The International Journal of Multidisciplinary Research Publications
Volume 1 Issue 2 ‖ Sep-Oct 2025.
www.theijmrp.com

Bridging Minds and Classrooms: A Peer Review of Neuroscience Integration in Education for the Fifth Industrial Revolution

Davendra Sharma
Lecturer and Course Coordinator. University Wide Programme and Bachelor of Interdisciplinary Studies Programme, University of Fiji, Fiji Islands. 2025.

Abstract: The rapid technological advancements characterizing the Fifth Industrial Revolution (5IR) demand innovative transformations in education to prepare learners for complex, interconnected, and human-centric futures. Integrating neuroscience into education presents promising avenues for enhancing teaching and learning by grounding pedagogical practices in an understanding of brain function, plasticity, and cognitive development. Neuroeducation is emerging as a foundational pillar of Education 5.0, aligning brain-based learning strategies with human-centric, ethical, and inclusive educational models envisioned in the Fifth Industrial Revolution." This paper provides a comprehensive peer review of current research on neuroscience integration in education within the context of 5IR, highlighting opportunities, challenges, and ethical considerations. Emphasizing the importance of interdisciplinary collaboration, evidence-based professional development, and digital tools, the review explores how neuroscientific insights into executive function, emotional regulation, and social cognition can inform curricula that foster critical thinking, creativity, and socio-emotional skills essential for the 5IR era. The analysis underscores persistent barriers such as neuromyths, knowledge retention gaps, and equity concerns, advocating for sustained investment in teacher education, longitudinal research, and inclusive policy frameworks. By bridging neuroscience and classroom practice, education systems can evolve to support adaptive, empathetic, and innovative learners equipped for the complexities of the Fifth Industrial Revolution.

Keywords: neuroscience interdisciplinary pedagogy cognitive collaboration 5th Industrial Revolution bridge emotional brain equity theory Adaptive complexities innovative evolve transformative life-long Neuro-education research gaps socio-emotional skills curricula.

I. Introduction

The Fifth Industrial Revolution (5IR) represents a paradigm shift marked by the fusion of advanced technologies with human creativity, empathy, and ethical responsibility (Schwab & Davis, 2018). Unlike previous industrial revolutions driven primarily by mechanization and automation, the 5IR emphasizes collaboration between humans and intelligent technologies to solve complex societal challenges (Bughin et al., 2022). This evolution necessitates transformative changes in education systems worldwide, requiring curricula and pedagogies that develop not only technical skills but also critical thinking, emotional intelligence, and adaptability (Darling-Hammond et al., 2020). Neuroscience, the scientific study of the nervous system and brain functions, offers valuable insights into the biological underpinnings of learning, memory, and behaviour, which can inform these educational transformations. Neuroeducation is emerging as a foundational pillar of Education 5.0, aligning brain-based learning strategies with human-centric, ethical, and inclusive educational models envisioned in the Fifth Industrial Revolution."

Integrating neuroscience into education, often referred to as educational neuroscience, bridges the gap between cognitive science, psychology, and classroom practice (Tokuhama-Espinosa, 2011). It provides educators with evidence-based understanding of brain plasticity, executive functions, emotional regulation, and social cognition, all of which underpin effective learning processes (Immordino-Yang & Damasio, 2007; Diamond, 2013). In the context of 5IR, such knowledge is critical for designing learning environments that nurture creativity, resilience, and socio-emotional skills alongside technological literacy (Ansari et al., 2012). Moreover, neuroscience can guide interventions to support diverse learners, including those with neurodevelopmental differences, contributing to more inclusive education systems (Shen et al., 2023).

Despite its potential, the application of neuroscience in education faces significant challenges. The persistence of neuromyths, misconceptions about brain function such as "learning styles" or hemispheric dominance, can hinder the translation of neuroscience into effective pedagogy (Howard-Jones, 2014). Additionally, educators often lack adequate neuroscience training, and professional development programs show variable success in knowledge retention and practical application (Rousseau et al., 2024). Ethical concerns related to data privacy, consent, and equitable access to neurotechnologies also arise in educational settings (Illes & Racine, 2005; Ienca & Andorno, 2017). These barriers call for sustained interdisciplinary collaboration among neuroscientists, educators, policymakers, and ethicists to ensure that neuroscience informs education responsibly and equitably.

