Editor's Note: Instructional design provides many techniques to assist learning. Brain-Based Learning looks at research on neural mechanisms that facilitate the learning process as a way to optimize performance. Some approaches are already used under other names; others provide leverage to optimize learning.

Brain-Based Learning:
Possible Implications for Online Instruction

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Abstract

As higher education institutions push for more online courses instructors are faced with issues and challenges related to teaching in the online learning environment. Regardless of whether higher education's impetus is fueled by cost-saving measures, or the belief that online courses answer the challenge of rapid tuition increases or changing student body, one issue that continues to resurface, concerning online courses is to how best to deliver the information and facilitate learning for the student.

Issues concerning student learning involve how they accept, retain and process information delivered in a course. This paper briefly defines and describes brain-based learning, a theory that is under investigation in higher education, and offers suggestions on how that theory may be implemented in the delivery of information and facilitation of online classes in higher education. Implications for online educators are also presented.

The brain is "not only the control center of the entire human body, organizing our behaviors and biological functions, but it also is the seat of our humanity. It defines who we are, how we act, and the very nature of our species." (Slavkin 2004, 38).

Introduction

As higher education institutions in the United States push for more online courses, instructors are faced with new issues and challenges related to teaching in the online learning environment. Regardless of whether higher education's impetus is fueled by cost-saving measures (Jaffee, 1998) or the belief that online courses answer the challenge of rapid tuition increased or changing student body (Feenberg, 1999; Hara & Kling, 2000), one

issue that continues to resurface, concerning online courses is to how best to deliver the information and facilitate learning for the student (Bolliger & Martindale, 2004). Student learning is impacted by how the human brain accepts and processes information delivered in the course.

The 1990's were recognized by the President of the United States and the Congress as the Decade of the Brain. They predicted findings from the neurosciences would result in significant benefits for society (Lucas, 2004). As the twentieth century waned, an explosion of information about the human brain and how it learns appeared in educational journals, popular magazines, and television documentaries (Stevens & Goldberg, 2001). Thousands of research projects, books, magazine covers, and television specials regaled the public with new facts and figures, and at times, suspiciously simple ways to improve our memories and make babies geniuses (Wolfe & Brandt, 1998).

As skeptical as some have been, findings from the neurosciences, a relatively new field with over 90% of all neuroscientists still alive and practicing today (Lackney, 2004), linked with educational needs, offers information for improving teaching and learning. Again, neuroscience is a field of study, separate form the field of education. Can findings about the brain that involve learning, assist in the development and facilitation of online courses? Although brain-based learning has been extensively explored as it relates to elementary and secondary education, could this research apply to learning in higher education? This paper briefly defines and describes brain-based learning, and offers suggestions for the delivery of information and facilitation of online classes in higher education. Implications for online educators are presented.

The review of literature involves the exploration of brain-based learning, brain-based instruction, and online instructional design. Although the review is brief in nature, websites are referenced to provde more information if desired.

Review of Literature

The Brain: A Synopsis

At birth, a child's brain has all the brain cells, or neurons, that it will ever have (Wolfe & Brandt 1998). The brain weighs about one pound and reaches about three pounds by adulthood (Sprenger, 2002). The human brain differs from other species in that 1) it has a larger cognitive area with the ability to use it for higher-order thinking, and 2) it requires nurturing for 18 to 20 years in comparison to other species whose offspring are born with almost fully developed brains (Sylwester, 1997). It wasn't too long ago that scientists thought the brain was fixed at birth (Wolfe & Brandt, 1998).

A simplistic way of looking at the brain is to divide it into three areas as outlined by Dr. Paul Maclean in his "triune brain theory" (Hermann, 1994). The lowest area of the brain, where information enters, is called the brain stem. This regulates such functions as breathing, heart rate, and waking/sleeping cycles. The second area, above the brain stem, is the limbic area, which controls emotions and, when encountering stimuli, the decision-making process. The third area is the cerebrum which is divided into the right and left hemispheres. The cerebrum is a collection of connections that send messages from the brain to the body and has a thin covering about 1/8th inches thick called the neocortex or "new bark" The neocortex is sometimes called the cerebral cortex, commonly referred to as "gray matter." The cerebrum invents, creates, writes, and calculates; its characteristics define our individual attributes.

