TYPE Opinion
PUBLISHED 08 April 2024
DOI 10.3389/feduc.2024.1342473

Check for updates

OPEN ACCESS

EDITED BY
Michael Thomas,
Birkbeck, University of London,
United Kingdom

REVIEWED BY
Stylianos Mystakidis,
Hellenic Open University, Greece
Liping Li,
Yunnan University of Finance and
Economics, China

*CORRESPONDENCE
Kim Calder Stegemann
kcalder@tru.ca

RECEIVED 21 November 2023
ACCEPTED 19 March 2024
PUBLISHED 08 April 2024

CITATION
Calder Stegemann K (2024) The brain on playdo: neuroscience in education. *Front. Educ.* 9:1342473.
doi: 10.3389/feduc.2024.1342473

COPYRIGHT
© 2024 Calder Stegemann. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

The brain on playdo: neuroscience in education

Kim Calder Stegemann*

Faculty of Education and Social Work, School of Education, Thompson Rivers University, Kamloops, BC, Canada

KEYWORDS

neuroscience, education, educational neuroscience, brain, learning, teachers, brain development, teacher education

1 Introduction

If the parent of one of your students asked you to explain what was going on in the head of their child, what would you say? You may panic and sputter something about "left brain—right brain" learning, or that a brain that is fed good nutrition is a brain that can learn, or maybe that most people only use 10% of their brain (a neuro-myth, by the way). If you are like me, when I was a classroom teacher, you would not be able to say much about the brain functioning of your students.

Though teachers are master observers who strive to create strong student–teacher relationships, behavioral observations only tell us so much. You might say, well, I can also do some standardized testing to figure out a bit more about how the child is processing information in their brain. That, too, only gets us so far. We need to go deeper, and yet, educators are reluctant to step up to the neuroscience plate. As Amen (2006) would say, we are among the only professions that never look at the organs that we deal with. Why is it that teachers do not consider the brain? There are several reasons for this, but I would argue that educators absolutely must begin to understand the brain and how it is impacted by teaching and learning.

1.1 Teacher knowledge to inform educational neuroscience research

Teacher training programs do not typically address the brain. Even educational psychology courses fail to adequately discuss the brain and how it relates to affect, body states, and self-regulation. However, many provincial curricula specifically talk about self-regulation to adjust brain and body states. For example, in one province in Canada, British Columbia, the curriculum aims for students to develop "healthy personal practices" and "understand that physical, emotional, and mental health are interconnected" (Physical and Health Education K-10 -Big Ideas Grade K-1, 2019, p. 1). What do physical, emotional, and mental health all have in common? The brain. Healthy brains support overall health and wellness. As Rueda (2020) noted, it is a closed loop where optimal learning leads to optimal brain functioning, which is essential, and then leads back to optimal learning. Therefore, the brain and how it functions or does not function are relevant to every teacher, regardless of their curriculum specialty.

Some, such as Dr. Stephen Campbell, founder of the ENGRAMMETRON: Educational Neuroscience Laboratory at Simon Fraser University in Canada, would contend that it is essential for teachers to learn about neuroscience and the brain to maintain agency within education (Campbell, 2011). His fear is that educational neuroscience will be dominated by scientists and neurologists, with little input from educators. Then, all research and treatment would be driven by the scientists and not educators, and the knowledge generated would remain clinical and potentially not practical, translatable, or usable. This outcome has been one of the barriers to educators stepping up to the neuroscience plate. Interdisciplinary collaboration (in this case, neuroscience and education) is challenging and well-documented by others (see Brown and Daly, 2016; Palghat et al., 2017). As Bruer (1997) posited, it is simply a "bridge too far" (p. 4).