This paper critically reviews recent peer-reviewed literature on the integration of neuroscience in education, focusing on opportunities and challenges specific to the Fifth Industrial Revolution. It synthesizes findings from studies on brain-based pedagogies, teacher training, digital neuroeducation, and social-neural dynamics in classrooms. Through this lens, the review highlights practical implications for curriculum design, instructional strategies, and policy development aimed at preparing learners for the demands and values of the 5IR era. By bridging minds and classrooms, education can evolve to foster adaptive, empathetic, and innovative individuals capable of thriving in an increasingly complex and interconnected world.

II. Brief Literature Review: Integrating Neuroscience in Education

The integration of neuroscience into education has gained momentum over the past two decades, as educators and researchers increasingly seek to ground pedagogical practices in an understanding of brain function and development. Neuroscience offers valuable insights into how students learn, retain information, and respond to emotional and social stimuli, which are all critical elements of effective teaching and learning (Tokuhama-Espinosa, 2011). Key findings in the field highlight the importance of neuroplasticity, the brain's ability to reorganize and adapt, supporting the idea that intelligence is not fixed and that learning potential can be enhanced through appropriate interventions (Doidge, 2007). This aligns with the growing emphasis on growth mindsets and lifelong learning in contemporary education.

Recent literature from 2020 to 2024 highlights significant advances and ongoing challenges in the integration of neuroscience into education. Goswami (2020) emphasizes the urgent need for more robust longitudinal and intervention-based study designs in developmental cognitive neuroscience to better support educational applications such as learning mechanisms, statistical learning, and language development. Complementing this, Rousseau et al. (2024) review professional development interventions aimed at dispelling neuromyths among in-service teachers. They find that approaches like refutation texts and immersive research experiences can reduce misconceptions in the short to medium term, although sustaining these gains over time remains a challenge. Teacher training programs informed by neuroscience also demonstrate promise: Dubinsky et al. (2019) and Ching et al. (2020) report that neuroscience-informed curricula empower educators to adopt evidence-based instructional strategies, while Hughes et al. (2020) investigate reasons why teachers continue to believe neuromyths despite such training.

Beyond individual cognition, interpersonal educational neuroscience has gained traction, with studies employing hyper-scanning methods to explore neural synchrony between teachers and learners during real-world classroom interactions, underscoring the importance of social-neural dynamics in education (Liu et al., 2024). Digital delivery of neuroeducation, particularly for special-needs teacher preparation, is another growing area. Wilcox et al. (2023) demonstrate that digital neuroscience modules can improve teacher knowledge and pedagogical application in inclusive settings, signalling potential for scalable training solutions. Furthermore, empirical studies measuring neuroscience literacy among educators and students reveal correlations between neuroscience awareness, motivation, study strategies, and academic performance, though the causal relationships require further investigation (Ching et al., 2020; Shen et al., 2023).

Overall, this body of work reveals that while professional development and educational neuroscience interventions are effective at reducing neuromyths and enhancing teacher knowledge, retention of this knowledge without reinforcement is fragile (Rousseau et al., 2024). Goswami's (2020) call for experimental rigor stresses moving beyond brain imaging to mechanistic understanding of learning processes. The emerging focus on teacher-student neurophysiological synchrony further highlights that human interaction plays a central role in learning outcomes. Finally, digital tools for neuroscience education show promise for broadening access and inclusion, though the uneven neuroscience literacy across disciplines calls for ongoing, context-sensitive efforts to embed neuroscience meaningfully into educational practice.

Despite its potential, the field faces several challenges. One major concern is the misapplication of neuroscientific findings, often seen in the spread of "neuromyths" such as learning styles or left-brain/right-brain dominance, which lack empirical support (Howard-Jones, 2014). Furthermore, the gap between scientific research and classroom practice persists due to limited neuroscience training in teacher education programs (Ansari et al., 2012). Addressing these gaps requires greater interdisciplinary collaboration, evidence-based professional development, and the ethical integration of neuroscience into policy and practice (Illes & Racine, 2005).

