Alien-Built Pyramids

Brain-based research is too young a science to provide the basis for educational practice.

By John T. Bruer

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We have almost survived the Decade of the Brain. During the 1990s, government agencies, foundations, and advocacy groups engaged in a highly-successful effort to raise public awareness about advances in brain research. Brain science became material for cover stories in our national newsmagazines.

Increased public awareness raised educators' always-simmering interest in the brain to the boiling point. Over the past five years, there have been numerous books, conferences, and entire issues of education journals devoted to what has come to be called 'brain-based education.'

Brain-based educators tend to support progressive education reforms. They decry the 'factory model of education,' in which experts create knowledge, teachers disseminate it, and students are graded on how much of it they can absorb and retain.

Like many other educators, brain-based educators favour a constructivist, active learning model. Students should be actively engaged in learning and in guiding their own instruction. Students should be actively engaged and immersed in complex experiences.

There is nothing new in this critique of traditional education, however. It is based on a cognitive and constructivist model of learning that is firmly rooted in more than 30 years of *psychological* research. Whatever scientific evidence we have for or against the efficacy of such educational approaches comes from the behavioural, not the biological, sciences. And none of the evidence comes from brain research.

To the extent that brain-based educators' recipe for school and classroom change is well grounded in this behavioural research, their message is valuable. Teachers should know about short- and long-term memory; about primacy/recency effects; about how procedural, declarative, and episodic memory differ; and about how prior knowledge affects our current ability to learn. But to claim that these are 'brain-based' findings is misleading.

While we know a considerable amount from psychological research that is pertinent to teaching and learning, we know much less about how the brain functions and learns.

For nearly a century, the science of the mind (psychology) developed independently from the science of the brain (neuroscience).

Psychologists were interested in our mental functions and capacities — how we learn, remember, and think. **Neuroscientists** were interested in how the brain develops and functions. It was as if psychologists were interested only in our mental software and neuroscientists only in our neural hardware.

It is only in the past 15 years or so that these theoretical barriers have fallen. This is an exciting and new scientific endeavour, but it is also a very young one. As a result, we know relatively little about learning, thinking, and remembering at the level of brain areas, neural circuits, or synapses. We know very little about how the brain thinks, remembers, and learns.

Yet brain science has always had a seductive appeal for educators. Brain science appears to give hard biological data and explanations that for some reason we find more compelling than the 'soft' data that come from psychological science.

But seductive appeal and a very limited brain science database are a dangerous combination. They make it relatively easy to formulate bold statements about brain science and education that are speculative at best and often far removed from neuroscientific fact.

And the ideas are far-ranging indeed. Within the literature on the brain and education one finds, for example, that brain science supports Bloom's Taxonomy, Madeline Hun-ter's effective teaching, whole language instruction, Vygotsky's theory of social learning, thematic instruction, portfolio assessment, and co-operative learning.

The difficulty is that the brain-based education literature is very much like a docudrama or an episode of "In Search of…" in which an interesting segment on Egyptology suddenly takes a bizarre turn that links Tutankhamen with the alien landing in Roswell, New Mexico.

Just where did the episode turn from archaeological fact to speculation or fantasy? That is the same question one must constantly ask when reading about brain-based education.

Educators, like all professionals, should be interested in knowing how basic research, including brain science, might contribute to improved professional practice. The danger with much of the brain-based education literature is that it becomes exceedingly difficult to separate the science from the speculation, to sort what we know from what we would like to be the case.

We might think of each of the numerous claims that brain-based educators make as similar to an "In Search of…" episode. For each one, we should ask: 'Where does the science end and the speculation begin?'

I cannot do that here. So, instead I'll concentrate on two ideas that appear prominently in brain-based education articles: the educational significance of brain laterality and the claim that neuroscience has established that there is a sensitive period for learning.

***(Adapted with permission from* Phi Delta Kappan, May 1999)**

Left-Brain, Right-Brain: One More Time

This is one of those popular ideas that will not die. According to popular myth, left-hemisphere-dominant individuals tend to be more verbal, more analytical, and better problem-solvers. Right-hemisphere-dominant individuals, more typically males, are supposed to paint and draw well, be good at math, and deal with the visual world more easily than with the verbal. In this scenario, schools are overwhelmingly left-hemisphere places in which left-hemisphere-dominant individuals, mostly girls, feel more comfortable than right-hemisphere-dominant individuals, mostly boys.