The brain has two hemispheres. The left hemisphere, within the cerebral cortex, is in charge of speech, logic, sequence, time, details, and math. The right hemisphere is related to music, art, strong emotional responses, intuition, images, and summarizing (Sprenger, 2002). The hemispheres are divided into lobes that 1) process visual and auditory information, 2) take charge of feeling and touch, 3) deal with decisions and planning, creativity, and problem solving, and 4) involve emotions, personality, working memory, attention, and learning (Sprenger, 2002).

Brain-Based Learning

To understand brain-based learning, a study of brain cells is needed. The brain consists of many cells; one type, which is basic to learning, is the neuron. Learning takes place when two neurons communicate. When the neuron gathers information, it grows appendages called dendrites (http://www.funderstanding.com/brain_based_learning.cfm.) More than 30,000 dendrites can fit onto the head of a pin (Sylwester, 1995). Dendrites constantly scan for information because the brain continually wants to learn. (It is sometimes hard to see the strong desire of the brain to learn in classrooms or online; however, the brain is always searching for meaning from gathered information and stimuli.) A synapse transmits messages between neurons via the axon (Sprenger, 2002). A synapse is a gap between the cells, an invisible bridge (Stevens & Goldberg, 2001) that allows the neurons to communicate as information travels through the brain. When neurons repetitively communicate with each other, a neural network is formed (Sprenger, 2002) and a pattern is repeated. See Figure 2.

Following are some of the findings from brain research (Stevens and Goldberg, 2001)

- Brains are specialized and are not equally good at everything.

- Brains are designed for fluctuations rather than constant attention
- Emotions are critical to successful learning.
- Brains are poorly designed for rote learning.
- Multi-sensory input is desired by our brains.
- Learning involves the whole body.
- Each brain is unique.
- Threat, high anxiety, and a sense of helplessness impairs learning.
- Brains process both parts and wholes simultaneously
- Brains are considered "plastic" and continue to develop throughout our lives.

Following are some of the core principles of brain-based learning.

1. The brain can perform several activities at once (e.g. tasting and smelling).
2. Learning engages the whole body.
3. The search for meaning is innate and comes through patterning.
4. Emotions are critical to patterning.
5. The brain processes wholes and parts simultaneously.
6. Learning involves focused attention and peripheral perception.
7. Learning involves both conscious and unconscious processes.
8. We have two types of memory – spatial and rote.
9. Learning and understanding are enhanced if facts are embedded in natural, spatial memory.
10. Challenge and threat inhibits learning.

Excerpts from "Brain-Based Learning" written by On Purpose Associates, 2004.

See the following websites for additional information on brain-based learning.

www.thebrainstore.com
http://www.designshare.com/Research/BrainBasedLearn98.htm
http://www.loloville.com/brain_based_learning.htm
http://www.brainconnection.com/

Physiologically, the genetic structure of the brain seeks for meaning, pattern interconnectedness, relevance and useful applications (Greenleaf, 2003) from its surroundings. This was supported in the 1960's with research revealing that brain structures are modified by the environment (Diamond and Hopson 1998). It established the concept of neural plasticity; the brain's ability to constantly change its structure and function in response to external experiences (Wolfe & Brandt, 1998). As information and skills are collected, they are organized according to meaning related to the information. As a result, students learn in different ways due to their previous experiences, perceptions, and prior knowledge about the subject (Slavkin, 2002). See Figures 1-3 to gather more information about brain based learning and enriched environments.

Enriched environments unmistakable influence the brain's growth and learning. These suggestions are adapted from "Enriching the Environment" by Diamond and Hopson, 1998).

