Review

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Review

Unlocking the Brain's Potential: A Conceptual Synthesis of Educational Neuroscience for Transformative Pedagogy, Inclusive Curriculum Design, and Teacher Empowerment

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Abstract

Educational neuroscience is rapidly reshaping how we think about learning. However, its promise will remain unrealised without an inclusive and ethical lens. This conceptual article positions neuroscience as a catalyst for re-imagining schooling that honours the full humanity of every learner. Guided by neuro-constructivism and inclusive cognition, the discussion reframes neurodiversity from a deficit perspective to a celebration of cognitive variety. Three critical arenas are explored. First, principles of attention, emotion, and memory suggest that lessons designed for cognitive engagement can ignite deeper understanding, especially for learners with autism spectrum disorder (ASD), attention deficit hyperactivity disorder (ADHD), and dyslexia. Second, curriculum reform built on Universal Design for Learning (UDL) invites adaptive multisensory pathways that connect content with culture and lived experience. Third, sustained professional development empowers teachers to translate laboratory insights into rich classroom practice while resisting popular neuro-myths. The article foregrounds neuro-ethics as a guardrail, calling for transparent guidelines that protect privacy, ensure informed consent, and secure equitable access to neuro-technology. By weaving together evidence, theory, and social justice, the paper paints a vivid picture of classrooms where curiosity, empathy, and resilience flourish alongside academic growth. Educational neuro-science emerges not as a mere tool for boosting test scores but as a transformative mindset that redefines the purpose of education itself. The argument invites researchers, policymakers, and practitioners to collaborate on learning environments that are scientifically anchored, morally purposeful, and capable of nurturing thriving citizens for an interconnected world. In doing so, it charts a bold agenda for the classroom of tomorrow and beyond.

Keywords: educational neuroscience; neuro-constructivism; inclusive pedagogy; universal design for learning (udl); neuro-ethics, professional development

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1. Introduction

The interface between neuroscience and education has emerged as a transformative perspective for enhancing teaching and learning. According to Treglia, et, al., (2022) defines neuroscience, as the science of mind, brain, and education, represents a convergence of cognitive neuroscience, developmental psychology, and educational research. This interdisciplinary field provides a biologically grounded foundation for understanding how learners acquire, process, store, and retrieve information. According to Darmanin & Pulis, (2023) educational neuroscience offers actionable insights for developing more effective, equitable, and inclusive pedagogical practices , by uncovering the neural underpinnings of learning, memory, attention, and emotion. In today's classrooms, where learner diversity, digital innovation, and socio-emotional complexity are increasingly evident, the application of neuroscience is both timely and necessary (Uden and Ching, 2023; Treglia, et, al., 2022).

Recent literature such as Gkintoni & Dimakos, (2022); Darmanin & Pulis, (2023) demonstrates that conventional pedagogical approaches, which often rely on repetition, memorisation, and uniform instruction, do not adequately address the cognitive variability that exists among learners. Neuroscience-informed education acknowledges that learning is not a passive reception of content but an active, dynamic process shaped by prior experiences, emotional states, sociocultural environments, and the malleability of the brain. This perspective reconceptualises the role of the teacher as more than a transmitter of knowledge. Instead, teachers are seen as designers of cognitively rich learning environments and facilitators of engagement and emotional well-being. Uden & Ching, (2023) highlights that the effects of the COVID-19 pandemic have further heightened the urgency to adopt pedagogical models that are sensitive to learner motivational challenges. Darmanin and Pulis, (2023); Gkintoni and Dimakos, (2022) suggests that teachers must be equipped with neuro-scientific knowledge that enables them to respond effectively to learners' cognitive and emotional needs.

This conceptual paper aims to explore how educational neuroscience can inform pedagogy, curriculum design, and teacher professional development. It identifies three core domains that require transformation through a neuroscience lens. These domains include cognitive engagement and the conditions that facilitate deep learning (Uden and Ching 2023), curriculum design that is inclusive and adaptable to neurodiverse learners (Darmanin and Pulis 2023), and the preparation of teachers to apply brain-based principles in practice (Gkintoni and Dimakos 2022). This conceptual paper argues that neuroscience-informed teaching enhances educational responsiveness and inclusivity by aligning instruction with the cognitive architecture of the learner. Such an alignment is particularly crucial for learners with learning differences, including those who exhibit characteristics of autism spectrum disorder (ASD), attention deficit hyperactivity disorder (ADHD), and dyslexia. When viewed from this perspective, differences in learning are not obstacles to be corrected but diverse manifestations of human potential that can be supported through pedagogical adaptation.

