Background and Purpose
Historically, the brain has not been well understood. It has been envisioned as an entity with a fixed capacity to absorb and understand information—a capacity fixed by one’s race.¹ Scholars at the turn of the 20th century unabashedly opined that intelligence—a function of the brain—was a matter of heredity and could be measured in the speed of one’s reflexes, and acuteness of sensory perception.² ³ Commensurate with these beliefs was that learning was simply a matter of remembering what the teacher said or did. It is not surprising, therefore, to find that the lecture and behavioristic approaches to teaching have been a dominant in American higher education since the 18th century.⁴ ⁵ ⁶ Formal learning throughout American history was teacher-centered, which is to say that instructors used highly standardized methods of instruction that varied little according to student needs.

With technology’s assistance, scholars now “view” how the brain operates and use that information to design learning activities that engage a variety of neurological structures with the objective of reinforcing memory and deepening understanding.⁷ ⁸ Educators are especially interested in the formation of critical thinking and problem-solving skills, which necessitates the creation of cognitive networks or associations between information, and which involves the executive functions including planning, organizing, synthesizing, judging, and analyzing. This most elevated form of thinking reflects learning in which individuals intentionally select and manipulate associations for a purpose and it these executive activities are essential for deep understanding.⁹

The purpose of this tutorial is to increase instructors’ awareness of what kinds of activity are likely to have a favorable impact on learning.

⁹ Ibid.
Outcomes
1. Participants will review discrete brain functions and their relationship to learning outcomes
2. Participants will explore “brain friendly” approaches to critical reading and mathematics
3. Participants will read ideas about how to apply these strategies in their own course work

Brain Regions

Survey of Strategies and Principles

Memory
Memory consists of two separate activities: 1) creating the memory, and 2) recalling the memory. The fundamental neurological process of forming memories is the generation of a physiological connection between neurons, which is often referred to as “wiring.” At birth, the human brain already contains millions of neurons that will be the basis of learning and already uses experiences to build neurological connections. Memories are more durable when reinforced by repetition and when associated with strong emotions. Negative emotional experiences associated with learning, however, such as sharp criticism, disrespect for the student, impatience in teaching, and conveying the sense that the student simply cannot learn all have adverse effects on the brain’s capacity to learn.

When people experience things, they take in information from their senses and the information is stored for only a few seconds as a means of buffering the senses and preventing overload due to the constancy of incoming stimuli. In order to retain the experience or remember the information, the brain requires its user to employ “rehearsal systems” which include multiple recitations of information,

11 http://natchem.wordpress.com/2010/05/18/multiple-sclerosis-a-long-known-unknown/
13 Ibid.
multiple executions of systematic procedures (such as tying a shoe or changing the car’s oil), and consciously linking concepts to discrete knowledge or events.16

While working memories are those readily accessible for working on a current problem, such as the memory of what someone said early in a meeting while the meeting concludes 20 minutes later, permanent memory refers to the “storehouse of records” wherein resides short-term memories that have been converted to long-term memories.17 To create permanent memory, individuals must devote sufficient attention to the experience or information they want to remember,” encode” the experience or information, and rehearse the process of recalling the information. Without sufficient attention, the sensory input that might be harvested from an experience may be compromised, leaving the individual with fewer raw materials with which to create a memory.

The process of encoding requires individuals to create representations of the experience (since every detail cannot be mentally reassembled with great accuracy), and to mentally “file” these experiences into the mind’s categories of experience. To encode the story of Oliver Twist, for example, the reader might associate the decaying and fetid streets of London with local areas of urban neglect and ruin, or by associating various characters with known persons and acquaintances.

**Some Strategies to Enhance Memory**

1. Begin each class with a preview of key ideas and/or procedures of each lesson  
2. Review the key ideas and/or procedures at the end of the lesson  
3. Pause at various points in the lesson to allow students to pair with a partner and recite key information or to define key concepts and/or procedures  
4. Pause during the lesson and have students write or recite something about a new concept or procedure that links the content to a previous personal experience  
5. Direct students to frequently articulate and review important knowledge, concepts, and procedures on their own time

**The Brain and Critical Reading**

Unlike other Earthly creatures, human beings have the neurological hardware to support syntactic language, the use of metaphor, and analogical reasoning. To a large extent, language and literacy have been at the heart of mankind’s transformation of the world and the ability to exert control over the natural environment. Literacy has been foundational not only in formal learning, as reading and writing are among the cardinal means of delivering and assessing information, but it is regarded a vital ingredient in the creation and maintenance of self-governance, modern commercial enterprise, and the inculcation of cultural norms and beliefs.18

Language itself is an abstraction as symbols are employed to represent sounds, collections of symbols represent words, which represent things, time, place, action, or constructs, and collections of words

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17 Ibid, p. 54-55.  
create sentences which represent ideas, transmit feelings, encapsulate speculation and vision for the future, and which places the content of all logic, memory, belief, imagination, planning, and cognitive activity in a format that can generally be understood by others.

