited by threat.

How Do the Dimensions of Learning Reflect Brain Research?

Dimensions of Learning **(DOL)** suggests that five interrelated aspects of learning should be addressed in all classrooms, each of which reinforces one or more of the major brain-based research findings:

1. ***Dimension One*** **(Developing Positive Attitudes and Perceptions About Learning)** reinforces the need to foster relaxed alertness in students by creating a classroom that is low in threat and high in challenge.

2. ***Dimension Two*** **(Acquiring and Integrating Knowledge)** emphasizes instructional activities to ensure that students retain essential declarative and procedural knowledge in semantic, procedural, and episodic/spatial memory.

3. ***Dimension Three*** **(Extending and Refining Knowledge)** reinforces neural branching (i.e., extending neural networks) by emphasizing multiple forms of higher-level questioning and students' hands-on inquiry.

4. ***Dimension Four*** **(Meaningful-Use Tasks)** reinforces the value of providing students opportunities to apply what they have learned in real-world settings and contexts, using their stored knowledge in authentic ways.

5. ***Dimension Five*** **(Productive Habits of Mind)** emphasizes the powerful value of intellectual dispositions (i.e., life-long habits of mind) that are extensions of students' creation of meaning in response to purposeful learning experiences.

How Does the Brain Construct Meaning?

The search for meaning is innate. All learners are trying to make sense out of what is happening at all times. According to Jensen (1996), three factors are critical to learner-created meaning:

1. ***Relevance.*** On a cellular level, it's the activation of existing connections in neural networks. It relates to something the learner already knows some information about. The more relevance this has to the learner, the greater the meaning.

2. ***Emotion.*** When the learner's emotions are engaged, the brain "codes" the content by triggering the release of chemicals that single out and "mark" the experience as important and meaningful. Emotions activate many areas in the body and the brain, including the prefrontal cortices, amygdala, hippocampus and often the stomach. This may give meaning to something without your having any understanding of it.

3. ***Pattern.*** Isolated information has little meaning. The brain builds larger patterns to help form genuine structures of meaning. The context helps make it part of an overall pattern. Context can be social, intellectual, physical, economic, geographic, political, or any other pattern which makes meaning.

Brain Physiology

The human brain is sometimes hailed as the most complex object in the universe. It comprises a trillion cells, 100 billion of them neurons linked in networks that give rise to intelligence, creativity, emotion, consciousness and memory.

At a very gross level, the brain is bilaterally symmetric, its left and right hemispheres connected by the corpus callosum and other axonal bridges. Its base consists of structures such as the medulla, which regulates the autonomic functions (including respiration, circulation and digestion), and the cerebellum, which coordinates movement. Within lies the limbic system, a collection of structures involved in emotional behavior, long-term memory and other functions.

When you see a picture of the brain, or a brain in a jar, the bulk of what you see is mostly the wrinkled cortex wrapped around the cerebrum. It has four dominant areas:

1. Frontal lobe: problem-solving, will power, planning
2. Parietal: reception of sensory information
3. Occipital: primarily deals with vision
4. Temporal: deals with hearing, language and some memory

Neurons

Neurons are nerve cells. Thirty thousand of them can fit into a space the size of a pinhead. A typical neuron is composed of a main cell body with nucleus and two branches; the outgoing is called the “axon” while the incoming branch is called the “dendrite.” The connecting point for the two is called the “synapse.”

According to Pat Wolfe, all information processing in the brain consists of neurons “talking” to one another. Learning is defined as “the establishment of new synapses” and the “modification of connectivity among neurons.”

According to Cardellichio and Field (Educational Leadership, March 1997), seven strategies can help to enrich students' environment to help them make new connections or “neural branching”: (1**) hypothetical thinking;** (2) **reversal** (what happens if we reversed...?); (3) **application of different symbol systems** (e.g., explaining the Pythagorean Theorem in words and pictures); (4) **analogies** (looking for correspondences); (5) **analysis of point of view**; (6) **completion** (filling in incomplete elements); and (7) **web analysis** (uncovering the complex multiple effects extending from a single source).

