Who Knows most about Learning? or, Why the Brain is not Talked about in Schools

Dr. Tracey Tokuhama-Espinosa, Ph.D.
Director of IDEA (Instituto de Enseñanza y Aprendizaje or Teaching and Learning Institute), and
Professor of Education and Neuropsychology at the of the University of San Francisco in Quito, Ecuador

The following is an excerpt from Mind, Brain, and Education Science: A comprehensive guide to the new brain-based teaching (W.W. Norton) a book based on over 4,500 studies and with contributions from the world’s leaders in MBE Science.

Conceptual Debates in the Discipline

One way to understand the conceptual debates in the discipline is to recognize that “neuroscience is focused on the neuron as the primary unit of study while psychology’s unit of study in the mind and pedagogy’s view is on society and the individual, as manifested through formal educational practice”[1] It is clear that a person who views learning through a microscope, one who concentrates on behavioral changes in animals (including humans), and one who views learning through classroom interaction all have different perspectives on learning. Mental schemas, including whom we view as key actors or mentors, and what we view as core loci for execution, are influenced by our academic formations.

In one of the first searches on “brain and learning” in academic journals I conducted, I found a surprising array of perspectives. When the key words “brain” and “learning” were inserted in a search engine, there was a myriad of interpretations of these two words ranging from the “neuro views” (how cells learn) to the pop psychology perspective. In a great number of cases
these peer-reviewed journals focused on nonhuman brains and the learning of cells and very few related to kids in classrooms. In other cases, as in peer-review psychology journals, the focus was on therapy and behavioral changes, but again, with no classroom application. Curiously enough, there were few journals in education that specifically considered the brain. Though it may seem ironic, brains and classrooms were not often found in the same articles. All of this is to say that each of these disciplinary perspectives views the brain and learning in very different ways, and each perspective impacts our understanding of how the brain learns to read, and subsequently, how we should teach to maximize that performance. Cross-germination of understandings about these different topics leads to a unique vision of how knowledge is learned and can be nurtured by specific teaching interventions. To unite these different and valuable perspectives, MBE scientists combine the knowledge from each of these disciplines and synthesize the findings to develop a new approach to learning substantiated by all three parent fields.

In terms of reading, the combined approach can be seem in research such as that of Juliana Pare-Blagoev (2006), Maryanne Wolf (2007), and Stanislas Dehaene (2009), who manage to balance information from neuroscience, psychology, and education to create more powerful teaching tools than those that come from just a single discipline. In terms of math, this is seen in work conducted by Stanislaus Dehaene (1997) and colleagues, as well as analyses by Donna Coch, Kurt Fischer, and Geraldine Dawson (2007).[2] Readers are invited to read these excellent treatises on a new view of teaching.

Viewing old learning problems through the new MBE science lens will change the traditional perceptions in neuroscience, psychology, and education. For example, let’s say a teacher observes that students’ retention of new information is enhanced through cooperative learning activities. The teacher wonders if cooperative learning can be considered an instrument worthy of MBE science. The teacher begins with a clear definition of cooperative learning: Cooperative learning techniques are activities in which groups of students democratically share the responsibility for generating solutions to problems. In such situations, the stress level felt by students is drastically reduced as the competition level is lowered. The teacher finds that cooperative learning and peer teaching include feedback and modeling.[3] She researches the literature in psychology for evidence and finds that
feedback and modeling have a great deal of evidence. Confirming the evidence in psychology, the teacher then turns to neuroscience. For educators (see Figure 3.1):

*Figure 3.1 Suggested Cycle of Information Generation for Educators*

Source: Tokuhama-Espinosa 2008a

Neuroscience studies show that learning is enhanced when stress levels are lowered. The release of stress hormones inhibits natural pathways for learning.\[4\] The documentation of such evidence provides a physiological explanation for the psychological discomfort that fear, stress, and anxiety cause in the brain. The teacher realizes that this information is evidence in favor of cooperative learning activities and determines that they fall into *MBE science* activities.

