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Response to Dougherty and Robey (2018) on Neuroscience and Education: Enough Bridge Metaphors—Interdisciplinary Research Offers the Best Hope for Progress

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In a recent article published in this journal, Dougherty and Robey (2018) argue that "the idea that neuroscience can have a direct impact in the classroom is a bit far-fetched" (p. 401). Following other commentators such as Bishop (2014) and Bowers (2016), they go on to say that investment of limited research funds in the cognitive and social psychological sciences is more worthwhile. In this response, I argue that for education, interdisciplinary research offers the best hope of progress at the interface of the learning sciences and that we should reject arguments that isolate scientific disciplines and pit them against each other.

Interdisciplinary Research

Arguments against educational neuroscience (the field is also known as *mind, brain, and education*) have repeatedly appealed to bridge metaphors to characterize the relationship among the disciplines of neuroscience, psychology, and education. This metaphor has become misleading and unhelpful. It leads to confusing and illogical propositions—for instance, Dougherty and Robey's assertions that understanding of mechanism is independent from understanding of behavior (pp. 401–402); that neuroscience makes a contribution to education only if its influence is "direct" and "original"; that to impact educational interventions, neuroscientific findings can be somehow "scaled up" (p. 401); or that the contribution of neuroscience is to provide "neural correlates" of interventions (p. 404) rather than help to build an understanding of how intervention works. It is important to make a clear statement: Interdisciplinary research is about integrating constraints from multiple levels of description to produce better theories at all levels.

Dougherty and Robey appear to construe education as concerning only behavior and behavioral change in classroom settings (for which "neuroscience is not even needed," p. 403). However, a narrow focus on behavior undermines the contribution of psychology as well. Indeed, Willingham (2018) recently argued that what is important for education is not psychological theory; instead, the goal should be for teachers to be familiar with behavioral observations in the classroom—consistent developmental patterns in children's thinking, motivation, and emotion. Many researchers in the learning sciences would argue that it is essential to go beyond behavior to an understanding of underlying mechanism.

Psychology Is Not Enough

For Dougherty and Robey, the necessary and sufficient mechanistic understanding is to be offered by psychology; however, psychology on its own is not enough. Psychology that is unconstrained by neuroscience risks positing possible cognitive systems rather than the actual one delivered by the brain (Thomas, Ansari, & Knowland, 2019).

The central example offered by Dougherty and Robey of the failure of "brain-training" approaches in fact exemplifies just this point. It is a failure of psychology and its tendency toward domain-general theoretical constructs, such as working memory. The contribution of neuroscience to brain training is merely that the brain is malleable and that behavior can be changed through training. It has been known since the beginning of the 20th century that training of abilities rarely

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leads to improvement of different abilities (a phenomenon known as *far transfer*; Thorndike & Woodworth, 1901). Yet, inspired by the traditional computational theory of mind and influenced by the high correlation between ability test scores, psychologists during much of the latter part of the 20th century determinedly posited domain-general mechanisms. If domain-general mechanisms are trainable, far transfer would be the norm. These psychological theories therefore led to the expectation and frequent pursuit of far-transfer effects, at odds with a slew of empirical data.

In contrast, from a neuroscience perspective, knowledge is stored in the connections among neurons—content is built into structure. This implies domain-specific circuits and the likelihood of mainly near-transfer effects after behavioral training. Far transfer would be expected from interventions that improve the functioning of all neurons, such as improved nutrition or energy supply. Putting issues of commercial exploitation aside, the failure of brain-training approaches, then, does not stem from neuroscience; it stems from psychology pursued independently of neuroscience. It is an example of why we need interdisciplinary science to inform education.

Legitimate Criticisms of Educational Neuroscience

Of course, educational neuroscience is a fledgling field, and there are legitimate criticisms that can be made of it. Here are some of them, drawn from a recent review (Thomas et al., 2019). First, educational neuroscience must amount to more than relabeling effects that are already well known from behavioral psychology with the names of brain structures (such as "executive function" with "prefrontal cortex" or "episodic memory" with "hippocampus"). It must progress psychological theory, and it must point to ways to improve brain health. Second, as Bishop (2014) argues, neuroscience methods are still limited in their sensitivity and specificity as screening or diagnostic tools for deficits. They can only complement more traditional behavioral and social markers of risk. However, some neuroscience measures may be available earlier, such as infant electroencephalographic measures of auditory processing to predict later dyslexia risk (Guttorm, Leppanen, Hamalainen, Eklund, & Lyytinen, 2009) or available-at-birth DNA measures to predict possible educational outcomes (Plomin, 2018). Early availability increases the opportunity for intervention or more targeted monitoring of traditional risk markers.

