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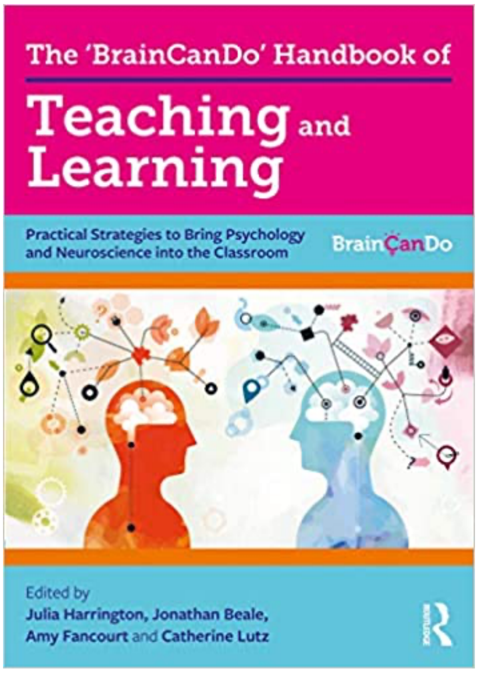

Foreword to the Volume: The BrainCanDo Handbook of Teaching and Learning

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In 2018, I was fortune enough to be invited to give a talk at the BrainCanDo conference entitled 'Pathways from Neuroscience to the Classroom', held at Queen Anne's School, Caversham, in the UK, where I discussed the relevance of neuroscience research to the classroom. BrainCanDo aims to develop an educational approach informed by the latest evidence in educational neuroscience and psychology. What impressed me most at that conference, and also in this volume, is the commitment of BrainCanDo to leverage the latest research in the learning sciences into practical strategies to improve teaching. As the audience politely listened to my description of new cognitive neuroscience research on the adolescent brain, I could sense their growing impatience: "Yes, this is all very nice, but how is this going to be relevant to what teachers *do* in the classroom, and to their students' lives both inside and outside school?"

The recent interest in mining educational neuroscience and psychological research for methods to improve educational outcomes belies the difficulty of translating research findings into classroom practice. For example, even with its 125-year history of studying learning, psychology still struggles to properly inform teaching practices – techniques can persist in the classroom despite a large body of evidence indicating a lack of effect (such as underlying / highlighting / rereading texts as methods to improve learning).[1] Effective translation crucially relies on a dialogue between educators and researchers, on the one hand to turn an understanding of how the mind works into techniques to improve learning; and on the other, to enable educators to move the research agenda onto issues that are most pressing in schools today. This dialogue is something BrainCanDo does really well, and the volume gives many excellent examples of how researchers and educators are fruitfully interacting. Moreover, it suggests where a scientific approach to learning finds its limits, such as in Beale's cautionary chapter on the perils of *scientism* (Chapter 1).

Should we focus more on the mind or the brain? As a proponent of educational neuroscience, I would argue that you can't talk about mind and brain separately.[2] The way the brain operates constrains the way the mind works. That is, the mind could have worked in lots of ways (which artificial intelligence is showing us). The way it *actually* works depends on what the brain can do, conditioned by its biology and that in turn by its evolutionary history. For example, the brain stores knowledge in the strength of the connections between neurons. This means that processing pathways tend to be content specific; they are not general purpose, dealing with lots of different types of content. You'll find a region of the brain for vision, one for audition, one for sensing the body, one for smell, not a general 'perception' mechanism.

Does this matter? Take working memory, which many advocate as a key capacity underlying academic success. Fancourt and Holmes (Chapter 4) argue that working memory is not a part of the brain but a faculty of the mind, a theoretical concept that is used to explain how active memory works. In the brain, it is carried out by lots of different regions, each 'keeping in mind' different types of content. How good these disparate systems are in an individual tends to correlate, giving the appearance of a unified single mechanism from the psychological perspective. When a child is held back in their academic progress because they have 'poor working memory', one might think the lesson is to give the child some activity that improves their working memory. But the shock finding of psychologists in this field is that training children on tasks that improve working memory, such as keeping numbers in mind, or keeping track of the objects you've seen, doesn't improve the children's academic performance. It only improves their ability to … keep numbers in mind or keep track of the objects they've seen. This is what you'd expect from the neuroscience perspective – you have only improved the working memory capacity of the particular circuits used in the training task, because there is no *general* working memory mechanism.

The narrow lesson from neuroscience in this case is that if you want to improve some cognitive capacity, it needs to be embedded in the (educational) content in which it is typically used, not abstracted out into some kind of brain-training computer game. In the current volume, this lesson is picked up chapters considering improving executive function skills (Faith, Hohnen, Bagnall & Moore-Shelley, Chapter 7) and techniques to enhance the learning of counterintuitive concepts in mathematics and science (Brookman-Byrne & Dumontheil, Chapter 10). This broad lesson is that understanding how the brain does things helps us understand the effects of training on behavioural change, the bread and butter of education.