At the very least, teacher training programs must include educational neuroscience in their curriculum. If teachers are better informed about the brain/body/behavior connection, they are less likely to believe neuromyths (Dekker et al., 2012; Torrijos-Muelas et al., 2021), such as "right-brain/left-brain learning". Additional neuroeducation also leads to more positive attitudes for teachers dealing with students with complex needs (Chang et al., 2021; Gola et al., 2022). Inservice teachers can bridge the knowledge gap by reading peer-reviewed publications or taking graduate courses in educational neuroscience (Torrijos-Muelas et al., 2021). Amiel and Tan (2019) and Tan and Amiel (2019) have demonstrated how collaborative action research enhances teacher knowledge and application of neuroscience concepts.

Another solution to the "bridge too far" common in interdisciplinary collaborations is to embed scientists in schools, jointly researching how neuroscience informs the learning and teaching process. One example of collaboration between educational neuroscientists and teachers is the Synapse School in California, which is connected to Stanford University's Educational Neuroscience Initiative. They created the Brainwave Learning Center within the school, and their educational neuroscientists play an integral role in the day-to-day functioning (White, 2023). Director Lyn Toomarian notes that there "has always been this … separation between neuroscientists studying the way kids learn and the places where kids are actually learning. . . .[but] we've been able to integrate the two" (White, 2023, p. 4). It is an excellent example of bringing neuroscience into the school and successful interdisciplinary collaboration.

However, even if you do not have educational neuroscientists in your school, there are many other reasons to stand up and pay attention to the brain.

1.2 Examples of neuroscience in education

Science and education have come a long way from "right-brain, left-brain". Every day, teachers are changing the brains of their students, and, at present, we have the technology to see how pedagogical choices impact the brain in different ways (Brult Foisy et al., 2020). For example, McCandliss (2011), Yoncheva et al. (2015) have investigated the impact of different reading programs on both skill development and brain changes (structural and functioning) using electroencephalogram (EEG) technology. This is not science fiction! Imagine that you would be able to determine the best teaching methods for a student based on their brain activity! Another example of adapting pedagogy/curriculum based on neuroscientific data relates to printing and handwriting. Though many primary schools have removed formal printing/handwriting instruction from the curriculum, James (2017) found that handwriting is important for brain development and specifically supports learning to read. Furthermore, research has also revealed distinct phenotypes or biomarkers of brain activity that are directly related to learning and emotional behaviors. That is, by looking at brain activity, we can identify or anticipate learning or emotional challenges that a student may experience (Xiao et al., 2023). There are specific applications for special education by identifying where in the brain cognitive processes are breaking down or may be bottlenecked (Kropotov, 2016).

Yet another application of neuroscience in education could be to measure brain health throughout a child's education, and in particular, if students are involved in physically demanding contact sports. Using EEGs, we could measure brain health in our student athletes at the beginning and end of each sport season, which is vitally important should they sustain any head injuries (Thanjavur et al., 2021). Finally, another application of neuroscience in education is simpler and more direct. Students themselves can learn about their own brain and body functioning, and acquire appropriate strategies to self-regulate (Moreno and Schulkin, 2020; Goldberg, 2022). After all, is not this one of our main goals as educators and which reflects the demands of the curriculum, as stated at the outset of this paper?

2 The new beyond

There are many realities that our students encounter, including digital technology. Numerous devices are available that can alter brain activity, such as the Muse (Science | MuseTM EEG-Powered Meditation and Sleep Headband, n.d.), which teaches the user to calm the brain and body, or more radically, a brain chip to implant memories (Hern, 2024). In addition, the use or misuse of gaming (Swingle, 2019), social media, virtual reality (Kaimara et al., 2021), and online learning (Firth, 2019; see also Tokuhama-Espinosa, 2021) will impact the developing brain. Educators need to know the impact in order to appropriately adjust pedagogy and policies. Why would we leave these types of applications to non-educators? If educators understood more about the brain and why it does or does not learn, they would be optimally situated to guide interventions and seek appropriate pedagogy. Again, to do this, we absolutely must learn about basic brain functioning.

