The Brain and Learning

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Learning is the result of real, observable physiological growth in the brain, occurring as a response to sensory input and the processing, organizing, and pruning it promotes. The richer the sensory input, the greater the physiological growth in the brain and thus the greater the learning that will be wired into long-term memory. This factor is the important issue in the great *nature* versus *nurture* debate about intelligence. There is now plenty of scientific evidence to establish the power of both.

Genetics was once thought to be an immutable determiner of intelligence - what you were born with was what you would end up with. This is not so, but genetic make-up does set parameters and a range of possibilities. However, within these parameters, *experiences* matter greatly. An undeveloped potential is just that, an undeveloped brain capable of less intelligent behaviors.

The work of Marian Diamond, UC Berkeley, Reuven Feurstein, Israel, as well as that of Paul Nussbaum, Neurological Surgery University of Pittsburgh School of Medicine; and many others — refutes the long-held beliefs that intelligence is a genetically-fixed, singular quality. Feurstein and his associates have even gone so far as to stipulate "Genetics is no barrier to learning." Marion Diamond's work shows that an enriched environment results in measurable growth in the brain. In short, if we know how the brain learns — what happens physiologically when learning occurs — we can assist a learner to create new "hardwiring" in the brain to transmit new learnings.

Intelligence, the capacity to solve problems and create products, is significantly influenced by environment and experience. For example, most "gifted" students in our programs for the gifted and talented are not "gifted" in the realm of such people as Einstein, Mozart, David Packard, Eleanor Roosevelt, Steve Wozniak, Sacagawea, or Maria Montessori. Rather, they are *advantaged*; they are students whose parents provided an enriched environment that nurtured a physiological development of neural networks, which became long-term memory of knowledge and skills and greatly expanded vocabulary.

In short, learning is the result of actual physical growth in the brain. To talk about learning is to talk about the physiology of the brain and how to enhance its physical growth and thus learning. According to Dr. Diamond, a number of physiological changes occur when the brain is immersed in an enriched environment:

- Dendritic spines grow, change shape, or shrink as we experience the world. Neurons grow larger. The brain becomes denser and heavier. Therefore, choose the types of input that will produce the greatest physiological change in the brain.

- The stimulation of an enriched environment results in significant physiological change in the brain—as much as 20% compared to brains in sterile, boring environments.
- There is a correlation between brain structure and what we do in life—what we spend time doing and not doing. In other words, how we spend our time—what we ask our brain to do on a daily basis—actually alters its physical structure. Vast amounts of time spent on television and/or video games (4-6 hours daily) wires the brain to do television and video games and does not wire the brain for other things such as physical exploration or high facility for initiating and processing language. If students cannot do what is expected of them, such as learn the periodic table of the elements, then time must be taken to build the neural wiring and structures that will enable them to do what is expected of them, or they may become discouraged and disengaged in the learning process.
- Much of the increase in the physical size of the brain (at birth, the brain is one quarter of its eventual adult size) is due to myelination, a process by which fatty tissue forms around the axons of frequently-firing neurons which act like rubber insulation on electrical cords. This allows for speedier and more reliable transmission of electrical impulses thus improving communication among neurons. While much of this process occurs with the unfolding maturation of the brain, much can be deliberately enhanced through ample practice in using the knowledge or skill being learned, particularly in real-world settings which allow for rich sensory input and feedback.
- "Use it or lose it" is a maxim for all ages — birth through old age. "Brains don't just steadily make more and more connections. Instead, they grow many more connections than they need and then get rid of (prune) those that are not used. It turns out that deleting old connections is just as important as adding new ones."[9] By removing connections no longer in use, the brain makes room for new connections.

Implications. If learning is the result of such physiological changes, then the question for teachers becomes: What should the classroom teacher do to maximize growth in the brain? The answers aren't mysterious or complicated yet they fly in the face of our traditional curricular tools and instructional processes.

- Provide large amounts of sensory-rich input from being there experiences or simulations in the real world. Purposefully reduce the amount of low-sensory input materials and processes such as textbooks, worksheets, and working in isolation. Remember, worksheets do not make dendrites! Move instruction and curriculum beyond the "A Quadrant" in the *Rigor/Relevance Framework*™
- Demanding performance when the requisite wiring is not in place is akin to keeping the high jump bar over someone's head when he/she does not have the physical skills for jumping at waist height. In track sports, this would be instantly recognized as both cruel and a foolish waste of time. Yet this expectation for student performance is frequently exhibited in the classroom without regard to the learners' level of necessary wiring. Ensure that learning is non-threatening and that all students may experience success.
- Design curriculum and instructional strategies to encourage practice and mastery in real-world situations, rather than aiming at quick quiz responses that usually stop short of ability to recognize content and don't demand students understanding or ability to use it. Using knowledge and skills in real-world applications — especially to solve problems with no "pat" solutions, as in the "D Quadrant" — greatly increases development and maintenance of neural connections. Once contextual learning has been established, the learning translates into other arenas for relevant use.

The most effective educators connect to the students, enrich the learning environment, and offer high-sensory experiences to optimize learning. Educators have a tremendous impact on the individual learners who will become the next global leaders.