Let’s look at another example from a psychologist’s perspective. Let’s say a psychologist observes that rats seem to learn in enriched environments where there are toys and other rats. The psychologist wonders if enriched environments also have an impact on human brains. To look for evidence in pedagogy and neuroscience, the psychologist must first define *enriched environments* and then decipher the elements that comprise such an environment. He determines that enriched environments include different types of stimulation, varying materials, manageable challenges, predictable rewards, and company. The psychologist then looks to pedagogy for evidence and finds that students who are given similar stimulation also tend to do better in school.\[5\] The psychologist also discovers that there is evidence
showing how a lack of stimulation affects the brain negatively, the most noteworthy in research done with Romanian orphans who were often left tied to their cribs with no human contact.[6] To confirm whether or not enriched environments are supported by all sub-disciplines in MBE science (which would elevate the likelihood of success), the psychologist turns to neuroscience for final confirmation. In neuroscience he finds that enriched environments change the brain, evidencing more synaptic activity, in rat, but not in human, studies.[7] The psychologist finds that this evidence, however, is generally related only to certain aspects of enriched environments, as in rehearsal of a skill in different environments,[8] or due to socialization, but not due to increased toys or plentiful and varied activities.[9] To top it off, “there is no evidence in humans linking synaptic densities and improved learning” (Hall, 2005, p. 17). There are also criticisms that the “enriched” environments in which the original rat studies upon which this theory is based were conducted were actually more like “normal” environments for rats (sewers), meaning that the studies proved that impoverished environments cause harm, but not necessarily that enriched environments are beneficial. The psychologist determines that there is compelling evidence for the inclusion of enriched environments in general, but that the evidence does not merit complete acceptance yet. This means that the consideration of good learning environments may be important, and the evidence shows it is “probably so” or “intelligent speculation,” but not “well established” at this point in time. The psychologist accepts that further compelling evidence should be offered before full acceptance.

For psychologists (see Figure 3.2):

*Figure 3.2. Suggested Cycle of Information Generation for Psychologists*
A final example from neuroscience helps us understand how information can and should be critiqued in the new discipline. Let’s say a neuroscientist notes that a patient loses the ability to read (or interpret humorus remarks, or spell correctly) after suffering a stroke. Using this information, she makes some generalizations about how language works in the brain.[10] This neuroscientist might wonder if the particular neural pathways, which appear damaged after the stroke, can contribute to knowledge about how to teach better. First, the neuroscientist must identify exactly what stimulates this part of the brain and precisely how the neurophysiology changed after the stroke. Once the neuroscientist can determine how to measure such changes, he can look for research in education and psychology that supports evidence that reading is, indeed, triggered through such mechanisms. Have experiments investigated the effects of extra stimulation of this particular brain region, for example? Did such experiments result in improved reading abilities of children? Have others documented how damage to these brain areas caused skill loss? If and when the neuroscientist can identify such support from education and psychology, then he can be sure that his single case was not unique and begin to generalize a theory of reading and the brain.

An illustrative case in neuropsychology was that of Phineas Gage, whose accident while working on a railroad caused the destruction of his right frontal and parietal lobes. This region was later identified to be related to metaphorical expressions and interpretation of humor via language.[11] This finding, though celebrated in psychology, is rarely shared with educators,
which means that we teachers have missed out on valuable information. For example, Gage's case led to the understanding that although some students might excel at some aspects of language, they may not do so in all, as different parts of language are mediated by different systems of the brain. Specifically, spelling travels through one neural network, metaphors another, vocabulary another, and syntax and grammar yet another. It should come as no surprise to teachers, then, to find that children may not be globally “good” at language, but rather they might have strengths and weaknesses. This finding also has policy implications because it means that not only should teachers differentiate their methodology, they must also differentiate their assessment of students by dividing up overall skill areas (e.g., in language) into several sub-skills (e.g., metaphors, spelling, grammar, written, spoken).

For neuroscientists (see Figure 3.3):

Figure 3.3. Suggested Cycle of Information Generation for Neuroscientists

The disciplines of neuroscience, psychology, and education can inform each other in many ways, as demonstrated in the contents of this book. Some specific examples of each of these exchanges are mentioned below as a way to summarize the findings and possible conclusions about the interdisciplinary nature of the discipline.

