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What Can Neuroscience Bring to Education?

MICHEL FERRARI
Centre for Applied Cognitive Science, Ontario Institute for Studies in Education, University of Ontario

Abstract

Educational neuroscience promises to incorporate emerging insights from neuroscience into education, and is an exiting renovation of cognitive science in education. But unlike cognitive neuroscience—which aims to explain how the mind is embodied—educational neuroscience necessarily incorporates values that reflect the kind of citizen and the kind of society we aspire to create. Neuroscience can help fulfill the mandate of public education, but only as a tool that is part of a broader conversation about what schools should strive to achieve for the millions of students who attend them. I propose that educational neuroscience must advance our understanding of how knowledge is embodied in light of efforts to promote personal learning and development.

Keywords: autism, ADHD, personal development, culture

Looking back over the mainstream relationship between psychology and education we seem to see a clear progression. At the turn of the 20th century we had educational psychology emerging as a broad discipline to apply psychological findings to educational practice—although already we find a tension between the pragmatic approach of Dewey and the behaviorist 'drill and skill' approach of Thorndike. By the 1960s we see the first efforts to apply cognitive psychology to education, both in information-processing models and in constructivist efforts like those of Piagetians and neo-Piagetians. By the early 1990s we find efforts to consider the importance of contextual variables like family and culture, or learning environment. By the late 90s, we find models like those of Fischer (Fischer & Bidell, 2006) that try to integrate all of these approaches into a comprehensive model of knowledge development. As the 21st century begins, we have a new development, educational neuroscience.

Educational neuroscience promises to incorporate emerging insights from neuroscience into education and is an exciting renovation of cognitive science, if integrated with sensitivity. Although educational neuroscience aims to explain learning and development generally, it seems particularly important to explaining atypical performances of students with special needs (e.g. ADHD, autism, dyslexia, or math disabilities). However, for a full understanding of these disabilities, educational neuroscience must consider how

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they manifest themselves in learning and education that occur within the broad context of people's lives, both inside and outside of school. My own work and that of my students suggests that although educational neuroscience can advance our understanding of how knowledge is embodied, it needs to do so in ways that promote personal learning and development. For example, Carrie Richardson (2002) and I looked at how students with Attention Deficit Hyperactivity Disorder (ADHD) managed the intake of Ritalin to control their attentional difficulties. In a series of six case studies, we found that adolescents made personally and contextually sensitive decisions about when to take Ritalin, depending on the kind of experiences that they expected to encounter. For routine school tasks they would take the drug, but for creative tasks like composing music they would be careful to let its effect wear off before engaging in that activity. Studying the neuroscience underlying attentional difficulties certainly allows us to better to understand what areas of the brain (and what cognitive subskills) are involved in cognitive performances, and where points of breakdown can contribute to ADHD, but what our study shows is that we must also understand the attentional demands of particular personally meaningful educational contexts (including both classroom and informal learning contexts). Likewise, Zopito Marini and his colleagues (Marini *et al.*, 2010) have also shown that learners who show similar kinds of bullying and aggression can require very different kinds of scaffolding or training when those behaviours occur for different neurobiological reasons that lead some people to be callous and others to be uninhibited; understanding these differences can allow educators to react more sensitively to students who engage in bullying, and to be much better prepared to help them manage their aggression.