- Include a steady source of positive emotional support.
- Encourage them to eat nutritious meals while learning.
- Provide an atmosphere free from undue stress but filled with pleasurable intensity.
- Encourage social interaction for a significant percentage of activities.
- Promote development of a broad range of skills that are mental, physical, aesthetic, social, and emotional.
- Promote exploration and fun of learning.
- Allow student to be active participant rather than passive observer.

Figure 3. Concrete Strategies for Enriching the Environment.

Previous studies have related the human brain and learning to computers by comparing the ability o each to store, retrieve, and organize files of information. However, that simile is limiting as the human brain constantly updates how it stores and networks information based on individual experiences (Slavkin, 2004). See the following website to locate articles concerning this topic. (http://www.findarticles.com/p/articles/mi_m4467/is_7_54/ai_64059320).

Understanding how the brain learns and relating it to the educational field resulted in the concept known as brain-based learning. It is defined as any teaching technique or strategy that utilizes information about the human brain to organize how lessons are constructed and facilitated with emphasis placed on how the brain learns naturally (Slavkin, 2004). Brain-based learning offers a framework to enhance student learning.

Brain-Based Instruction

Brain-based or brain-compatible instruction requires instructors to understand how the brain works and thus, design instruction with that information in mind (Stevens & Goldberg, 2001).Teachers have been encouraged to combine knowledge about their profession with findings from brain research to create learner-centered environments – whether online or in physical classrooms. Applying brain research to instructional design can result in the practice of brain-compatible instruction instead of brain-antagonistic instruction (Stevens & Goldberg, 2001).

Instructional Design – Online Classes

Instructional design is measured by how well the design supports and facilitates the achievement of the instructional objectives (Koohang & Du Plessis, 2004). It relies on learning models and theories that encourage learning and is considered by some an art and science that "brings the learner from the state of not being able to accomplish certain tasks to the state of being able to accomplish those tasks" (Broderick, 2001). Attention is shifting to concept of active learning that involves constructing new knowledge based on prior knowledge, real-world observation with real problems in real situations, and constructing interpretations of observations (Adler, 1998; Gagne et al, 1992).

Instructional design for online classes must include learning principles and conditions that meet the learner's needs (Egbert & Thomas, 2001). Key elements of instructional models for online classes include: learner consideration, learning task, learning content, content organization, instructional strategies, media, learning environment, assessment of instruction, materials for delivery and evaluation/feedback (Sherry & Morse, 1995; Moore & Kearsley, 1996; Simonson, et al., 2000). Recently, Koohang and Du Plessis (2004) developed an online model that demonstrates the interconnectedness of the instructional design (content), learning (user) and usability (system). Instructional design for online classes is constantly being assessed and reassessed to determine quality learning outcomes.

Implications for Development/Facilitation of Online Classes

There are many suggestions for integrating brain-based learning into the educational environment that are applicable to online courses. Following are four suggestions based on findings from neuroscience research: memory/retrieval, learning styles, increasing attentiveness, and the role of emotion in learning. In addition, other suggestions are briefly mentioned in bullet format to encourage personal reflection concerning existing online courses.

Memory and Retrieval

The first suggestion involves the physiology of the brain as it relates to memory and retrieval. There are three types of memory: sensory, short-term (or working) and long term. Sensory memory sifts all incoming stimuli through the five senses, recognizes it, passes it along to working memory or discards it. Short-term memory refers to the ability to retain limited amounts of information for brief periods. Long-term memory refers to the storage of large amounts of information, procedures, and events. Scientists typically group retrieval into two categories: implicit and explicit memory. Implicit memory refers to subconscious retrieval of information; for example, searching for a word rarely used that pops into the mind. Explicit memory relates to the intentional recall of information and events. There are two types of memory tests for explicit memory: recognition and recall (Lucas, 2004).