Educators should be wary of these claims. Although males are superior at mentally rotating objects, for example, this seems to be the only spatial task where a difference is found. Moreover, where gender differences are found, they tend to be small. The scientific consensus among psychologists and neuroscientists is that whatever differences exist may have interesting consequences for the scientific study of the brain, but no practical or instructional consequences.

Now let's consider whether the brain sciences offer support for the use of particular teaching strategies based on hemisphere dominance. Although the research does point to differences in the information-processing abilities and biases of the brain hemispheres, those differences are found at a very fine level of analysis.

The use of visual imagery is a good example. According to the folk theory, generating and using visual imagery is a right-hemisphere function. But even at a crude level of analysis, visual imagery involves at least five distinct mental subcomponents.

- To create a visual image of a dog, you must transfer long-term visual memories into a temporary memory store.
- To determine if your imagined dog has a tail, you must zoom in and identify details of the image.
- To put a blue collar on the dog requires that you add a new element to your previously-generated image.
- To make the dog look the other way demands that you rotate your image of the dog.
- To draw or describe the imagined dog, you must scan the visual image with your mind's eye.

There is an abundance of neuroscientific evidence that this complex task is not confined to the right hemisphere. There are brain-damaged patients who can recognize visual objects and draw or describe visible objects normally, yet be unable to answer questions that require them to generate a mental image. These patients have damage to their *left* hemispheres.

The same problem also subverts claims that one hemisphere or the other is the site of number recognition or reading skills. Numerical comparison, for example, involves at least two mental subskills: identifying the number names and then comparing the numerical magnitudes that they designate. We identify number words using a system in the brain's left hemisphere, but we identify Arabic numerals using brain areas in both the right and left hemispheres.

What modern brain science is telling us — and what brain-based educators fail to appreciate — is that it makes no scientific sense to map gross, unanalyzed behaviour and skills — reading, arithmetic, spatial reasoning — onto one brain hemisphere or another.

Brains Like Sponges: The Sensitive Period

A new and popular, but problematic, idea found in the brain-based literature is that there is a critical or sensitive period in brain development, lasting until a child is around 10 years old, during which children learn faster, easier, and with more meaning than at any other time in their lives.

If there were neuroscientific evidence for the existence of such a sensitive period, such evidence might appear to provide a biological argument for the importance of elementary teaching and a scientific rationale for redirecting resources, restructuring curricula, and reforming pedagogy to take advantage of the once-in-a-lifetime learning opportunity nature has given us. If teachers could understand when sensitive periods begin and end, the thinking goes, they could structure curricula to take advantage of these unique windows of opportunity.

Surprisingly, however, brain-based enthusiasts appeal to a very limited body of evidence. In fact, practically the only scientific study cited is the work of Dr. Harry Chugani at Wayne State University in 1987. Dr. Chugani and his colleagues reported the results of PET (positron emission tomography) scans on 29 epileptic children, ranging in age from 5 days to 15 years. Because PET scans require the injection of radioactive substances, physicians cannot scan 'normal, healthy' children just out of scientific curiosity.

The scientists administered radioactively-labeled glucose to the children and used PET scans to measure the rate at which specific brain areas took up the glucose. The assumption is that areas of the brain that are more active require more energy and so will take up more of the glucose.

One of their major findings was that metabolic levels reached adult values when children were about 2 years old and continued to increase, reaching rates twice the adult level by age 3 or 4. Resting glucose uptake remained at this elevated level until the children were around 9 years old. At age 9, the rates of brain glucose metabolism started to decline and stabilized at adult values by the end of the teenage years.

Now to connect high brain metabolism with a critical period for learning requires some fancy footwork — or maybe more accurately, sleight of hand. We know that from early childhood until around age 10 children have extra or redundant synaptic connections in their brains. Linking this period of excess brain connectivity with learning requires an implicit appeal to another folk belief that appears throughout the history of the brain in education literature — namely that periods of rapid brain growth or high activity are optimal times, sensitive periods, or windows of opportunity for learning.

There is no neurological evidence to support this belief. And where there is no scientific evidence, there is no scientific fact. We have a considerable amount of research ahead of us if we are to amass the evidence for or against this belief.

So despite what you read in the papers and in the brain-based education literature, neuroscience has *not* established that there is a sensitive period between the ages of 4 and 10 during which children learn more quickly, easily and meaningfully. Brain-based educators have uncritically embraced neuroscientific speculation.

In other words, the pyramids were built by aliens — to house Elvis!