The Brain, Learning, and Teaching

Can a better understanding of the brain help us teach?

By Steve Masson

SEVERAL YEARS AGO, the relevance of neuroscience research in education was fairly limited. Researchers, teachers, and others in the field of education intuitively suspected that there was a profound and significant link between the brain and school learning. As this link was neither clear nor based on sound scientific knowledge, the educational benefits from brain research were few and meager.

Today, however, due to advances in brain imaging in particular and neuroscience in general, the situation has changed significantly. In this article, I present three major discoveries that will not only help build stronger links between the brain and school learning, but that also support the hypothesis that a better understanding of students' brains can help us teach them better. These three discoveries relate to how learning affects the brain, how the brain's architecture influences learning, and how teaching impacts brain development.

Discovery No. 1: Learning changes the architecture of the brain

The first discovery concerns the relationship between learning and the brain. For many years, we believed that the brain was a set organ that developed during pregnancy and early childhood, influenced primarily by genetic factors, but that remained relatively stable thereafter.

We now know that this idea is, for the most part, incorrect. In fact, though the brain is particularly malleable in early childhood, it retains a surprising degree of plasticity throughout our lives. As we learn, our brains change. More specifically, connections between neurons are altered by learning; new connections can be created...
and existing connections can come loose, be reinforced or weaken. The brain is therefore not a set - but a dynamic - organ that is constantly adapting its architecture to its environment.

The fact that learning shapes the brain's function and architecture is a sine qua non for establishing a clear link between the brain and education. What interest would there be in the relationship between the brain and education if learning did not shape the way the brain functions or its architecture? Brain imaging lets us observe brain activity associated with school tasks such as reading and counting, but it does not tell us how the brain develops these skills. Because learning shapes the brain, we can use brain imaging to identify the effects of school learning on the brain and thus build the first bridge between the brain and education.

Discovery No. 2: The architecture of the brain influences learning

The first major discovery (discussed above) highlights an essential condition for establishing links between the brain and education, whereas the second major discovery leads us to believe that a better understanding of the brain could provide clues as to how we can better teach students.

This second discovery concerns how the brain architecture influences learning. A growing number of researchers think that the brain's architecture (that is, how neurons are interconnected) significantly influences and constrains how school learning takes place in the brain.

When students learn to read, for example, they already have a well-defined brain architecture. They have specific areas of the brain for recognizing objects (the left occipito-temporal cortex and the right occipito-temporal cortex located in the posterior part of the brain) and areas responsible for oral comprehension, speech production, and understanding words (located mainly in the left temporal lobe in most students). Learning to read relies on these areas and the pre-existing brain architecture.

To read, students must first learn to recognize visual objects such as letters and words. The left and right occipito-temporal cortices are well suited to this task as they are largely responsible for identifying objects in general. However, since letters and words represent a new class of objects, students must still alter their neural connections to learn to read. This process, whereby a brain area is altered to acquire new skills, is called neuronal recycling. It is interesting to note a first learning constraint that depends on students' initial brain architecture: because the brain naturally recognizes objects regardless of how they are positioned, it is initially difficult for students to distinguish among the letters p, q, b, and d, which are naturally treated by the left and right occipito-temporal cortices as a single object presented in different positions.

But reading does not simply involve recognizing letters and words; perhaps first and foremost, it requires assigning meaning to what is read. Students must not only recycle the part of their brains dedicated to identifying objects in general, but they must also establish connections between this area, which is responsible for recognizing objects, and the left temporal lobe, which in some way contains a mental dictionary of the words acquired when learning to speak. As the left occipito-temporal cortex is physically closer to the brain areas associated with language, it seems more prone than the right hemisphere to recognizing letters and words. In fact, several studies have confirmed that the ability to read involves the left occipito-temporal cortex, not the right.