Neuroscience Can Inform Pedagogy
There are a myriad of ways in which neuroscience can inform pedagogy. Some of the most prominent studies can be found in math and reading. Other areas are less developed, but equally important. For example, the cognitive neuroscience of category learning[12] points to specific practices that help teachers instruct their pupils in a way that corresponds with the brain’s natural categorization mechanisms. This is one of the first formal skills small children learn in school as they begin to sort out the concepts in their world. Other studies on the neuroimaging perspective of conceptual knowledge illustrate how different types of ideas are linked in different ways in the brain.[13] These neuroscience studies can help educators understand which concepts are best taught in tandem, and which create problems if taught together. For example, it has been found that it is harder if someone studies French and Spanish (which are very similar, as far as languages go) at the same time, than if they study French and Japanese (which are very different due to orthography and syntax). Other studies in neuroscience attempt to bridge the gap between our understanding of mind and brain through the study of neurobehavioral integration.[14] Such studies consider how the brain and mind work to manage all external as well as purely mental activity, which helps teachers understand the complexities of decision-making, for example. To what extent do external stimuli distract or guide thought patterns and how does this effect impact student behavior in classroom? Other neuroscientific studies explain the relationship between sleep and learning, which has huge implications for teachers. For example, we now know that sleep is vital for memory consolidation, yet many students “pull all-nighters” to study for tests, then wonder why just a few days later, they cannot remember what they thought they had studied.[15] There are literally thousands of different ways in which neuroscience can inform pedagogy, but this is only one of several paths through which information can be generated. There should be a three-directional exchange of information—for example, pedagogy can inform psychology.

**Pedagogy Can Inform Psychology**

There are several ways in which pedagogy can inform psychology. Teacher observations about student reactions to different methodologies as well as a measurement of their metacognitive development can inform psychology. Similarly, the study of differentiated teaching practices related to perceived
learning styles can identify preferences for memory storage.[16] These studies profess to enhance memory and therefore learning. Teaching and assessing students based on their individual potential in a subject area is a basic tenet of MBE science. Students’ different levels of intelligence and cognitive preferences, combined with their varying levels of knowledge and skills, justify differentiation in classroom practices. This does not mean that instruction is conducted in a one-on-one fashion, but rather that the teacher takes the time to diagnose student needs and plan learning experiences in a more personalized way. We now know that it is more effective to avoid rushing through topics to cover the material (even if in a logical order), unless those topics are anchored to the past knowledge or mental schemas (read “realities”) of students.

If we can increase teachers’ perceptive abilities about the different ways people learn, then they could become better in their practice. Likewise, research into how different methodologies and classroom activities impact the quality of student output within classroom settings is a valuable way of gaining insight into psychological thought processes.[17] Perhaps the most common studies are those of classroom activities that test the validity of psychological concepts, including those related to self-esteem and motivation[18] and their impact on learning. Just as pedagogy can inform psychology, psychology can also inform neuroscience.

**Psychology Can Inform Neuroscience**

Psychology has been, perhaps, the principle source of neuroscientific investigation. Indeed, what has been “known” for years in psychological contexts is now being “proven” in terms of brain activity through neuroscience. For example, psychologists have known for centuries that humans tend to imitate one another for social reasons; people act like their valued peers in order to “fit in” and be accepted. Such studies can be used to develop theories of brain activation during social cognition,[19] including that which occurs in classroom settings. In other instances, psychological hypotheses about certain behavior can be documented in neuroscience to determine patterns or systems of brain mechanisms during that specific behavior.[20] For example, Staumwasser (2003) demonstrated how the psychological development of the mind of a child can actually be measured
within neuroscience. He sought to better define “what is truly ‘unique’ in the development of the [human] mind” by comparing human and chimpanzees and the mental pathways used to make decisions. He was able to show that there are “four inherent behavioral differences” demonstrable through Event-Related Potential (ERP) brain activity measurement between the species (p. 22). This is, in effect, the true mind–brain confirmation. Not only has psychology had an impact on neuroscience, it can also inform pedagogy.

**Psychology Can Inform Pedagogy**

Psychology has been a rich source of information for pedagogy. For example, the basic conceptual beliefs about the thinking process were contemplated first in psychology with subsequent applications in formal learning environments.[21] In other studies, psychology has demonstrated how beliefs about intelligence influence learning success[22]—such research can greatly impact the way in which we teach and our relations with our students. Students tend to live up to the expectations of their teachers: High expectations yield better results.

Some of the links between psychology and pedagogy are overt. *Monitor on Psychology*, a journal of the American Psychological Association (APA), considered how brain scans can turn into lesson plans, for example.[23] Other psychological research is subtler in its consideration of the hypothetical role of working memory on education,[24] or of evidence for pedagogical practices that engage the learner. For example, Sherrie Reynolds’s work (2000) reminds practitioners that “learning is a verb,” or an active process, when considering the psychology of teaching and learning. All of these studies clearly demonstrate the major role psychology has played in designing current teaching methodologies in MBE science. In a similar fashion, pedagogy can inform neuroscience.