The literature reveals that while educational neuroscience holds great promise for improving teaching and learning, its success depends on accurate interpretation, ethical application, and meaningful collaboration between researchers and educators.

3.1 Table 1: Recent Literature on Neuroeducation in the Context of the Fifth Industrial Revolution

Study / Source	Focus	Key Findings	Relevance to 5IR
Rueda-Castro et al. (2024)	Neurobiological approach to human-machine interface (BCI) in Industry 5.0	Brain-computer interfaces conceptualized as bridging human cognition and technology in engineering education Journal UNTIADAR+6ObserveNow Media+6Medium+6Wikipedia+6Frontiers+6PubMed+6	Supports human-centric upskilling and sustainable, ethical use of neurotech in future industry
Taylor (2022)	Neuroeducational innovations in general pedagogy	Highlights role of neuroplasticity, social interaction, sleep, nutrition, and personalized learning Journal Pie	Aligns with 5IR demands for adaptive, whole-person learning experiences
Frontiers in Education (2024)	Adaptive neuroeducation models in schools	Shows neuroeducation tools (e.g. cognitive load management, retrieval practice, AI-based personalization) improve engagement and retention Frontiers	Supports scalable, AI-enhanced, brain-aligned educational systems
Alves (2025)	Converging neuroscience with Education 5.0 and AI	Argues for adaptive learning experiences integrating brain insights and AI interventions New Science	Bridges neuro-informed pedagogy with AI-driven, ethical, inclusive Education 5.0
Nascimento (2023)	Case examples of classroom neurotechnology adoption (e.g. mobile EEG, neurofeedback, mindfulness)	Demonstrates improved engagement, attention, memory, and social synchrony in real classrooms Medium	Illustrates applied neurotech in learning environments aligned to human-centric 5IR values

3.2 Interpretation

- **Brain–technology convergence**: Studies like Rueda-Castro et al. (2024) frame BCIs and neurotechnology as enablers of Industry 5.0's human-technology synergy, helping learners and workers adapt through cognitive augmentation and sustainable design.
- **Educational enrichment beyond cognition**: Taylor (2022) emphasizes holistic development, emotional, social, physiological—all relevant to nurturing 5IR skills like empathy and adaptability.
- **AI-based personalization**: Both Frontiers (2024) and Alves (2025) highlight how AI, informed by neuroscience, enables adaptive, inclusive learning experiences, aligning with human-centered, sustainable Education 5.0 principles.
- **Real-world classroom impact**: Nascimento (2023) provides tangible examples of neuroeducation in practice, mobile EEG, neurofeedback, mindfulness—that yield measurable improvements in engagement and cognitive function.

III. Neuroscience and Its Relationship to Education

Neuroscience is the scientific study of the nervous system, with a particular focus on the brain's structure, function, and development, as well as its influence on behaviour, cognition, and learning processes. This interdisciplinary field draws from biology, psychology, and medicine to better understand how the brain processes information and guides human behaviour (Kandel et al., 2013). In recent decades, the emerging field of educational neuroscience, also known as neuroeducation, has sought to bridge the gap between neuroscience and classroom practice by applying insights about brain function to inform and enhance teaching and learning strategies (Tokuhama-Espinosa, 2010).

The integration of neuroscience into education provides a deeper understanding of how students learn, process, and retain information. Cognitive functions such as memory, attention, motivation, and emotional regulation are central to learning, and neuroscience helps explain how these processes are influenced by brain development and external stimuli (Sousa, 2017). For example, research on memory has shown that the brain retains information more effectively through strategies such as spaced repetition and retrieval practice (Brown, Roediger, & McDaniel, 2014). Similarly, studies of attention and executive functioning have led to instructional methods that are better aligned with students' cognitive capacities and developmental stages.