All this seems a very promising use for educational neuroscience by educators, and many seem very excited about the possibilities of what neuroscience can bring to education. However, as Geake and Cooper (2003a, b) point out, there are also dangers in efforts to apply neuroscience to education. One danger is when neuroscience adds nothing new to existing understanding of the issues, but lowers one's guard about the value of particular kinds of educational practice—simply riding a bandwagon and the wave of popularity of neuroscience explanations generally. Indeed, a recent study showed that explanations with neuroscience included seemed better, even when neuroscience added nothing in support of the arguments presented (Weisberg *et al.*, 2008). As a real-life case in point, although there are clear neurocognitive differences between people diagnosed with autism and the rest of the population, what these differences mean for autistic individuals as they live their lives outside the lab is not immediately apparent. Indeed, lab study results from neuroscience and cognitive science can often lead to false generalizations from lab situations to people's lives. For example it is sometimes reported that people with autism have no understanding of other minds—that they are, in a sense, 'mind-blind' (Baron-Cohen, 1995). Ljiljana Vuletic and I conducted an in-depth case study of Teodor Mihail, an adolescent with Asperger's Syndrome (Vuletic, Ferrari & Mihail, 2005)—which many place on the Autism spectrum—and found that he showed great sensitivity and insight into other people's condition when those people were significant to him. For instance, he was concerned that his grandmother might become too tired if they took too extensive a bus tour, despite his own fascination with the Toronto bus system; and he had no trouble understanding that people in Romania (where he had visited) could not know about Toronto buses because they had never been to Toronto.

Another danger of uncritically applying neuroscience to educational practice is reductionism. We must guard against claiming that the root cause of learning difficulties is a mechanical failure or abnormality that operates at the genetic or neural level. It is important to acknowledge that the brain changes itself in response to environmental influences and based on personal effort and choices (Doidge, 2007). This is a point Bandura (2006) makes in his critique of studies in *cognitive* neuroscience that seem to undermine human agency. Following Bandura, it is important that *educational* neuroscience be careful to promote frameworks in which agency is possible and valued.

We can see the importance of agency in the examples, mentioned earlier, of students determining how to manage the use of Ritalin. Likewise, in our case study of Asperger's Syndrome, Teodor later asked Ljiljana what most adolescents would put on a website, so he could be sure to do the same. Not only atypical adolescents such as these, but the people who care about them—friends and parents—all work to position these youth in light of, and sometimes as resisting, master narratives about disabilities that are culturally very powerful and as formative for their lives as any neuroscientific evidence concerning what is or is not possible for them to do (Hammack, 2008; Harré, 2008; Harré & van Langenhove, 1999). This point is particularly clear when we consider people with Asperger's who have left school and function as adults in society—sometimes (but not always) as successfully as anyone else, as Ljiljana's interviews with adults with Asperger's clearly show (Vuletic, 2010).

Thus, we endorse the Dalai Lama's (2006) view that although mind and self are empty of inherent existence, that does not mean that there is no lived experience of mind or self; rather it means that to fully understand them, one needs to understand the causes and conditions of their existence. While neuroscientific evidence points to an important role for 'upward' neural causes for various kinds of experience, the kind of mind or person we become is also 'downwardly' caused by our education and our choices (Sperry, 1993). Of course, not everything about our mind or person is a product of our education, even very broadly defined. The physical environment has as important an effect on the brain as the brain has on our capacity for learning. As Martha Farah (2010) has shown in a series of studies, low socioeconomic status (SES) has dramatic effects on the brain due to associated physical effects of malnutrition, stress, as well as the psychological effects of lack of cognitive stimulation; hence we need to be alert to powerful impact of poverty on education through its direct effect on neurocognitive development, and work to mitigate that impact before low SES produces lasting effects on children's brains and minds that education can only partially remediate. In that light, educational neuroscience studies such as those of Farah (2010) can provide evidence in support of something as basic as the importance of providing nutritious lunches at school—which can be critical in assuring healthy brain development. Educational neuroscience can also help design educational programs, for example, based on observed differences in learning success and brain functioning of those more or less skilled in math.

How, then, to proceed to make the most efficient use of the new information gained by studies in educational neuroscience and their meaning for people's lives? Ironically, history gives us good models that have not been maximally exploited to date. In particular, the original writings of both Piaget (1967, 1983 [1970]) and Vygotsky (1997) [1934] show that they had already incorporated the neuroscience of their day into overarching research programs that considered their implications for education in ways that might be adopted in outline today. For instance, Piaget proposed a reciprocal assimilation of the findings from biology and cognitive science (as well as other allied disciplines). While appreciating the distinction between causal explanations in neurobiology and implicative explanations in psychology he granted a certain isomorphism between the kinds of structures and their relation to learning activities (Ferrari, 2009).