A third legitimate criticism is that while educational neuroscience bears on learning, learning is only one aspect of education that influences outcomes; others include institutional, professional, curricular, political, economic, and societal aspects (Bronfenbrenner, 1992). Fourth, educational neuroscience needs to improve the quality of the dialogue between teachers, psychologists, and educators to ensure that the discussion is genuinely bidirectional, for example, through codesigning studies with teachers to improve the relevance of research and increase the chance of changing practices in the classroom. Finally, educational neuroscience's progress has been gradual. Researchers (e.g., Howard-Jones et al., 2016; Thomas et al., 2019) have been clear on the complexity of the challenge of linking the classroom phenomenon of learning with learning in the brain, which is the interplay of perhaps eight different neural systems. Much of the groundwork in educational neuroscience will consist of understanding why the educational methods that work do indeed work (Thomas, 2013) in order to ultimately improve them.

Spurious Criticisms of Educational Neuroscience

There are also spurious criticisms of educational neuroscience. One is that to contribute, the influence of neuroscience on education must be direct, circumventing psychology. Skepticism is expressed that direct influence is possible. On the contrary, the contribution of neuroscience to education can be direct. For example, animal models of the effect of air pollution on brain function are able to demonstrate the causality of the link between air pollution and cognitive ability, whereas human studies are stuck with guessing from correlations (Donaldson et al., 2005; Sunyer et al., 2015). Neuroscience can speak directly to brain health in the sense that cognition is delivered by a biological organ with certain energy and nutritional needs. But as Dougherty and Robey agree, neuroscience can also contribute indirectly to education via its influence on psychology. Both direct and indirect influences are valuable.

Another spurious criticism is that to contribute to education, the insights of neuroscience must be entirely original. The fact that there may be preexisting folk theories about, say, the importance of a good night's sleep does not undermine the possible contribution that the neuroscience of sleep may bring to consolidation effects on learning through its investigation of the interactions between hippocampal and cortical structures. Even when behavioral effects are already known, they can be improved by understanding mechanisms at lower levels of description. To take an example from medicine, it was known 300 years ago that chewing the bark of the cinchona tree was effective in alleviating the symptoms of malaria. Via the extended contributions of the natural sciences—biology, physiology, biochemistry, pharmacology—the U.S. Centers for Disease Control and Prevention now list a range of medicinal treatments for malaria. Understanding mechanism can improve something that already works.

A third spurious criticism is that any of (a) so-called neuromyths, (b) commercial products that use neuroscience as window dressing, or (c) contextual-framing effects of placing brain images in educational articles bear on the potential of the interdisciplinary learning sciences: These are distractions.

Is the Brain Really Far Too Complex?

Finally, Dougherty and Robey endorse Bruer's (1997, 2006) view that "the brain is far too complex and we know far too little about how it works for this knowledge to be useful for education" (p. 401). This pessimism is unwarranted. We understand a good deal about the broad principles of brain function and certainly enough to begin to draw implications for learning (see, e.g., Thomas, 2018). Although interdisciplinary research and evidence-based translation are challenging, they are the best hope for accelerating progress in education.

Recommended Reading

Churches, R., Dommett, E., & Devonshire, I. (2017). *Neuroscience for teachers: Applying research evidence from brain science*. Carmarthen, England: Crown House. An overview of the neuroscience of learning written for teachers, with the goal of improving classroom delivery.

Dubinsky, J. M., Roehrig, G., & Varma, S. (2013). Infusing neuroscience into teacher training. *Educational Researcher*, *42*, 317–329. doi:10.3102/0013189X13499403. A case study of how the core concepts of brain plasticity can be brought to in-service teachers to directly transform teacher preparation and professional development and ultimately affect how students think about their own learning.

Howard-Jones, P. (2014). *Neuroscience and education: A review of educational interventions and approaches informed by neuroscience*. London, England: Education Endowment Foundation. Retrieved from https://educationendowmentfoundation.org.uk/public/files/Publications/EEF_Lit_Review_NeuroscienceAndEducation.pdf. A review identifying areas of neuroscience that have successfully informed education, as well as areas of neuroscience that could inform education in the future if further work were undertaken to translate them into classroom-based approaches or interventions.

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Thomas, M. S. C., Ansari, D., & Knowland, V. C. P. (2019). (See References). A recent review that traces the origins of educational neuroscience, its main areas of research activity, and the principal challenges it faces as a translational field.

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