Furthermore, neuroscience offers valuable insights into learning differences and disabilities, enabling more inclusive and personalized teaching approaches. Understanding the neurological basis of conditions like dyslexia, ADHD, and autism spectrum disorder allows educators to adopt more effective, evidence-based interventions (Goswami, 2006). Additionally, neuroscience has underscored the significance of emotions in learning. The brain's emotional centre, particularly the amygdala, plays a crucial role in how students respond to classroom environments; when students feel emotionally secure and supported, their brains are more receptive to learning (Immordino-Yang & Damasio, 2007).

Educational neuroscience also supports the development of metacognitive and critical thinking skills. The prefrontal cortex, which governs reasoning, self-regulation, and decision-making, is not fully developed until early adulthood, suggesting the need for teaching strategies that cultivate these higher-order thinking skills over time (Blakemore & Frith, 2005). Encouraging students to reflect on their own thinking, or to engage in metacognition, enhances their ability to plan, monitor, and evaluate their learning processes.

Neuroscience provides a powerful foundation for understanding how the brain learns, and it holds significant implications for educational theory and practice. While neuroscience does not prescribe specific teaching methods, it offers valuable evidence that can inform more effective, inclusive, and developmentally appropriate education. The collaboration between neuroscientists, educators, and psychologists promises a more scientifically grounded and learner-centred approach to education in the 21st century.

IV. Neuroscience, Education, and the Fifth Industrial Revolution

The evolving relationship between neuroscience and education is gaining renewed importance in the context of the Fifth Industrial Revolution (5IR), which emphasizes the convergence of advanced technologies with human-centric values such as empathy, ethics, and sustainability. While the Fourth Industrial Revolution (4IR) was characterized by the integration of artificial intelligence, automation, and big data, the 5IR seeks to humanize technological advancement by placing equal importance on emotional intelligence, creativity, and social responsibility (Schwab & Zahidi, 2020). Neuroscience plays a critical role in this transition by offering insights into how the brain learns, adapts, and responds to both technological stimuli and human interactions. This has profound implications for reimagining education systems that are not only technologically competent but also emotionally and socially intelligent.

Educational neuroscience helps in shaping curricula that align with how the brain processes information in complex, high-tech environments. As digital tools and virtual learning platforms become more embedded in classrooms, understanding how students' cognitive and emotional systems respond to screen time, multitasking, and information overload becomes increasingly important (Tokuhama-Espinosa, 2011). Neuroscience research shows that the human brain requires balance, deep cognitive processing must be supported by emotional regulation and opportunities for social interaction. Therefore, 5IR-aligned education must go beyond technical skills and foster what the World Economic Forum calls "human skills", such as compassion, critical thinking, resilience, and collaboration (WEF, 2023). These skills are deeply rooted in brain functions involving the prefrontal cortex, limbic system, and mirror neuron networks, areas responsible for decision-making, empathy, and social cognition (Immordino-Yang & Damasio, 2007).

Moreover, the principles of neuroscience support the move toward personalized and inclusive learning environments that accommodate diverse neurological profiles and learning styles. In the 5IR context, there is a greater demand for education systems to embrace neurodiversity and leverage brain-based strategies to promote equity and well-being (UNESCO, 2022). This includes designing learning experiences that stimulate cognitive engagement, reduce stress, and promote emotional safety, factors that are essential for brain-friendly education. Additionally, neuroscience reinforces the importance of lifelong learning, as neuroplasticity demonstrates that the brain remains capable of change and growth throughout life, a key consideration in a rapidly evolving labour market where continual reskilling is necessary (Doidge, 2007).

In conclusion, the intersection of neuroscience, education, and the Fifth Industrial Revolution represents a paradigm shift from mechanistic models of schooling to holistic, brain-based learning ecosystems. By integrating neuroscientific insights with the human-centred ethos of 5IR, education systems can cultivate not only technologically adept learners but also compassionate, adaptive, and socially responsible global citizens.