**Pedagogy Can Inform Neuroscience**

Pedagogy can inform neuroscience in a variety of ways. For example, educators have written about the need to have a better presentation of scientifically based research.[25] This evaluation informs neuroscience about education’s level of understanding of scientifically based research, which can
be corroborated in future neuroscientific study. In essence, neuroscientists are asking neuroscientists to find utilitarian aspects to their research that have direct applications to the classroom. In other instances, educational settings can confirm or defy findings in neuroscience labs by offering environmentally valid settings—something often missing in lab research. [26] Other educational studies have provided specific methodology for scrutiny in neuroscience and have shown that how we teach impacts what can be learned. [27] Some educational research has demonstrated how classrooms are the ultimate proving ground for neuroscience related to MBE science—which literally means that without this final “passing grade,” neuroscientific research remains purely an intellectual exercise without real-life applications. [28] Finally, evidence in pedagogy should be used as the bases of confirming hypotheses in psychology that have been confirmed in neuroscience. [29]

Perhaps the most important link between pedagogy and neuroscience occurs when neuroscientists take proposals in education and put them to the test in real classrooms. For example, neuroscientists can compare the basic premises in Alfie Kohn’s work (1999) (called The schools our children deserve: Moving beyond traditional classroom and tougher standards) and Kathie Nunley’s layered curriculum design (2002) with information in the neurosciences. Educational claims are an underused and rich source to access in identifying new neuroscientific questions for research. Far more research in neuroscience should begin with educational premises, rather than with neuroscientific findings that are molded to fit educational settings. In a similar way, neuroscience can inform psychology.

**Neuroscience Can Inform Psychology**

Neuroscience can inform psychology in several ways. Perhaps the most obvious way is through the confirmation of specific claims. For example, psychology has spent centuries discussing consciousness. Neuroscientists such as Russell Poldrak and Anthony Wagner (2004) have ventured to ask “what can neuroimaging tell us about the mind?” In a similar vein, others have queried “how the emerging neurosociety is changing how we live, work, and love.” [30] Others have tackled the nature versus nurture query in psychology and reframed the question as one of the combination of “genes, brain, and
cognition"[31] to consider the “making of the self.”[32] Neuroscience is being used to establish psychological claims about social, cognitive, and affective learning.[33] While many are enthusiastic about what neuroscience can do for psychology, there are a good number of more conservative perspectives that put parameters around the debate of “what neuroimaging and brain localization can do, cannot do, and should not do for social psychology.”[34] These types of studies point to the natural interaction of neuroscience and psychology as well as their many areas of overlap. Considering how the three parent fields can successfully inform one another is exciting and points to a potentially bright future for MBE science.

Using multiple lenses and a transdisciplinary perspective, MBE science can facilitate the advancement of teaching methods through the reinterpretation of findings in neuroscience, psychology, and pedagogy. There are dozens of ways this reinterpretation can take place. For example, best-practice pedagogy can guide the focus of studies in neuroscience, as leaders in the discipline have noted: “The identification and analysis of successful pedagogy is central to research in education, but is currently a foreign field to cognitive neuroscience” (Goswami, 2004, as cited in Hall (2005, p. 3). Similarly, educational psychology can inform educational neuroscience, which in turn can inform pedagogy. Currently “it is rare to find an article written by a neuroscientist in the educational literature,” (1998b, p. 9) according to John T. Bruer; educational journals should solicit articles from the neurosciences in order to inform their readership of relevant information. Likewise, neuroscientists can and should point out errors or overgeneralizations of information about the brain to the public at large and educators in particular. This type of gentle correction can elevate the quality of information used in classrooms.

**References**


Meltzoff, A., & Decety, J. (2003). What imitation tells us about social cognition: A rapprochement between developmental psychology and


**Books on this topic by Tracey Tokuhama-Espinosa:**


[4] As demonstrated in the work conducted by Lupien, Maheu, Tu, Fiocco, & Schramek (2007).

[5] As in examples offered by writers such as Jensen (2006a); Marzano, Pickering, & Pollock (2004).


[8] A classic study in this area can be found in Maguire (2006).


[10] For examples of this kind of study, see Booker, Invernizzi, & McCormick (2007); Holden (2004); Schlaggar & McCandliss (2007).


[12] For a good example, see Keri (2003).


[14] For examples, see Meissner (2006); Saxe (2006)


[16] An example of this can be found in Sprenger (2003).

[17] For example, see Stalh (1990).


[21] For an example, see Markham & Gentner (2001).

[22] This can be seen in work by Mangela, Butterfeld, & Lamb (2007).


[26] For an example, see Harley (2004).


