# Brain Science in the Classroom:

## Enhancing all Students' Capacity to Learn

***One of the potentially greatest breakthroughs in education today is that we are now beginning to use new knowledge of brain function to assist students at all levels.***

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***Our knowledge of how the brain learns has expanded greatly over the last decade, thanks research by neuroscientists.***

***Traditionally educators have sought to improve the effectiveness of educational methods through two primary routes: Improved curriculum and enhanced professional development.***

For example, in Australia, the National Enquiry into the Teaching of Literacy made recommendations on both these domains. The Enquiry highlighted the importance of training teachers in evidenced based methods of teaching reading, emphasising systematic, explicit phonics instruction for foundational reading proficiency and providing an integrated approach to reading that supports the development of oral language, vocabulary, grammar, reading fluency and comprehension.

Another example of this process in curriculum can be seen in the clarification and standardisation of the optimum content of instruction such as that seen in the U.S. National Reading Panel recommendations for mastery of the curriculum content of phonemic awareness, phonics, vocabulary, comprehension and fluency.

In recent years, professional development in many countries has stressed helping teachers standardise curriculum content and adhere to standards which are assessed by periodic uniform testing.

An element of the optimum educational outcomes that has been harder to tackle using this model is the natural ability and motivation to learn that the student brings to the classroom. What does a teacher do, for example, if a student has trouble learning phonics or if fluency lags behind accepted norms despite the best efforts of the teacher and use of the accepted curriculum?

Educators are constantly plagued by the question, "Is it the teacher's fault when a child cannot learn?" Every classroom has a proportion of students who continue to struggle to learn to read despite the best attempts to provide various interventions. Most teachers and administrators agree that some of the problem seems to involve the learner – but the question is, how?

In the past ten years, neuroscientists have begun the effort to solve this problem. Neuroscience is a scientific discipline that includes a range of areas that explore, among other things, how the human brain learns and what factors affect that learning. As such then, neuroscientists are poised to begin exploring what human cognitive variables enable some students to learn easily and others to struggle. As brain scientists have sought answers to these questions, it turns out the answers are predictably complex. But, factors have emerged that are leading to an understanding of "Why Johnny still can't read."

### *Learning Capacity = brain plasticity*

All humans who do not have a damaged brain or a marked developmental delay have the capacity to learn throughout the life span. It is remarkable, for example, that each of us, at any stage in our lives, can learn a foreign language and become reasonably competent after about 100 hours of instruction. This capacity to learn new things has a neurological basis, the brain changes. Brain changes occur each time a person learns and retains new information. Brain scientists term that capacity, neuroplasticity. Neuroplasticity is evident whether a child learns to rhyme or an adult masters an IPod. The brain changes involve new connections that form among brain cells (neurons) as well as chemical changes that enable those connections.

Learning capacity (neuroplasticity) is known to vary as we age. In a young child, learning takes place without any effort.

In a new book, Alison Gropnik, a prominent developmental psychologist at University of California Berkeley, has helped us to understand how a child's brain is programmed by early experience to handle complex cognitive tasks like reading. In her book, The Philosophical Baby, she summarises years of research on brain development in young children, highlighting new findings that the young brain is remarkably plastic and flexible. She sees the young child as an explorer, with an open attention that allows the child to seek out relevant features of their environment from the mass of information that is getting into their brains through their eyes, bodies and ears. From the exploration of the world around him, the child will learn to make hypotheses about what to do with that all of that information.

One aspect of this exploration is the child's native language. From birth, the infant is exposed to an array of speech sounds that the child must gradually learn to distinguish and sequence and ultimately associate with meaningful objects and events in her world. The innate capacity of the child to learn language is both tempered and augmented by the child's especially plastic brain, which enables the child first to master the complex details of their native language and later superimpose visual symbols onto that system for reading.