V. Integrating Neuroscience in Education: Opportunities and Challenges

The integration of neuroscience into education presents both promising opportunities and notable challenges as educators, policymakers, and researchers seek to bridge the gap between brain science and classroom practice. Educational neuroscience offers the potential to transform teaching and learning by aligning instructional strategies with how the brain naturally learns, processes, and retains information (Tokuhama-Espinosa, 2011). By understanding the neurological basis of learning processes such as attention, memory, and emotion, educators can design more effective, inclusive, and developmentally appropriate learning environments. For instance, neuroscience supports strategies like formative assessment, spaced learning, and multisensory instruction, which align with cognitive processes and enhance learning outcomes (Sousa, 2017).

One of the most significant opportunities lies in improving support for diverse learners. Neuroscientific insights have contributed to a deeper understanding of neurodevelopmental conditions such as dyslexia, ADHD, and autism spectrum disorders, allowing for more targeted and evidence-based interventions (Goswami, 2006). This has important implications for inclusive education, where individual learning profiles are respected, and differentiated instruction is practiced. Additionally, research on neuroplasticity—the brain's ability to reorganize and form new connections—underscores the importance of fostering growth mindsets and lifelong learning, key principles in today's rapidly changing world (Doidge, 2007).

Moreover, neuroscience can inform social and emotional learning (SEL), an area gaining increasing importance in 21st-century education. Findings from affective neuroscience emphasize that emotions play a central role in learning. When students feel safe, supported, and emotionally engaged, they are more likely to achieve positive educational outcomes (Immordino-Yang & Damasio, 2007). This reinforces the need for schools to create emotionally intelligent and empathetic learning spaces.

Despite these benefits, integrating neuroscience into education is not without its challenges. A major obstacle is the gap between scientific research and classroom application. Neuroscience often operates at a highly technical level that is not easily translated into educational practice, leading to the risk of misinterpretation or oversimplification, a phenomenon known as "neuromyths" (Howard-Jones, 2014). Common misconceptions such as learning styles, left-brain/right-brain dominance, or the idea that people use only 10% of their brains are examples of how neuroscience can be misused when not critically examined.

Another challenge is the limited neuroscience training among educators. Most teacher education programs do not provide sufficient exposure to brain science, leaving many teachers without the tools to critically evaluate neuroscientific claims or apply them meaningfully in the classroom (Ansari et al., 2012). In addition, there is a need for more interdisciplinary collaboration between neuroscientists, educators, and psychologists to ensure that research is both scientifically robust and practically applicable.

Ethical considerations also emerge, particularly in the use of neurotechnology and cognitive enhancement tools in educational settings. As neuroscience advances, technologies such as brain imaging, neurofeedback, wearable EEG devices, and brain-computer interfaces are increasingly being explored for educational purposes, ranging from monitoring attention levels to enhancing memory and cognitive performance (Jwa, 2015). While these technologies offer exciting possibilities, they also raise serious ethical concerns regarding autonomy, consent, data protection, and equitable access.

One of the primary concerns is informed consent, especially when dealing with children and adolescents who may not fully comprehend the implications of participating in studies or using neurotechnological tools. The use of any brain-monitoring or enhancement devices in schools must involve transparent communication with students and guardians about the purpose, risks, and benefits of such tools (Illes & Racine, 2005). Moreover, when neuroscience is integrated into classroom assessments or interventions, it is crucial that participation remains voluntary and free from coercion, especially in contexts where power imbalances exist between students and institutions.

Data privacy is another pressing issue. Neurotechnological devices can collect sensitive neurological data that may reveal not only cognitive patterns but also emotional states, stress levels, and psychological vulnerabilities. If such data are misused or insufficiently protected, it could lead to breaches of privacy or even stigmatization of students based on their neurocognitive profiles (Ienca & Andorno, 2017). The ethical handling of such data requires robust data governance policies, secure storage systems, and clear regulations on who can access and interpret the data—and for what purposes.

Equity is a further concern. Advanced neuro-technologies may only be available to well-resourced schools or private institutions, exacerbating existing educational inequalities. If cognitive enhancement tools or neurofeedback training are used to improve learning outcomes, students from underserved communities may be left behind, creating a new form of cognitive divide (Gabriel, 2019). Thus, there is a need for careful policy planning to ensure that neuroscience-based educational innovations are implemented in ways that are inclusive and just.