Furthermore, the conceptual orientation of this paper is rooted in an effort to integrate theoretical insights and empirical evidence. In order to articulate a renewed vision of education that is intellectually rigorous and socially just. Drawing on both international and South African literature, the discussion advocates for a paradigm shift in education that places neuroscience at the centre of pedagogical reflection. Educational neuroscience is not regarded as a supplementary discourse but as a foundational science that informs how teachers can design learning experiences that are emotionally attuned, cognitively effective, and developmentally responsive (Treglia, et, al., 2022; Centre for Educational Neuroscience, 2019; South African College of Applied Psychology, 2020). In doing so, this paper presents educational neuroscience as a transformative approach that reimagines what it means to teach and learn in an increasingly complex and diverse educational landscape.

2. Theoretical Foundations of Educational Neuroscience

This conceptual paper is grounded in the complementary theoretical perspectives of neuro-constructivism and inclusive cognition. Thomas, et, al., (2019) indicates that neuro-constructivism posits cognitive development results from continuous and dynamic interactions between neural structures, environmental factors, and lived experiences. This theory rejects static conceptions of intelligence and instead highlights the adaptive and context-sensitive nature of brain development. According to Thomas et al. (2019), neuro-constructivism suggests that learning is shaped by a multiplicity of factors that influence how neural pathways are formed and strengthened. In educational context, this implies that each learner constructs knowledge uniquely based on interactions within their cognitive and sociocultural environment. Thus, the pedagogical strategies must be sensitive to these multiple layers of influence and must actively support learners in developing their cognitive skills over time.

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In addition to neuro-constructivism, the paper employs the framework of inclusive cognition to foreground the importance of recognising and responding to neuro-diversity in educational contexts (Treglia, et, al., 2022). Inclusive cognition asserts that differences in cognitive functioning; such as those associated with ASD, ADHD, and dyslexia, should be viewed as part of the natural variability in human development (Darmanin and Pulis 2023). Therefore, this perspective challenges deficit-based views of learner diversity and promotes a strengths-based understanding of how learners engage with content, in their learning environments. Inclusive cognition is supported by the principles of UDL, which advocate for multiple means of engagement, representation, and expression (Albright, 2020). As noted by Darmanin and Pulis (2023), UDL offers a flexible framework for designing curricula that accommodate a wide range of learner needs without requiring retroactive modifications.

These theoretical lenses converge to support a holistic and equity-driven approach to education. They underscore the need to personalise learning experiences in ways that not only support academic achievement but also enhance learners' sense of agency, identity, and belonging (Treglia, et, al., 2022). According to Thomas et al. (2019), neuro-constructivism offers a scientific explanation of how learning takes place through interaction and adaptation. While inclusive cognition provides a normative vision for what education should aim to achieve: the full participation and success of all learners, regardless of neurological profile (Darmanin and Pulis 2023). As Treglia, et, al., (2022) point out, such an approach to pedagogy calls for proactive, intentional design of learning environments that are emotionally safe, cognitively stimulating, and socially inclusive. Therefore, drawing from both neuro-constructivism and inclusive cognition, this conceptual paper establishes a conceptual foundation that informs the subsequent exploration of neuroscience-informed pedagogy. These frameworks not only validate the use of brain-based strategies in educational practice but also reinforce the moral imperative to cultivate learning environments where all learners can thrive (Albright, 2020). Together, they support the development of teaching practices that are informed by evidence, enriched by diversity, and guided by an unwavering commitment to inclusion and growth.

2.1. Operationalising Educational Neuroscience

Building on the theoretical foundations of neuro-constructivism and inclusive cognition, the emerging body of literature seeks to operationalise educational neuroscience within the lived realities of contemporary classrooms (Thomas et al., 2019; Treglia, et, al., 2022). Central to this conceptual paper is the argument that neuroscience-informed education must transcend abstract theorisation and actively shape pedagogical practices, curriculum architecture, and teacher development in ways that affirm learner diversity and promote equity (Darmanin & Pulis, 2023; Rao, 2021). To advance a transformative and humanising educational vision, it is critical to align instructional methods with the cognitive, emotional, and social profiles of learners, recognising the brain's malleability and its responsiveness to experience and environment (Conkbayir, 2022; Fleur, et, al., 2021).