Because language is an abstraction, it poses several challenges to teachers and students, most immediately the challenge to effectively transmit what are very subjective and abstract sensations, thoughts, and feelings from one human being to another. As the brain is hard wired to decode language, it is relies not only on discrete knowledge about a given language system and symbols, but knowledge about how the context of communication reveals the meaning of what is communicated.

In making the transition from a causal reader to a scholarly reader, many students require explicit training on what to pay attention to when they read, and how to monitor their thinking as they read. Because words can obfuscate truth as easily as it can reveal truth, reading well requires readers to be adept at critical thinking as they read.

**Some Strategies to Enhance Critical Reading**

1. Become familiar with the developmental approach to reading and identify the differences between readers with basic skills and readers with high reading proficiency
2. Be mindful of the diversity of reading skills represented in the class; remember that like many other skills, the ability to read well is learned over a period of time and not something college students automatically possess
3. Be explicit about the critical reading skills you want students to improve, such as ability to detect main ideas, draw inferences, see implications, or distinguish peripheral ideas from central ideas
4. Promote contextual understanding of readings, by considering the author’s purpose, the time, place of publication, circumstances of the publication, and the instructor’s purpose for reading the material
5. Reading stimulates new associations between information and so the care given to building vocabulary and accurate use of words and concepts is important
6. Model the thinking behind the reading by taking time in class to examine the text, summarize main ideas, identify peripheral ideas, closely scrutinize key assertions and their logic or accuracy, and identify the implications of the assertions and the overall function of the text in society

**The Brain Mathematical Ability**

The neurological basis for mathematical skills and quantitative reasoning is among the most perplexing of all mysteries regarding the brain and learning and like the debate over other kinds of ability, such as the ability to compose music, excel in sports, and speak foreign languages, generates claims favoring a biological foundation (nature) and claims favoring acquired skill (nurture). 19

Building student proficiency in math skills begins in pre-school wherein students may be first exposed to the concept of procedural knowledge and wherein children may begin to link their own experiences with numbers to more formal knowledge about them. 20 Procedural knowledge is critical and when rehearsed

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19 Ibid.
20 Ibid.
provides students with a sense that problem-solving is systematic and requires a great deal of patience and attention to complete successfully.

**Strategies to Enhance Mathematical Skill**

1. Have students solve multiple problems that are similar in structure and have them articulate the discrete steps taken to solve the problem and explain why the steps were necessary; this enriches the students metacognition of the relationship between the procedures, formulas, numbers and unknown integers and fractions.

2. Take time to have students explore why their answers are right or wrong and be explicit with this information as to deepen their metacognitive understanding.

3. Take care to distinguish between lessons that are directed toward helping students understand how the math is applied in the real word and the mathematical procedures, principles, and formulas themselves; they are different learning outcomes and should be taught and assessed as such.

**Summary of Key Principles of Brain-based Instruction**

- Creating a positive and friendly environment enables learning.
- Engaging students in activities such as discussions, writing exercises, debates, research, peer-editing, lab experiments, creating graphic organizers, outlining, summarizing, pair-sharing, problem-solving, and creating products stimulates memory and improves understanding.
- Constant formative assessment enriches student’s sense of progress and reinforces the brain’s executive capacity to be self-evaluative.
- Designing curriculum and instruction to meet the development needs of one’s students requires an understanding of the knowledge and skill level of students and their particular developmental needs.
- Explicit instruction and information helps the brain organize material and direct executive activity; communication that is vague or incomplete generates anxiety.
- Diversify the ways in which information is delivered, processed, applied, and assessed in order to stimulate cognitive networking.

**Where to begin:**

1. Get peer and student feedback on the extent to which your instruction is explicit.
2. Identify the number of times students are formally required to reflect upon information, a problem, a process, or an experience for the purpose of deepening their metacognition or understanding.
3. List the things students are supposed to “do” with information (other than recall it) and identify the opportunities your course provides to “do” those things and receive formative assessment of their progress.
4. Make necessary revisions in the scope, sequence, and pace of the course as needed to meet course objectives relative to metacognition and critical thinking skills.

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