We know from Hart and Risely's research in the 1990's that when children are raised in environments where they are not exposed to a great deal of adult language, as is the case in some lower socio-economic homes in the U.S., they have a 32 million word disadvantage when then enter school – that is they have heard 32 million fewer words on which to base their knowledge of their language and use. Fortunately, as Gropnik emphasises, the plasticity of the young brain also provides an opportunity to build young brains through exposure to information that will help the brains become equipped for our educational process. Neuroscience-based technological programs provide such an opportunity for children whose early experiences and language exposure have not provided optimal experiences for later school success.

Researchers have shown repeatedly, that the child does not need to be "listening" to speech or paying attention to speech; the brain organises on its own.

But, as any adult who has tried to learn a foreign language knows, after this critical period in infancy ends, learning to 'hear' the differences between speech sounds of foreign languages requires careful attention to the speech sounds; we must be taught what to listen for and what to ignore. All humans have this neurological capacity to change that we call learning. And, although easier when we are young, the brain can grow, adapt, and learn at any age. The brain changes that result are actually new connections between and among neurons.

### *Learning speed = brain efficiency*

How easily the brain processes new information, changes and adapts (learns,) may be referred to as brain efficiency. Often, brain capacity and efficiency overlap, but not always. Educators use the term "quick learner", euphemistically, to refer to a student who learns easily. We all differ with respect to cognitive areas where we learn easily and others where we do not. In the recent biography of Albert Einstein, the author, Walter Isaacson, noted that as a student Einstein was not especially "quick" at maths.

Neuroscientists consider brain efficiency as speed of processing. Like capacity, it can vary from one cognitive domain to another and even from one sense to another. Hearing specialists, audiologists, such as my colleague Dr. Nina Kraus at Northwestern University and cognitive psychologists, like Dr. Paula Tallal at Rutgers University, both in the U.S., have attributed some problems learning language in young children to early limitations with hearing efficiency. This should not be confused with deafness or hearing loss. Rather the problem, called an auditory processing disorder, has been shown to represent, at least in part, a difficulty perceiving the rapidly changing acoustic patterns of speech.

Brain efficiency is also affected by brain chemistry. Most likely everyone has had the experience of "processing slowly" when tired, or under the influence of alcohol or some medications. In these cases the brain's efficiency is slowed down by neurotransmitters that have an inhibitory affect on most processing. There are also neurotransmitters that make it easier to pay attention to new material and to hold on to newly learned information. These latter neurotransmitters are just starting to be understood. Some of the neurotransmitters that researchers believe help with new learning include acetylcholine, which generally keeps attentional levels high, dopamine, which maintains motivation and helps the brain save new connections, and norepinephrine which, among other things has been shown to keep one alert and interested in new material.

It turns out, that the way we present information to a child or adult, in many ways enhances these 'learning' neurotransmitters. For example, when a teacher uses novel materials, or commends a student on a job well done, norepinephrine and dopamine are naturally increased.

### *Application to Education*

So what does this new brain science contribute to education? Neuroscience now helps educators in two ways. First, it can provide teachers with an understanding of why some kinds of learning may be more difficult for some students than others. And, perhaps more important, neuroscience is providing educational tools that enhance learning capacity and efficiency. Neuroscientists have demonstrated that all students exhibit different patterns of learning that equate to underlying cognitive capacities of memory, attention, processing and sequencing. Surprisingly, this has little to do with native intelligence or IQ, rather it relates to learning patterns.

Attention - Some students are better able to attend to the internal detail of words, others are not. Those students who attend to internal detail of words are naturally 'good' at tasks like phonemic awareness: activities like rhyme and isolating initial consonants of words.

Other students, however, despite equal intelligence, process words like most of us perceive faces, as a unit. Those students appear to pay more attention to the context in which a word is embedded, or the prosody of a sentence, than specific internal details. For example, when a person says, "Wow, did I ever h--- a bad day!" The exasperation of the person speaking and context provided by the other words (and perhaps the person's facial expression and body language,) help us to understand what the fifth word was, even though it was not spoken intelligibly.