This necessitates the design of curricula that are flexible, multisensory, and universally accessible from the outset, rather than retrofitted for inclusion (Debasu & Yitayew, 2024; Rao, 2021). It also requires empowering teachers through sustained, research-informed professional learning communities that encourage reflective engagement with neuro-scientific insights (Heni, et, al., 2023; Uden & Ching, 2023). Furthermore, the integration of neuroscience into education must be guided by a robust neuro-ethical framework that critically interrogates the purposes, implications, and socio-cultural consequences of brain-based interventions in schools (Racine, et, al., 2021; Nouri, 2025). Collectively, these dimensions affirm that educational neuroscience is not a supplementary add-on to pedagogical practice, but a foundational paradigm through which responsive, inclusive, and socially just education can be envisioned and enacted.

2.2. Neuroscience-Informed Pedagogy

Cognitive engagement represents the intellectual effort and psychological investment that learners commit to the processes of understanding and mastering academic content. From Quinn,

(2025) perspective, this engagement is supported by the activation of specific brain networks that govern attention regulation, information processing, and reward anticipation. At the centre of this activity are regions such as the anterior cingulate cortex and the dorsolateral prefrontal cortex, which are crucial for managing attention, resolving cognitive conflict, and maintaining goal-directed behaviour (Clairis & Lopez-Persem, 2023; Cruz, et, al., 2023). These executive functions operate in synergy with subcortical structures, particularly the nucleus accumbens, which plays a central role in processing novelty, challenge, and the anticipation of reward (Bayassi-Jakowicka, et, al., 2021; Alexandre, 2021). As a result, educational tasks that are intellectually stimulating, emotionally meaningful, and contextually relevant are more likely to elicit sustained engagement and promote deeper learning processes (Friedman & Robbins, 2022; Ducret, 2024).

Moreover, emotion exerts a profound influence on the processes of learning, particularly through its interaction with the limbic system. The amygdala and hippocampus, key components of this system, are responsible for emotional memory and the modulation of motivation (Smith & Torregrossa, 2021). Positive emotional experiences have been shown to enhance learners' capacity for attention, encoding, and the retrieval of information (Pahutar, et, al., 2024). In contrast, negative emotional states such as fear and anxiety can inhibit these cognitive functions by activating stress responses within the brain (Green, 2023). Neuroscience-informed pedagogies therefore prioritise the cultivation of emotionally supportive learning environments (Pradeep, et, al., 2024). Strategies such as narrative storytelling, collaborative peer interaction, the use of humour, and fostering strong teacher-learner relationships have all been linked to increases in positive affect and intrinsic motivation (Howe, et, al., 2022). These elements collectively enhance learners' readiness to engage with cognitively demanding tasks (Pahutar, et, al., 2024; Pradeep, et, al., 2024). Furthermore, insights from self-determination theory, particularly those related to the psychological needs for autonomy, competence, and relatedness, are now supported by neurobiological evidence (Champ, et, al., 2023). These dimensions have been found to activate neural reward systems, reinforcing persistence in goal-oriented behaviours (Champ, et, al., 2023; Uden and Ching, 2023).

Furthermore, pedagogical strategies that align with the principles of neural functioning are increasingly recognised for their potential to generate long-term benefits in education. Approaches such as spaced retrieval practice, interleaved learning, and dual coding are all grounded in neuro-scientific research on memory consolidation and neural plasticity. For example, the practice of spaced repetition helps learners overcome the brain's natural tendency to forget by repeatedly reinforcing neural connections over time. Similarly, the use of multimodal learning, combining visual, auditory, and kinesthetic inputs; engages multiple sensory pathways, which contributes to the formation of richer and more durable memory traces (Yelyzaveta, et, al., 2024; Carpenter, et, al., 2022). Additionally, effective instructional design also necessitates the management of cognitive load. This can be achieved through practices such as content chunking, scaffolding, and the incorporation of visual supports, all of which reduce the strain on working memory and facilitate comprehension (Komilovna, 2025). Moreover, promoting metacognitive awareness by encouraging learners to reflect on their own thinking processes has been linked to activation in the prefrontal cortex, which is associated with self-regulation and executive decision-making (Fleur, et, al., 2021; Conkbayir, 2022). These strategies are not only supported by empirical evidence but are also adaptable to a wide range of educational contexts, including those characterised by limited resources.