The above example suggests that the contribution of neuroscience to education will largely comprise improvements in psychological theories of learning. However, there may also be direct implications of neuroscience for education, by virtue of thinking about the brain as a biological organ that has certain metabolic needs – for nutrition, for energy, to consolidate changes to its structure, to avoid the harmful effect of chronic exposure to stress hormones. This produces a parallel avenue of dialogue that can be thought of in terms of 'brain health', of optimising the condition of each child's brain for learning when he or she enters the classroom. Brain health draws focus to factors like nutrition, physical fitness, stress reduction, and sleep.[3]

Educational neuroscience is relatively new compared to the psychology of learning, and it is perhaps more controversial. Certainly, most of neuroscience research is not relevant to education (it is too low level, such as the role of ion channels in producing action potentials) and most of education research is not relevant to neuroscience (it concerns social, cultural, and economic factors, such as designing curricular and determining organisational structures). No neuroscience data will ever be 'classroom ready' without an extensive process of translation into and testing of practical techniques and strategies. And there are distractions, such as the misunderstandings found in neuromyths, or the influence of commercial organisations seeking profits from training packages with neuroscience window-dressing. However, some resistance to educational neuroscience runs deeper: principled arguments that the sort of thing that neuroscience does *can never* be relevant to education. I won't go into those arguments here (see my contretemps with Daugherty and Robey, for a flavour of the lively debate[4,5]) other than to suggest that this resistance is more about academic turf wars (arguing about who has the right to do research in a given area) than being solution focused (i.e., getting a crack team of people together with different expertise to investigate the area and come up with solutions). For me, it's an argument not to be settled on philosophical principles but on actual outcomes: can neuroscience contribute to educational improvements?

Two great things about this book

What most sets this volume apart from others in the field is its focus on adolescence. It is noticeable how the educational neuroscience and psychological research taken to be of translational interest to education differs with the age of the child. For early years education, the interest is in basic sensori-motor skills, oral language development, behavioural regulation, and socio-emotional development – skills that contribute to school readiness. For primary school age, the focus shifts to core cognitive skills underlying academic abilities, such as numeracy, literacy and reasoning, the limits imposed by the development of skills of cognitive control, and more sophisticated socio-emotional skills involved in peer group formation and dynamics. Consider then, the topics considered in a volume aimed at secondary school: character development, gratitude, motivation, mindset, metacognition, regulation of sleep, extended musical training (Chapters 3, 5, 6, 7, 8, 9, 11). The focus has shifted again, beyond core skills to children's understanding of their own learning and their motivations to learn. The individual must learn where he or she needs to put in effort to achieve their goals, and indeed to decide what those goals are – *who they are as individuals*.

Despite the welcome openness of BrainCanDo to neuroscience, many of the chapters focus on psychological approaches. This is because there is still much we do not understand about how the brain achieves more sophisticated skills around metacognition, motivation, and planning and decision making, as well as their interaction with peer group influence. (See Sarah-Jayne Blakemore's excellent recent book, *Inventing Ourselves: The Secret Life of the Teenage Brain*, for an overview of current knowledge).[6] Buckingham and Buckingham present the fascinating example of gratitude, a powerful socially embedded pathway to improving life satisfaction (Chapter 9). Adults whose brains were scanned while they experienced gratitude showed notably increased activation in two brain areas, the medial prefrontal cortex and the anterior cingulate cortex. Cognitive neuroscientists proposed that feelings of gratitude may involve the medial prefrontal cortex's processes of gauging subjective value and of considering the mental states of other people. This gives us an inkling of the processes that may be involved in gratitude, but only that – let alone insights into the best way to harness gratitude to improve life satisfaction.

Perhaps the most important contribution of neuroscience to understanding adolescence is to lay bare exactly how long many of these sophisticated skills take to develop, revealed by evidence that brain circuits can still be found to be changing into the late teens and early twenties. This has even been shown for levels of verbal and non-verbal intelligence.[7] The extended developmental trajectory means that we need to shape educational environments across the same time span to provide the best outcomes for each individual as they reach adulthood.

The second crucial strength of this volume is how it encourages a culture of research – that at all levels of education, teaching should be informed by evidence. Little gives examples of ways this can be achieved, such as generating a teacher handbook, or convening regular learning study groups for teachers (Chapter 2). An evidence-informed approach is no shortcut, however, because with so many influences on a child's development, causal pathways can be complex and tricky to unpick. Does reduced sleep in adolescence cause poorer mental health, or is a difficulty in sleeping a sign of worsening mental health? (see Le Cornu Knight, Chapter 8). Does success at learning a musical instrument cause improved academic outcomes, or are they both the result of a character trait to work hard and persist with practice? (see Müllensiefen & Harrison, Chapter 11). These kinds of questions cannot be resolved in large correlational studies. They need longitudinal studies and well controlled intervention studies, supported by experimental studies showing the viability of the causal mechanisms these effects purport to exploit. Determining what works can be tricky, when educational outcomes may be the result of so many small influences, each hard to assess in isolation (a problem not readily rectified by the use of large-scale randomised control trials).

While not a shortcut, an evidence-informed approach holds the best hope for progress in education, through a gradual accumulation of knowledge of what works and for whom. I imagine a teaching profession suffused by a culture of research, where teachers will be empowered by an understanding of why effective teaching methods work. They will have the autonomy to vary teaching methods according to the context of their classroom and of the particular children in front of them, knowing what features of the methods can be varied at no cost, and which must be retained as they carry the causal power. They will be less prone to be distracted by faddish approaches (even those supported by brain images!!!), more reluctant to rely on anecdotal evidence to confirm pet theories or reject disfavoured hypotheses. But teachers will also understand that evidence-based, mechanistic accounts of learning in individual children are only a small part of the educational picture. Crucially, however useful, such accounts do not determine the values which our educational systems embody and reflect. These are quite rightly an issue for society, not to be reduced to the workings of single minds and brains.

Notes

[1] Roediger, H.L. (2013). Applying cognitive psychology to education: Translational educational science. *Psychological Science in the Public Interest*, *14*, 1–3.

[2] Thomas, M.S.C, Ansari, D., & Knowland, V.C.P. (2019). Annual Research Review: Educational neuroscience: progress and prospects. *Journal of Child Psychology and Psychiatry*, *60(4)*, 477–492. doi:10.1111/jcpp.12973

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[4] Dougherty, D. R., & Robey, A. (2018). Neuroscience and education: A bridge astray? *Current Directions in Psychological Sciences*, *27*, 401–406. doi:10.1177/0963721418794495

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