Additionally, there is the risk of over-medicalizing education or reducing students to neurological profiles. While neuroscience can offer valuable insights into learning processes, it should not be used to rigidly categorize learners or to undermine the broader socio-cultural, emotional, and contextual factors that shape educational outcomes (Rose & Abi-Rached, 2013). Ethical integration requires a balanced, interdisciplinary approach that respects the complexity of both human development and educational environments.

While the intersection of neuroscience and education holds transformative potential, it must be navigated with rigorous ethical oversight. Key issues such as consent, privacy, fairness, and the potential misuse of neuroscience in education must be addressed through collaborative frameworks involving educators, scientists, ethicists, and policymakers to safeguard learners' rights and well-being.

While integrating neuroscience into education holds great promise for advancing inclusive, effective, and emotionally supportive learning environments, it requires careful navigation of scientific, practical, and ethical challenges. The success of this integration depends on sustained collaboration between researchers and educators, improved teacher training, and a commitment to evidence-based practice that is sensitive to the complexities of both the brain and the classroom.

6.1 Table 2: Neuroeducation in the Context of the Fifth Industrial Revolution (5IR)

Theme	Neuroeducation Focus	5IR Implication	Opportunities	Challenges
Human-Centric Learning	Emphasizes brain-based, personalized learning informed by neuroplasticity	5IR emphasizes human-centric technology and well-being	Customised pedagogy; holistic education; inclusive learning	Balancing technology use with ethical learning practices
Emotional Intelligence & SEL	Acknowledges role of emotion in cognition (e.g., amygdala, limbic system)	Emotional intelligence is a core human skill in 5IR	SEL integration into curricula enhances empathy, collaboration	Teacher training in SEL remains inconsistent globally
Cognitive Enhancement	Informs cognitive training, executive function, memory consolidation	Brain-computer interfaces and neuro-technologies in 5IR	Enhanced learning through neurofeedback, AI tutors	Ethical concerns around cognitive augmentation, access disparity
Digital-Age Pedagogy	Promotes understanding of digital learning's neurological effects	Blends human values with AI-driven tools	Brain-aligned digital tools and immersive learning (VR/AR)	Overexposure to screens, attention span decline
Lifelong Learning	Supports adaptability through lifelong neuroplasticity	5IR demands continual upskilling and adaptability	Growth mindset culture supported by neuroeducation	Institutional resistance to flexible, learner-driven models
Equity & Access	Recognizes diversity in cognitive development and neurodivergence	5IR seeks inclusive progress, digital democratization	Neurodiverse-inclusive pedagogy; equitable support strategies	Digital and neuroethical gaps between Global North and South

VI. Conclusion

The integration of neuroscience into education represents a transformative opportunity to reshape teaching and learning for the complex demands of the Fifth Industrial Revolution (5IR). As educational systems evolve amid rapid technological advances, increased human–machine collaboration, and shifting societal expectations, neuroscientific insights offer critical guidance on how learners develop cognitively, emotionally, and socially (Schwab & Davis, 2018; Ansari et al., 2012). Understanding brain plasticity, executive function, and socio-emotional processes allows educators to design curricula and pedagogies that foster creativity, adaptability, and empathy—skills essential for thriving in the 5IR era (Diamond, 2013; Immordino-Yang & Damasio, 2007). However, bridging the gap between neuroscience research and classroom practice remains a fundamental challenge. Persistent neuromyths and the uneven translation of scientific evidence into practical strategies limit the potential benefits of educational neuroscience (Howard-Jones, 2014; Rousseau et al., 2024). To overcome these barriers, sustained interdisciplinary collaboration is necessary, involving neuroscientists, educators, policymakers, and ethicists working together to co-create contextually relevant and ethically grounded applications (Illes & Racine, 2005; Ienca & Andorno, 2017). Additionally, investment in comprehensive teacher education, curriculum reform, and longitudinal research is crucial to embed neuroscience in education meaningfully and equitably (Tokuhama-Espinosa, 2011; Gabriel, 2019).