Tips for online classes. Students will remember content more if it is moved from short-term memory to long term memory through a technique called "elaborate rehearsal." Class content, or a concept to be learned, can be contained in role plays, debates, video clips, art or music (Stevens & Goldberg, 2001). Some of these teaching strategies are easier to put into place in online classes. However, technology is making it easier every day.

Another technique to help students retain information via online classes is "chunking." This is effective if students are required to recall lists of information. Chunking is a strategy of grouping items into smaller chucks of seven, plus or minus two "chunks." Examples of seven used every day include telephone numbers with area codes, social security numbers, license plate numbers, postal zip codes in the United States, or the "Seven Habits of Highly Effective People. Other techniques include the use of acronyms and rhymes (Lucas, 2004). Chunking can be easily implemented into online classes through such areas as discussion points, downloadable handouts, and PowerPoint lecture notes.

Learning Styles

The brain uses its hundred billion plus cells to process information and images in many ways and on different levels. Most students have a preferred and a secondary modality for learning commonly called learning styles. These preferences involve receiving information through auditory, visual or kinesthetic means (Clemons, 2004). Ninety percent of learning is visual with eighty-five percent of the brain wired for visual processing. Rhythm/music allows us to encode information effortlessly. Music at 60 beats per minute may maximize retention (Lucas, 2004).

Tips for online classes. It is understandable that an instructor of any course delivers the information in a way that is easy for them, personally, to learn. However, it is important to develop and deliver the course with several learning modalities in mind. Auditory learners enjoy talking to themselves when reviewing information (Lucas, 2004). Therefore, encourage group discussions with someone at their site (even if not enrolled in the class) and have them report the results. In addition, use audio/video/animation clips, voice-overs of "lecture"

materials, or send students to websites with audio components. Visual learners gain understanding from stimuli through their eyes. Use of PowerPoint software slides and images, video clips, or animation will be appealing to this learner. In addition, use of color, diagrams, charts, bold lettering, pictures, extra white space, and symbols will impact a visual learner. The kinesthetic/tactile learner will gather maximum information via an activity or task. They learn best through exploring, manipulating, and assembling or disassembling ideas or objects. Online courses can be developed with assignments that involve model building, sketching/drawing, and field trips or scavenger hunts (Clemons, 2004). Digital images of models or designs can be uploaded for grading. Encourage the upload of five to seven images per model for effective grading results.

Increasing Attentiveness

The average learner attention span is 15-20 minutes -- depending on age, gender, and background. Learners, especially traditional-aged college students, have been conditioned to speed and quick sound bytes rather than prolonged learning tasks. The average student packs more into his/her workday than can effectively be managed. Technology offers an additional distraction including cell phones, I-Pods, DVD players, microwave ovens, satellite television and computerized toys. Online techniques can be used to minimize distractions and maximize attention.

*Tips for online classes.*The opening and closing of your online session are the last bits of information remembered. Gain attention by using quotes by famous people that relate to content, humorous video clips (e.g. Muppets), post tests in the form of crossword or words search puzzles that contain key content terms and concepts. Incorporate originality into the design of your materials. Stimulate emotions with such techniques as excitement, fun, curiosity, anticipation, or surprise to enhance learning (Lucas, 2004).

Interaction will enhance attentiveness in online courses. Distance learning theory and subsequent research studies advocate that interaction is an essential characteristic of successful distance learning courses (Roblyer & Wiencke, 2003). Increased interaction is associated with higher achievement and student satisfaction (Zirkin & Sumler, 1995). Distance courses must use different, often more intensive means than traditional courses do to infuse instruction with interactive qualities (Rheingold, 2001) but with worthwhile success.

Role of Emotion

Learning is strongly influenced by emotion. Strong emotion connected with an experience causes chemicals in the brain to send a message to the rest of the brain such as, “This information is more important. Retain it for future use.” However, if the emotion is too strong (usually dealing with a threat or stress) there is a decrease in efficiency of the rational thinking cortex of the brain and learning stops (Wolfe & Brandt, 1998). Blood moves

away from the frontal lobes, thereby reducing the ability to think clearly or recall information. Peak learning happens when the brain is in high challenge and low stress (Lucas, 2004).