As we plunge into this new reality, we are right to be cautious. Indeed, there are numerous ethical issues to consider. One of these issues relates to the use and security of the biometric brain data collected (Guidelines for Practice | ISNR | Neurofeedback Training and Research, n.d.). Another issue is using technology as an intervention, and there is a need to research the long-term impacts of devices such as the Muse, a neurofeedback device (Thibault et al., 2016), or other brain stimulation technologies on the developing brain. Fortunately, the IEEE (Frankston et al., 2021) is working to develop a neuro-ethics framework for use in education and other disciplines as a starting point to guide our plunge.

My challenge to you, as educators, is to learn as much as you can about the brain now, despite a potentially steep learning curve. This can be done by enrolling in a course in educational neuroscience, reading peer-reviewed journals, or finding out more about the work of neurotherapists and how they can complement the teaching and learning process. We can no longer ignore what is going on inside the heads of our students, and more importantly, we have the technology to do it!

Author contributions

KC: Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

Amen, D. G. (2006). *Making a Good Brain Great: The Amen Clinic Program for Achieving and Sustaining Optimal Mental Performance*. New York: Three Rivers Press.

Amiel, J. J., and Tan, Y. S. M. (2019). Using collaborative action research to resolve practical and philosophical challenges in educational neuroscience. *Trends Neurosci. Educ.* 16, 100116. doi: 10.1016/j.tine.2019.100116

Brown, T. T., and Daly, A. (2016). Welcome to educational neuroscience. *Educational Neuroscience* 1, 237761611663206. doi: 10.1177/23776161166 32069

Bruer, J. T. (1997). Education and the brain: a bridge too far. *Educ. Res.* 26, 4. doi: 10.2307/1176301

Brult Foisy, L. M., Matejko, A. A., Ansari, D., and Masson, S. (2020). Teachers as orchestrators of neuronal plasticity: effects of teaching practices on the brain. *Mind, Brain, and Educ.* 14, 415–428. doi: 10.1111/mbe.12257

Campbell, S. R. (2011). Educational Neuroscience: Motivations, Methodology, and Implications. *Educational Philosophy and Theory* 43, 7–16. doi: 10.1111/j.1469-5812.2010.00701.x

Chang, Z., Schwartz, M. S., Hinesley, V., and Dubinsky, J. M. (2021). Neuroscience concepts changed teachers' views of pedagogy and students. *Front. Psychol.* 12, 1. doi: 10.3389/fpsyg.2021.685856

Dekker, S., Lee, N. C., Howard-Jones, P., and Jolles, J. (2012). Neuromyths in education: prevalence and predictors of misconceptions among teachers. *Front. Psychol.* 3, 429. doi: 10.3389/fpsyg.2012.00429

Firth, J. (2019). The 'online brain': how the internet may be changing our cognition. *World Psychiatry* 18, 119–129. doi: 10.1002/wps.20617

Frankston, S., Army, U., Judy, J., Martinez-Martin, N., Robinson, J., and Sullivan, L. (2021). *IEEE Neuroethics Framework Addressing the Ethical, Legal, Social, and Cultural Implications of Neurotechnology.* Available online at: https://brain.ieee.org/wp-content/uploads/2021/10/ieee_brain_neuroethics_flyer_OCT2021.pdf (accessed February 22, 2024)..

Gola, G., Angioletti, L., Cassioli, F., and Balconi, M. (2022). The teaching brain: beyond the science of teaching and educational neuroscience. *Front. Psychol.* 13, 823832. doi: 10.3389/fpsyg.2022.823832

Goldberg, H. (2022). Growing brains, nurturing minds—neuroscience as an educational tool to support students' development as life-long learners. *Brain Sci.* 12, 1622. doi: 10.3390/brainsci12121622

Guidelines for Practice | ISNR | Neurofeedback Training and Research. (n.d.). *ISNR*. Available online at: https://isnr.org/guidelines-for-practice (accessed September 1, 2023).