In the context of the Fifth Industrial Revolution, neuroscience should be viewed not as a singular solution but as a powerful complementary framework that enhances pedagogical wisdom, cultural responsiveness, and socio-emotional expertise. When thoughtfully integrated, it can contribute to learning environments that are adaptive, inclusive, and human-centred, preparing learners to navigate the ethical, cognitive, and interpersonal

complexities of a rapidly changing world. By bridging minds and classrooms, education can evolve to meet the demands of the 5IR and cultivate the innovative, empathetic, and resilient individuals that the future requires.
A sustained investment is needed in three key areas to embed neuroscience meaningfully into education. First, teacher education programs must integrate brain-based research into their curricula to prepare educators with foundational knowledge of cognitive and neural development (Tokuhama-Espinosa, 2011). Second, curriculum reform must reflect evidence-based pedagogies that leverage what we know about memory consolidation, feedback, cognitive load, and emotional engagement. Third, interdisciplinary research must continue to refine our understanding of how individual differences in brain development interact with sociocultural and environmental factors to shape learning outcomes (Gabriel, 2019).

As we continue to navigate the complexities of the Fourth and Fifth Industrial Revolutions, global health crises, and growing demands for inclusive and equitable education, neuroscience offers a powerful, but not solitary, framework for innovation. It should complement, not replace, pedagogical wisdom, cultural understanding, and socio-emotional expertise. When integrated thoughtfully, educational neuroscience can help create learning environments that are not only more effective but also more empathetic, inclusive, and responsive to the diverse needs of 21st-century learners.

References

[1]. Bruer, J. T. (1997). Education and the brain: A bridge too far. *Educational Researcher, 26*(8), 4–16. https://doi.org/10.3102/0013189X026008004

[2]. Blakemore, S. J., & Frith, U. (2005). *The learning brain: Lessons for education*. Blackwell Publishing.

[3]. Illes, J., & Racine, E. (2005). Imaging or imagining? A neuroethics challenge informed by genetics. *The American Journal of Bioethics, 5*(2), 5–18. https://doi.org/10.1080/15265160590945156

[4]. Blackwell, L. S., Trzesniewski, K. H., & Dweck, C. S. (2007). Implicit theories of intelligence predict achievement across an adolescent transition: A longitudinal study and an intervention. *Child Development, 78*(1), 246–263. https://doi.org/10.1111/j.1467-8624.2007.00995.x

[5]. Doidge, N. (2007). *The brain that changes itself: Stories of personal triumph from the frontiers of brain science*. Viking.

[6]. Immordino-Yang, M. H., & Damasio, A. (2007). We feel, therefore we learn: The relevance of affective and social neuroscience to education. *Mind, Brain, and Education, 1*(1), 3–10. https://doi.org/10.1111/j.1751-228X.2007.00004.x

[7]. Giedd, J. N. (2008). The teen brain: Insights from neuroimaging. *Journal of Adolescent Health, 42*(4), 335–343. https://doi.org/10.1016/j.jadohealth.2008.01.007

[8]. Dehaene, S. (2009). *Reading in the brain: The science and evolution of a human invention*. Viking.

[9]. Tokuhama-Espinosa, T. (2011). *Mind, brain, and education science: A comprehensive guide to the new brain-based teaching*. W. W. Norton & Company.