Memory Systems

Semantic/Declarative: linguistic memory activated by associations, similarities, and differences; it is the short-term or working memory, good for less than 15 seconds unless rehearsed, reviewed, or relearned. It can only hold discrete, finite information, called “chunks.” It is located in the cerebral cortext. It requires practice and rehearsal to keep fresh.

Procedural: also known as body-kinesthetic or motor memory, it is activated by association with physical movement, places, events, feelings, and sensory experiences. It lasts for years and has an unlimited storage capacity. It requires minimal intrinsic motivation. It is based upon physiological states and very natural for the brain to use.

Contextual/Episodic: also known as spatial memory, it is activated by direct association with events, circumstances, or location. It can last for years with moderate review and has unlimited storage capacity. Our brain sorts and stores information based upon whether it is heavily embedded in context or in content. It is effortless and used heavily by everyone. E. Jensen. (1996). *Completing the Puzzle.*

Attention and Retention

1. Teachers can manage discipline through changes of activity, emotional arousal, or curiosity in order to help students control their reactive brain stems.

2. Our neo-cortex is a pattern-seeking, pattern-making organ. Something goes from information to meaning by organizing data into patterns.

3. Feedback, immediate and dramatic, is the all-time best way to foster intelligence.

4. Learners are constantly switching from internal to external, focused to diffused learning. It is natural that students will move in and out of phase during the learning process.

5. "Enriched" environments mean greater compansionship and more active involvement in challenge and novelty, helping neural branching to occur with appropriate stimulation.

6. The brain is not designed to take on big ideas easily. It has to chunk them in pieces or build up its own mental models over time Graphic and other advanced organizers are helpful.

7. Experience-based learning reinforces context-based learning, the form of learning proven best in promoting long-term retention.

8. Much of the most powerful learning may not show up for months or years. Teaching and testing in traditional modes may not capture the true extent of student learning.

9. "Our brain is a box packed with emotions." One of the major roles of the mid-brain is to tell us if something is meaningful. Students must receive support to feel that something is true and has personal relevance to them if they are to retain it.

Implications for Teachers

1. Good teaching orchestrates the learner's experience so that all aspects of brain operation are addressed (i.e., emotions, imagination, analytical thinking, etc.).

2. Everything that affects our physiological functioning affects our capacity to learn. We need to be sensitive to physical needs and the maturation continuum.

3. The learning environment needs to provide stability and familiarity; at the same time, provision must be made to satisfy students' curiosity and hunger for novelty, discovery, and challenge.

4. Learners are patterning, or perceiving and creating meanings, all the time in one way or another. Ideally, teaching should present information in a way that allows brains to extract patterns, rather than attempt to impose them.

5. Because it is impossible to isolate the cognitive from the affective domain, the emotional climate in the school and classroom must be monitored on a consistent basis, using effective communication strategies and allowing for student and teacher reflection and metacognitive processing.

6. Good teaching builds understanding and skills over time because learning is cumulative and developmental. Learning occurs best in authentic, meaningful contexts that allow the student to relate new information to previous learning and experiences.

7. Peripheral information can be purposely organized to facilitate learning. Teachers need to engage the interests and enthusiasm of students through their own enthusiasm, coaching, and modeling, so that the unconscious signals appropriately to the importance and value of what is being learned.

8. “Active processing” allows students to review how and what they learned so that they begin to take charge of learning and the development of personal meanings. Active processing refers to reflection and metacognitive activities.

9. We understand and remember best when facts and skills are embedded in natural, spatial memory. Teachers should also reduce the amount of times learners have to learn material by rote, or they should embed this material in conceptual/thematic contexts to reinforce its meaning and relevance.

10. The brain downshifts under perceived threats, and learns optimally when appropriately challenged. Teachers and administrators need to create a state of relaxed alertness in students. This combines general relaxation with an atmosphere that is low in threat and high in challenge.

11. Since each brain is unique, teaching should be multifaceted to allow all students to express visual, tactile, emotional, and auditory preferences.

Resources

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