Memory For other students, attending to internal detail of words may be adequate, but they may have trouble remembering what they hear. Psychologists call this auditory working memory. If it affects remembering sounds of words, reading experts may refer to this as phonemic or phonological memory. Students who have trouble with this may have experienced difficulties learning grammatical endings and small grammatical words when they were learning their own native language. Later, when learning to read, they may struggle to remember which sounds go with which letters of the alphabet, or later still, remembering all the parts of directions given aloud or details from paragraphs they read or hear.

Processing We have already discussed processing speed as a cognitive efficiency variable that affects learning. Some of us are naturally quick at picking up athletic skills, others musical skills, still others science and maths. Students with auditory processing disorders may struggle to 'hear' information clearly in a classroom and may respond slowly to auditory instruction but do very well with other kinds of instruction that is more hands-on or visually based. These students may appear to have poor listening skills or seem to be poorly motivated for classroom activities. However, when those students are tutored in quiet rooms, one-on-one, they may show much better learning aptitude.

Sequencing Finally, some students struggle learning how to deal with the order of sounds in words, words in sentences, sentences in paragraphs and paragraphs in longer narratives. During early development, children with sequencing problems may have trouble learning rules of grammar and get confused about use of prefixes and grammatical word endings (morphology). When they are learning to read, students with this difficulty may decode words reasonably well but struggle to comprehend what they read because the grammar and morphology confuse them. Small differences in the sequence of words or phonemes can entirely change the meaning of sentences that are almost alike. For example, the sentences, "the boy hits the ball" and "the ball hits the boy" require awareness of sequencing differences to know who or what is hit. Or, the sentences "the boy hits the balls" and "the boys hit the ball" vary in meaning due only to which word has the 's' at the end.

### *What can be done?*

The exciting news from neuroscience is that computer-based programs have now been developed that can increase anyone's brain capacity and efficiency, at any age. A neuroscience company called Posit Science, in the US, has developed a product called "Brain Fitness" that enhances attention, memory and processing speed in aging adults. Another neuroscience company called Scientific Learning, also in the U.S., has developed eleven educational products, called the Fast ForWord family of products, which are specifically designed to enhance students' capacity to learn language and to learn to read. Other products are likely on the horizon as well.

In addition, neuroscientists are reaching out to educators to help them enhance their teaching methods in ways that increase ability to reach all students, regardless of learning styles or individual cognitive strengths and weaknesses. They are also helping teachers understand the ways in which they can enhance the natural learning brain chemicals through new teaching methods and materials. In the past few decades, educators have developed excellent curricula and educational standards. Applying neuroscience to education promises to open many additional doors for all students, whether they are struggling to learn and read, or whether they simply wish to improve their capacity to learn more easily and more rapidly.

Dr Martha Burns will be a guest speaker at a key education conference series, 'Building Brains for Learning: "It's all in the Connections' to be held in Sydney on March 8, Melbourne on March 10, and Auckland NZ on March 12. Dr Burns will address the implications of new neurological and literacy research and how both parents and educators can help children with learning difficulties achieve much better results.

For further information on the seminars, please visit www.fastforWORD.com.au/seminars2010

Web links:

www.brainconnection.com

www.positscience.com

www.scilearn.com

www.fastforward.com.au

### *Recommended Reading:*


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Leonard, L., Weismer, S., Miller, C., Francis, D., Tomblin, J., Kail, R. (2007) Speed of Processing, Working Memory, and Language Impairment in Children. Journal of Speech Language Hearing Research, 50(2), 408-428.

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Dehaene, Stanislas. Reading and the Brain: the science and evolution of a human invention. Viking Press, 2009.

Gopnik, Alison The Philosophical Baby: What Children's Minds Tell Us About Truth, Love and the Meaning of Life. New York: Farrar, Straus and Giroux. 2009

Changing Brains: Effects of Experience on Human Brain Development. The Brain Development Laboratory, University of Oregon. 2009



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