[10]. Ansari, D., De Smedt, B., & Grabner, R. H. (2012). Neuroeducation – A critical overview of an emerging field. *Neuroethics, 5*(2), 105–117. https://doi.org/10.1007/s12152-011-9119-3

[11]. Ansari, D., Coch, D., & De Smedt, B. (2012). Connecting education and cognitive neuroscience: Where will the journey take us? *Educational Philosophy and Theory, 44*(1), 33–42. https://doi.org/10.1111/j.1469-5812.2011.00787.x

[12]. Diamond, A. (2013). Executive functions. *Annual Review of Psychology, 64*, 135–168. https://doi.org/10.1146/annurev-psych-113011-143750

[13]. Howard-Jones, P. A. (2014). Neuroscience and education: Myths and messages. *Nature Reviews Neuroscience, 15*(12), 817–824. https://doi.org/10.1038/nrn3817

[14]. Ienca, M., & Andorno, R. (2017). Towards new human rights in the age of neuroscience and neurotechnology. *Life Sciences, Society and Policy, 13*(5), 1–27. https://doi.org/10.1186/s40504-017-0050-1

[15]. Schwab, K., & Davis, N. (2018). Shaping the Fourth Industrial Revolution. *World Economic Forum*. https://www.weforum.org/focus/fourth-industrial-revolution

[16]. 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. https://doi.org/10.1111/jcpp.12973

[17]. Dubinsky, J. M., et al. (2019). Contributions of Neuroscience Knowledge to Teachers and Their Practice. *Neuroscientist, 25*(5), 394–407. https://doi.org/10.1177/1073858419835447

[18]. Ching, F. N. Y., So, W. W. M., Lo, S. K., & Wong, S. W. H. (2020). Preservice teachers' neuroscience literacy and perceptions of neuroscience in education: Implications for teacher education. *Trends in Neuroscience and Education, 21*, 100144. https://doi.org/10.1016/j.tine.2020.100144

[19]. Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science, 24*(2), 97–140. https://doi.org/10.1080/10888691.2018.1537791

[20]. Hughes, B., Sullivan, K. A., & Gilmore, L. (2020). Why do teachers believe educational neuromyths? *Trends in Neuroscience and Education, 21*, 100145. https://doi.org/10.1016/j.tine.2020.100145

[21]. Goswami, U. (2020). Toward realizing the promise of educational neuroscience: Improving experimental design in developmental cognitive neuroscience studies. *Annual Review of Developmental Psychology, 2*, 133–155. https://doi.org/10.1146/annurev-devpsych-042320-100040

[22]. Bughin, J., Seong, J., Manyika, J., Chui, M., & Joshi, R. (2022). The future of work in the Fifth Industrial Revolution. *McKinsey Global Institute*. https://www.mckinsey.com/future-of-work

[23]. Taylor, J. (2022). *Neuroscience and educational innovations*. *Perspectives in Innovative Education, 4*(2), 35. https://doi.org/10.69610/j.pie.20221222

[24]. Shen, R., Wilcox, B., Gola, M., & Schiff, A. (2023). Implementing digital neuroscience in special-needs-teacher education: Exploring student-teachers' learning outcomes. *Frontiers in Psychology*. https://doi.org/10.3389/fpsyg.2023.1232315

[25]. Nascimento, B. (2023). *How Neuroeducation is changing teaching & learning*. Medium. PubMed+4Medium+4Frontiers+4FrontiersNew ScienceFrontiers

[26]. Rousseau, S., et al. (2024). Dispelling educational neuromyths: A review of in-service teacher professional development interventions. *Mind, Brain, and Education*. https://doi.org/10.1111/mbe.12414

[27]. Frontiers in Education. (2024). *Neuroeducation: Understanding neural dynamics in learning and teaching*. *Frontiers in Education, 2024*, Article 1437418. https://doi.org/10.3389/feduc.2024.1437418

[28]. Liu, H., Novembre, G., Pan, Y., Song, W., Li, X., & Hu, Y. (2024). Interpersonal educational neuroscience: Neurophysiological investigations of teacher–student interaction. *Sciencedirect*. (preprint)

[29]. Rueda-Castro, V., Azofeifa, J. D., Chacon, J., & Caratozzolo, P. (2024). *Bridging minds and machines in Industry 5.0: Neurobiological approach*. *Frontiers in Human Neuroscience, 18*. https://doi.org/10.3389/fnhum.2024.1427512

[30]. Alves, W. d. S. (2025). *Education 5.0 and neuroscience in the age of artificial intelligence*. *ARACÊ, 7*(6), 35127–35136. https://doi.org/10.56238/arev7n6-348