In addition to enhancing engagement and learning outcomes, the field of educational neuroscience has significantly influenced the discourse on inclusive education. Megari, et, al., (2024) notes that neuro-developmental conditions such as ASD, ADHD and dyslexia are increasingly understood as manifestations of neurological diversity rather than deficits. Neuro-scientific studies have revealed that learners with these profiles often process information in ways that differ from neuro-typical patterns (Norris, 2023), necessitating instructional approaches that are both differentiated and responsive. Classroom practices such as movement integration, sensory regulation, and the use of varied instructional media are particularly beneficial in accommodating these diverse cognitive styles (Yang, 2025; Aulina, et, al., 2024). According to Rao, (2021) the UDL

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framework offers a comprehensive approach for constructing curricula that are inherently inclusive. Rather than adapting existing materials retroactively, UDL advocates for the design of flexible learning environments from the outset, ensuring accessibility for all learners (Debasu & Yitayew, 2024; Rao, 2021). Therefore, encouraging multiple pathways for engagement, representation, and expression. Thus, the integration of neuroscience, cognitive science, and inclusive education points toward a transformative vision of pedagogy. This vision is grounded in the recognition that educational practice must honour the cognitive and emotional complexity of all learners (Bușu, 2020). This paradigm shift redefines the role of the teacher as a facilitator of cognitive growth and emotional well-being, rather than a mere transmitter of knowledge.

2.3. Curriculum Design and Construction

Contemporary curriculum design must evolve beyond rigid, standardised frameworks to reflect a nuanced understanding of learners' diverse neuro-cognitive profiles. Educational neuroscience has underscored the need for curricular architectures that reflect how learning is shaped not only by cognitive development but also by socio-emotional factors, environmental stimuli, and individual neurobiology. As highlighted by Gkintoni and Dimakos (2022), traditional curricula often marginalise learners who do not conform to normative cognitive patterns, thereby reinforcing educational inequities. A neuro-inclusive curriculum foregrounds variability in learning pathways, advocating for curricular flexibility that addresses both strengths and barriers (Efthymiou, 2024). This shift requires a re-conceptualisation of curriculum as an adaptive system capable of responding to fluctuating cognitive demands and learning conditions across time, context, and learner profiles. At the core of this re-conceptualisation is the integration of UDL, which provides a neuroscience-informed methodology for anticipating learner diversity at the point of curriculum planning. Unlike reactive models of accommodation, UDL promotes proactive curriculum design that ensures accessibility from the outset (Kontio Jr, 2025). Treglia et al. (2022) emphasise that when learners are given autonomy and choice in how they interact with material, their sense of competence and self-efficacy increases, which in turn enhances neuro-cognitive resilience. Curriculum design should therefore move beyond rigid sequences of content coverage and embrace dynamic, learner-driven pathways that promote agency and cognitive empowerment.

Furthermore, an inclusive curriculum must be contextually responsive. In many South African and global contexts, learners encounter curriculum in environments marked by inequality, systemic exclusion, and limited access to resources. As Darmanin and Pulis (2023) observe, curricular effectiveness is significantly mediated by social context, which interacts with neuro-developmental trajectories in complex ways. This calls for curricular content that is both culturally situated and socio-emotionally enriching. Embedding themes of identity, community, social justice, and emotional literacy enables the curriculum to speak to learners' lived realities while fostering emotional regulation and cognitive empathy (Bozek, 2025). Such content also activates brain regions involved in narrative processing and moral reasoning, thereby linking curricular relevance with neurological engagement. Inclusive curriculum design must not only ask what learners should know, but also what learners need to feel, question, and transform in their worlds.

In addition, neuro-inclusive curriculum design benefits from the strategic use of digital technologies that enhance both access and engagement. Digital tools, when thoughtfully integrated, can personalise learning experiences, support multisensory processing, and scaffold complex concepts. According to Thomas et al. (2019), technologies such as augmented reality and interactive simulations can activate spatial reasoning, promote embodied learning, and extend conceptual understanding beyond what is possible through static texts. Moreover, adaptive learning platforms can provide real-time feedback and adjust content delivery based on learners' performance, thereby supporting differentiated instruction aligned with each learner's cognitive zone of proximal development. However, the incorporation of technology must be intentional and grounded in neuroscience to ensure it supports, rather than fragments, cognitive coherence (Alkhassawneh & Al

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Sharif, 2025). When used to enhance reflection, creativity, and problem-solving, digital tools contribute meaningfully to a curriculum that is inclusive, engaging, and biologically attuned.