Hern, A. (2024). Elon Musk says Neuralink has implanted its first brain chip in human. *The Guardian*. Available online at: https://www.theguardian.com/technology/2024/jan/29/elon-musk-neuralink-first-human-brain-chip-implant

James, K. H. (2017). The importance of handwriting experience on the development of the literate brain. *Curr. Direct. Psychol. Sci.* 26, 502–8. doi: 10.1177/0963721417709821

Kaimara, P., Oikonomou, A., and Deliyannis, I. (2021). Could virtual reality applications pose real risks to children and adolescents? a systematic review of ethical issues and concerns. *Virtual Reality* 26, 563. doi: 10.1007/s10055-021-00563-w

Kropotov, J. D. (2016). *Functional Neuromarkers for Psychiatry: Applications for Diagnosis and Treatment*. London: Elsevier Science.

McCandliss, B. (2011). *Review of Selective Attention as a Bridge between Education and Neuroscience: How Differences in Instruction Change the Brain Circuity Involved in Learning to Read*. In Paper Presented at the Third Conference of the International Mind, Brain and Education Society.

Moreno, J. D., and Schulkin, J. (2020). *The Brain in Context a Pragmatic Guide to Neuroscience*. New York: Columbia University Press.

Palghat, K., Horvath, J. C., and Lodge, J. M. (2017). The hard problem of 'educational neuroscience.' *Trends Neurosci. Educ.* 6, 204–10. doi: 10.1016/j.tine.2017.02.001

Physical and Health Education K-10 -Big Ideas Grade K-1 (2019). Available online at: https://curriculum.gov.bc.ca/sites/curriculum.gov.bc.ca/files/curriculum/continuous-views/en_phe_k-10_big_ideas.pdf

Rueda, C. (2020). Neuroeducation: teaching with the brain. *J. Neuroeduc.* 1, 108–113. doi: 10.1344/joned.v1i1.31657

Science | MuseTM EEG-Powered Meditation and Sleep Headband. (n.d.). *Choosemuse.com*. Available online at: https://choosemuse.com/pages/science

Swingle, M. K. (2019). *I-Minds 2.0: How and Why Constant Connectivity Is Rewiring Our Brains and What to Do about It*. Gabriola Island, BC, Canada: New Society Publishers.

Tan, Y. S. M., and Amiel, J. J. (2019). Teachers learning to apply neuroscience to classroom instruction: case of professional development in British Columbia. *Profession. Dev. in Educ.* 48, 1–18. doi: 10.1080/19415257.2019.1689522

Thanjavur, K., Babul, A., Foran, B., Bielecki, M., Gilchrist, A., Hristopulos, D., et al. (2021). Recurrent Neural Network-Based Acute Concussion Classifier Using Raw Resting State EEG Data. *Sci. Rep.* 11 (1). doi: 10.1038/s41598-021-91614-4

Thibault, R. T., Lifshitz, M., and Raz, A. (2016). The self-regulating brain and neurofeedback: experimental science and clinical promise. *Cortex* 74, 247–261. doi: 10.1016/j.cortex.2015.10.024

Tokuhama-Espinosa, T. (2021). *Bringing the Neuroscience of Learning to Online Teaching*. New York: Teachers College Press.

Torrijos-Muelas, M., González-Víllora, S., and Bodoque-Osma, A. R. (2021). The persistence of neuromyths in the educational settings: a systematic review. *Front. Psychol.* 11, 591923. doi: 10.3389/fpsyg.2020.591923

White, J. (2023). *Review of Going All in at the Brainwave Learning Center.The Synapse Optimist.* Texas: Spring 2023.

Xiao, X., Hammond, C. J., Salmeron, B., Wang, D., Gu, H., Zhai, T., et al. (2023). Brain functional connectome defines a transdiagnostic dimension shared by cognitive function and psychopathology in preadolescents. *Biol. Psychiatry.* doi: 10.1016/j.biopsych.2023.08.028 [Epub ahead of print].

Yoncheva, Y. N., Wise, J., and McCandliss, B. (2015). Hemispheric specialization for visual words is shaped by attention to sublexical units during initial learning. *Brain Lang.* 145–146, 23–33. doi: 10.1016/j.bandl.2015.04.001