Tips for online classes.

Establish early that the learning environment will be safe and that students are free to challenge ideas, question facts or thoughts, and voice opinions. Outline objectives, the course schedule, and assignments in such a way that it puts control into the students' hands. Alleviate stress of failure in the online course. Maintain contact with each student, offer encouraging, positive feedback and avoid penalizing mistakes that come from the learning curve associated with technology.

Realize that gender differences can impact learning. The male brain is great at hunting (e.g. video games) while the female brain is great for seeing, listening, memorizing, reading, nonverbal cues, and articulating emotion (Lucas, 2004).

Additional Brain-Based Instructional Suggestions

Make learning contextual and related to student interests. The big picture should not be separated from the details. Studies show that, especially with adults, there is a need to understand the big picture to recognize the value of each piece of information encountered (Lucas, 2004; On Purpose Associates, 2004).

Structure learning around real problems and in teams
(On Purpose Associates, 2004).

Immerse learners in rich, complex interactive experiences
(On Purpose Associates, 2004).

Offer personally meaningful challenges to enhance learning. The student's mind is stimulated to the desired state of alertness. (On Purpose Associates, 2004).

Humor aids in learning. (On Purpose Associates, 2004).

Develop educational tools that are artistic to create brain-friendly environments
(On Purpose Associates, 2004)

Offer two minutes of time for the students to process the information for every ten minutes of information shared with students (Stevens & Goldberg, 2001). Present online information in chunks; then offer an activity that incorporates content and gives downtime to process information.

Use patterns. The brain is able to retain the equivalent of 500 encyclopedias. When knowledge is organized as a pattern, it is easier to retrieve. Use mnemonic devises to help students recall difficult subject matter concepts (Stevens & Goldberg, 2001).

Suggest periodically the value of good nutrition. Nutrition is crucial to effective learning (Lucas, 2004). The immune and endocrine systems as well as the brain contain many of the same types of chemicals and chemical receptors (Pert, 1997).

In addition, the brain's super fuel is oxygen, with water the next most important. Protein helps boost memory and attention. Carbohydrates promote release of the relaxant serotonin (hence drowsiness after lunch). Fruit is an excellent source of

energy that requires minimal digestion (Lucas, 2004). Studies indicate that students who eat nutritious food while studying earn statistically higher test scores, and increase reading speed and accuracy (Dunn & Milgram, 1993).

Conclusion

Brain-based or brain-compatible learning theory focuses on concepts that create an opportunity to maximize attainment and retention of information. A key to successful application is for everyone involved in the learning process (online course developers, educators, students) to understand the structure of the brain and consciously focus on learners' needs and styles to evaluate and improve the course format and delivery system. In brain-based learning environments, materials and instruction must be learner-centered and delivered in a manner that is fun, meaningful, and personally enriching (Lucas, 2004). These goals are possible to achieve in online courses – perhaps even more so than in traditional resident instruction.

Brain-based learning and strategies emerging from the neuroscience's body of research are still at a "buzzword stage." Other valid theories concerning intelligence and brain-based learning (Lucas, 2004) are available. Gardner himself has been frustrated by "reductionist thinking" of many educators that "talk the language", but walk using old instructional strategies--dividing up content into distinct learning modalities to the exclusion of other dimensions (Lackney, 2004). Researchers continually caution educators to resist the temptation to use neuroscience as a promotional tool for a pet program; much work needs to be done (Wolfe & Brandt, 1998).

Online educators who seek to base practice on the sciences should assess recommendations stemming from these theories and ideas to determine if they can improve delivery and course content. Keeping cautionary advice in mind, brain-based learning makes some good sense.

> "The brain is the last and grandest biological frontier, the most complex thing we have yet discovered in our universe. It contains hundreds of billions of cells interlinked through trillions of connections. The brain boggles the mind."
>
> James Watson Director,
> National Center for Human Genome Research

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