2.4. Empowering Teachers

Over the years, the integration of neuroscience into teacher professional development is increasingly recognized as a pivotal strategy for enhancing pedagogical competence. Despite the burgeoning body of neuro-scientific research on learning, many teacher education programs have yet to meaningfully incorporate this knowledge into their curricula(Pugach, et, al., 2020). Neuroscience provides evidence-based insights into how learners process information, regulate emotions, and sustain attention; core processes that are essential for effective instruction (Pradeep, et, al., 2024). Therefore, professional development initiatives must evolve from short-term workshops into long-term, reflective communities of practice where teachers can engage critically with neuroscientific concepts and translate them into pedagogical action. Programs like BrainU and NeuroTeach Global exemplify this paradigm by combining theory (Alkhassawneh & Al Sharif, 2025), classroom experimentation, and collaborative reflection to deepen teachers' understanding of how the brain learns.

However, a persistent challenge in translating neuroscience to the classroom lies in the proliferation of neuro-myths; widely held misconceptions about brain function that often shape teaching practices in unhelpful ways. For example, beliefs in fixed learning styles, or the idea of distinct "left-brain" and "right-brain" learners, persist despite a lack of empirical support (Newman, 2023). These myths can inadvertently reinforce pedagogical rigidity and limit teachers' capacity to meet diverse learner needs. Thus, a neuroscience-informed professional development model must explicitly address these misconceptions, equipping teachers with a critical lens to distinguish between popularized misinformation and scientifically validated principles.

Importantly, when teachers are provided with the tools to understand and apply neuroscience, their sense of professional efficacy is strengthened (Hachem, et, al., 2022). Research suggests that teachers who participate in neuroscience-based training demonstrate increased confidence in implementing differentiated instruction, emotional regulation strategies, and formative assessment practices that align with cognitive development (Alkhassawneh & Al Sharif, 2025). Furthermore, neuroscience supports the moral imperative of inclusive education by affirming the neurobiological diversity of learners. Teachers trained to understand the neuro-logical bases of learning differences are better positioned to design responsive, equitable classrooms that value each learner's cognitive profile. Thus, sustained, research-based training in educational neuroscience enhances teaching and promotes an inclusive, science-informed vision of education.

2.5. Challenges and Ethical Considerations

Although educational neuroscience has generated considerable enthusiasm for its potential to improve teaching and learning, its practical application is accompanied by significant methodological and ethical challenges. A central methodological issue concerns ecological validity. Many neuro-scientific studies are conducted in highly controlled laboratory settings that do not reflect the complexity of real classrooms (Schmied, et, al., 2021). As a result, findings from these studies may lack relevance for everyday teaching contexts where learners are influenced by socio-emotional, cultural, and environmental variables. This limitation leads to concerns about reductionism, where multifaceted learning processes are simplified into discrete neural correlates (Raj, et, al., 2023). Such interpretations can obscure the social and cultural dimensions of learning and may result in pedagogical practices that are ill-suited to the holistic needs of diverse learners. If neuroscience is to inform education meaningfully, it must engage with the realities of classroom practice and take into account the lived experiences of learners and teachers across varying contexts.

In addition to methodological concerns, the proliferation of scientifically unsupported ideas presents another barrier to effective integration. Neuro-myths such as the claim that individuals only use ten percent of their brains (Grospietsch & Lins, (2021), or that learners are either left-brained or right-brained continue to appear in teacher education materials (Shin, et, al., 2022). These misconceptions undermine the credibility of neuroscience and lead to instructional strategies that lack empirical support (McAfee & Hoffman, 2021). Therefore, addressing this issue requires the inclusion of neuroscience in teacher education programmes in a sustained and reflective manner. Teachers must be trained to critically assess and apply research findings in ways that are pedagogically sound. In essence, teachers require continuous collaborative training to effectively apply neuroscience in their practice.