This knowledge allows us to highlight another constraint that the architecture of the brain imposes on reading. Because the parietal-temporal cortex (the area associated with speech sounds) is located particularly close to the occipito-temporal cortex, it acts as a prime gateway for neural networks linked to language, especially those containing the meaning of words. This physical proximity could explain why graphophonic approaches are often effective when it comes to teaching reading - simultaneously activating the neurons linked to identifying letters and graphemes and the neurons linked to identifying speech sounds leads to establishing connections between the left occipito-temporal cortex and the left parietal-temporal cortex.

Another example supports the idea that students' initial brain architecture has a significant influence on their ability to learn. Several studies on education have shown that students often have non-scientific conceptions about various natural phenomena that are particularly difficult to change. They believe, for example, that heavier objects fall faster than lighter ones regardless of air resistance, or that a single wire between a power source and a bulb is sufficient to light it.

A recent study involving brain imaging suggests that students' non-scientific conceptions might never be completely erased from their brains because they stem from basic intuitions etched in the brain in the form of well-established neural networks that most likely cannot be changed. The results of this study show that students who are further along in their science education must use brain areas linked to inhibition (such as the ventrolateral prefrontal cortex) to scientifically answer questions about common non-scientific conceptions. Inhibition is the brain's ability to control intuitions, strategies, and natural responses by releasing inhibitory neurotransmitters that hinder the activation of neural networks responsible for these intuitions, strategies, and responses.
As in the example of learning to read, this study on science learning supports the idea that students’ brain architecture plays a key role in learning because it influences and constrains how learning takes place in the brain. In the coming years, studies are expected to identify the factors that could help develop inhibition. We may then be able to help students better understand certain scientific concepts by developing their ability to control their core intuitions that lead to non-scientific reasoning.

**Discovery No. 3: Teaching influences how learning affects the brain**

More recent and even more relevant to the field of education, the third major discovery (closely related to the second one) concerns the idea that teaching influences how learning affects the brain.

Knowing that learning changes the architecture of the brain and that the architecture of the brain influences learning are both very interesting to the field of education. However, this knowledge would be of little use if teachers and others in the field of education could not, through their pedagogical choices, affect students’ brain plasticity, neuronal recycling, and ability to use inhibition.

A study on two methods of teaching reading is particularly eloquent on this subject. It shows that directing students’ attention to correspondences either between graphemes and phonemes or to whole words (without directing attention to graphemes) could have a dramatic effect on students’ brain function. The results of this study show that people who receive graphophonetic instruction mostly use their left occipito-temporal cortex (an area linked to reading proficiency, which seems to connect more easily to the areas associated with language due to spatial proximity), whereas those who receive whole-word instruction rely more on their right occipito-temporal cortex (an area often linked to reading difficulties, which is relatively far from the areas associated with language).

Another study also shows that the type of instruction used (particularly warning students about traps and teaching them to recognize tempting yet incorrect answers) has an impact on brain function and the ability to use inhibition to correct common errors. Like the previous study, this one shows that the type of instruction can significantly influence brain function and development.

**A better understanding of the brain to help us teach better**

Can a better understanding of the brain help us teach better? The three discoveries presented in this article support this idea: a better understanding of students’ brain architecture and the impact of different types of instruction on the brain could provide clues to improving learning and teaching.

Despite these major discoveries, it is important to remain cautious about the educational benefits that may result from brain research. In fact, in recent years, an increasing number of books and educational programs have claimed to use brain-based education. Unfortunately, these books and programs (often popular among teachers) frequently contain neuro-myths, that is, nonscientific beliefs regarding brain function. When discussions turn to learning styles, hemispheric dominance (left brain/right brain), the fact that students only use 10 percent of their brains, or Brain Gym, beware! One thing, however, is certain: all students’ brains demonstrate plasticity. Students’ learning difficulties should not, therefore, be perceived as unchangeable, but rather as challenges to overcome for students whose brains can change and improve through learning. Another thing is certain: teachers are important. Through the pedagogical choices they make every day, teachers can help students develop neural connections that will allow them to read, write, count, and solve all kinds of problems. This more positive observation comes, however, with great responsibility: teachers and education systems must strive to provide instruction adapted to students’ brain function and architecture.

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