Furthermore, although Vygotsky has little to say about isomorphic knowledge structures and how they relate to specific brain activity, he had much more to say about the relations between culturally developed bodies of knowledge and the individuals who must learn them. In particular, he was deeply concerned with how people with physical deficits (e.g. those born with handicaps like blindness or deafness, or acquired injuries such as brain damage) must learn through alternative pathways—a point echoed by Fischer and Bidell (2006). I wholeheartedly endorse this view, but would like to add that we must also include technology and the extended environment when considering the scope and limitations of educational neuroscience. Consider, for instance, Vaughan, Rogers, Singhl and Swalehe's (2000) report on how collective self-efficacy surrounding family planning and sexual responsibility can be promoted through educational entertainment. In particular, a specially designed radio show significantly increased HIV/AIDS prevention in the part of Tanzania in which it aired.

In sum, we need an educational neuroscience that follows the medical model at least in this way: that pure research informs practice, especially for rare cases that deviate from the norm. But unlike medicine, which aims at promoting health, education promotes values that reflect the kind of citizen and ultimately the kind of society we aspire to create. Although educational neuroscience necessarily involves evidence from cognitive neuroscience about the brain, it also concerns people and how they choose to live their lives, as shaped by the cultural influences they are exposed to. This point is wonderfully articulated in a debate between the neuroscientist Jean-Pierre Changeux and the philosopher Paul Ricœur (Changeux & Ricœur, 2000) about whether neuroscience can enter into a 'third discourse' that unites biological and personal experience. However, this debate did not specifically address the issue of education.

Still, the issue of creating a common discourse seems relevant to this debate about how to integrate education and neuroscience, at least to the extent that one agrees with Egan (1997), who proposes that there are at least three aims of public education: (1) job preparation; (2) truth seeking and (3) personal flourishing. All three of these may not only conflict with each other, they may also call for different relations between education and neuroscience, depending on what we choose to include within them. In other words, neuroscience will inform each of these three aims of education, but does not set any aims itself; educators or policy makers must look to neurobiology to answer the specific questions that concern them personally, questions such as 'What is the biological basis of personal flourishing?' or 'What biological support is needed to allow particular people to learn in ways that will get them a good job?'. Existing research programs in educational neuroscience that aim to help promote literacy and numeracy might be an important part of any answer to such questions, but different questions suggest different aspects of our biology may need to be explored to answer them. What are the biological foundations of authentic and deep understanding? Of an appreciation of art and beauty? Or of compassion for those in need at home and around the world? All these concerns reflect different values that matter to particular communities and neuroscience could inform us about all of them.

Thus, again, as cases in point, students with ADHD or Asperger's certainly have trouble with certain aspects of the contemporary educational context—like sitting still for long periods of time performing tasks deemed important in our school curriculum. Such difficulties can be traced to features of their underlying neurochemistry (Dalley *et al.*, 2008), but those features and those difficulties are neither the last word about them as people, nor even about what they are able to learn under other socio-cultural conditions, nor what other kinds of learning they and others might consider a valued contribution to society.

True, neuroscience cannot study everything, but then, neither can all learning of interest fit into a K-12 curriculum with only limited time and resources. Thus, educational neuroscience must itself become part of a broader debate about the aims of education and how to help students flourish, understand deeply, and become socially productive members of society. Perhaps learning basic skills like reading and mathematics is not enough, and we also need to encourage students to gain self-insight (or personal wisdom) through practices such as mindfulness meditation (Rosch, 2008). If so, and recent efforts at promoting contemplative education alongside the basic curriculum become successful, then contemplative neuroscience will suddenly become as central to educational neuroscience as are efforts to understand the neurocognitive basis of dyslexia and dyscalculia.

In other words, educational neuroscience can help fulfil the mandate of public education, but only as a tool that is part of a broader conversation in Canada, and in other countries around the world, about what schools should strive to achieve for the millions of students who attend them.

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