Moreover, the ethical challenges surrounding educational neuroscience are equally important and require urgent attention. As neuro-technologies become more integrated into educational settings, concerns about privacy, consent, and data security emerge (Nouri, 2025). For example, the collection of brain-based data through wearable devices may lead unintended profiling of learners (Kellmeyer, 2021). These practices could exacerbate existing educational inequalities by disproportionately affecting learners from marginalised communities. Furthermore, discussions surrounding cognitive enhancement raise ethical questions about fairness and access (Racine, et, al., 2021). If certain learners are afforded access to neuroscience-informed interventions while others are not, the principle of educational equity is compromised (Levinson, et, al., 2022). To address these challenges, education systems require robust ethical frameworks to govern the use of neuroscience tools in schools. Such frameworks must prioritise learners' dignity, autonomy, and rights, while promoting equitable access to scientifically grounded pedagogical innovations.

2.6. Towards a Neuro-ethical and Transformative Educational Future

Educational neuroscience, often celebrated for enhancing cognitive performance and instructional effectiveness, must not be constrained by a technocratic agenda that prioritizes efficiency over meaning. Its most profound contribution lies in reorienting education towards a humanistic, inclusive, and ethically grounded paradigm. Neuro-scientific research consistently demonstrates that the brain is not merely a computational organ but a dynamic system shaped by social relationships, cultural contexts, and experiential learning (Conkbayir, 2022; Fleur, et, al., 2021). This understanding compels a shift from decontextualized and standardized teaching models toward pedagogical practices that recognize learners as embodied, affective, and meaning-making individuals (Rao, 2021; Megari et al., 2024).

Informed by this perspective, transformative neuroscience-based education must promote practices that honour neuro-diversity, cultivate emotional safety, and nurture intrinsic motivation and identity formation (Norris, 2023; Bușu, 2020). The development of such pedagogical sensitivity requires sustained professional development, collaborative inquiry, and reflective practice that go beyond one-off training sessions (Heni, Iriani, & Ismanto, 2023; Sai'in, et, al., 2023). Therefore, teachers must be equipped not only with the scientific understanding of the brain but also with critical frameworks that interrogate the ethical, cultural, and relational dimensions of applying neuroscience in educational settings (Schmied, et, al., 2021; Alkhassawneh & Al Sharif, 2025).

To this end, education systems must adopt robust neuro-ethical frameworks that interrogate the purposes, assumptions, and values driving the integration of neuro-scientific tools and data. Moreover, Neuro-ethics raises critical questions about autonomy, justice, equity, and inclusion, challenging teachers and policymakers to ask not only whether a strategy is neuro-logically effective, but whether it is ethically sound and socially responsive (Racine, et, al., 2021; Levinson, et, al., 2022). For instance, while neuro-technologies such as biometric feedback can yield insights into attention or stress levels, they simultaneously evoke concerns about data privacy, consent, and potential misuse (Nouri, 2025; Centre for Educational Neuroscience, 2019). Similarly, cognitive enhancement interventions must be evaluated critically to ensure they do not pathologize neuro-divergent learners or entrench normative conceptions of intelligence (Megari et al., 2024; Efthymiou, 2024).

Realizing this vision necessitates collaborative infrastructure. Policymakers, neuro-scientists, curriculum designers, and communities must co-construct educational environments that are not only brain-aligned but culturally grounded and socially just (Debasu & Yitayew, 2024; Aulina, et, al., 2024). Teacher education programmes should embed neuroscience-informed principles that cultivate metacognitive awareness, emotional literacy, and pedagogical adaptability (Bozek, 2025; Haque, 2024). Classroom instruction must evolve to integrate multisensory and multimodal strategies that accommodate learner variability and promote deeper cognitive engagement (Komilovna, 2025; Yang, 2025). Moreover, institutional cultures should nurture professional learning communities that sustain a dialogue between empirical research and reflective practice (Uden & Ching, 2023; Darmanin & Pulis, 2023).

Therefore, the convergence of neuroscience, ethics, and education offers an opportunity to reimagine the very aims of teaching and learning in the twenty-first century. It urges a departure from mechanistic metaphors of the brain as a machine, advocating instead for an understanding of learners as relational beings shaped by their emotional, cultural, and social realities (Shin, Lee, & Bong, 2022; Treglia, et, al., 2022). Such a paradigm not only enhances educational outcomes but reframes education as a vehicle for cultivating curiosity, empathy, and resilience; capacities essential for lifelong learning and civic engagement (Carpenter, et, al., 2022; Budhan, 2025). In doing so, educational neuroscience becomes a morally purposeful and socially transformative force.

3. Findings on Neuroscience-Informed Pedagogy

3.1. Teacher Awareness and Neuroscience Integration

A substantial body of scholarly literature indicates that teachers are increasingly recognising the significance of neuroscience as a foundational framework for understanding teaching and learning processes. This awareness is, however, characterised by notable differences in conceptual depth and the extent of practical application. According to Tyng, et, al., (2017) and Gkintoni, et, al., (2021), some teachers are able to articulate the influence of neural processes such as memory encoding, emotional regulation, and attention on learning. Nevertheless, a considerable number of teachers exhibit only a superficial familiarity with neuroscientific concepts, often employing terms like "brain-friendly teaching" and "neuroplasticity" without connecting them to specific instructional strategies.

This inconsistency in conceptual understanding is frequently attributed to the absence of structured training in neuroscience during initial teacher preparation and subsequent professional development. Im, (2025) observe that the limited uptake of neuroscience concepts within pedagogical practice is largely a result of inadequate exposure to empirical, research-based frameworks. However, when neuroscience principles are introduced through established pedagogical models such as UDL, teachers are more likely to internalise and translate them into actionable teaching strategies (Triana & Supena, 2023). Tan & Amiel, (2022) highlight the usefulness of such frameworks in bridging theoretical neuroscience with classroom realities, making the concepts more relatable and applicable for practicing teachers.

According to Dubinsky, et, al., (2022), notes that the meaningful integration of neuroscience into pedagogical knowledge has been shown to enhance teachers' abilities to design and deliver instruction that is developmentally appropriate and cognitively responsive. Neuroscience contributes critical insights into how learners process, retain, and apply information by elucidating functions related to cognitive load, executive functioning, memory consolidation, and motivational systems within the brain. Dubinsky, et, al., (2022) advocate for the positioning of neuroscience within Shulman's category of "Knowledge of Learners," asserting that a sound understanding of brain function is fundamental to responsive and effective teaching.

Teachers who undergo training in neuroscience-informed pedagogical methods report improvements not only in their instructional effectiveness but also in their sense of professional identity. Empirical findings by Balan, (2024), as well as Liu & Ball, (2019), indicate that such training contributes to enhanced teacher efficacy, more reflective decision-making, and heightened sensitivity to learner diversity. The result is a greater degree of pedagogical agility, enabling teachers to adapt instructional approaches to match learners' cognitive readiness and developmental stages. This adaptability is particularly valuable in contexts marked by educational inequality, where responsive and inclusive teaching practices are essential for promoting equitable learner outcomes.

3.2. Professional Development and Training Gaps

The reviewed literature for this conceptual study reveals a dual narrative concerning teacher professional development in neuroscience-informed pedagogy. On one hand, there is a clear and pressing gap in formal training structures. Studies consistently report that most teachers acquire their knowledge of brain-based education from informal and often unreliable sources such as online videos, and popular science articles, leading to widespread acceptance of neuro-myths including the left-brain or right-brain dichotomy and the idea of fixed learning styles (Stalling, 2024; Antonenko & Abramowitz, 2023). Arslan, (2025) argue that the absence of neuroscience in both pre-service and in-service teacher education contributes to superficial understanding and poor implementation fidelity in classrooms. Despite this shortfall, there is evident enthusiasm among teachers for learning about the brain. For instance, Justus, (2024) found that teachers in underserved schools expressed strong interest in professional learning communities and workshops focused on neuroscience. The demand for such training is particularly high in contexts where inclusive, differentiated instruction is most needed.

When neuroscience-informed professional development is made available, the impact on pedagogy is substantial. Teachers who receive structured training are more likely to move away from rote, teacher-directed practices and adopt strategies aligned with cognitive science, such as spaced repetition, multimodal instruction, emotional anchoring, and cognitive chunking (Matthias & Pillay, 2022; Roehrig et al., 2022). These evidence-based strategies not only enhance learner engagement and retention but also build teacher confidence in responding to diverse learner needs. Crucially, neuroscience-informed professional development also reshapes teachers' interpretations of learner behaviour. Teachers gain a deeper understanding of how trauma, stress, and poverty influence brain development and learner performance. This neurobiological insight fosters empathy and shifts classroom management approaches from punitive discipline to emotional regulation and cognitive support (Reddy, 2025). However, systemic barriers persist. The lack of institutionalised neuroscience content in teacher education curricula means that most teachers remain dependent on fragmented, often anecdotal knowledge (Zameer & Akhtar, 2025). This highlights the urgent need for sustained investment in neuroscience-based professional development, embedded within broader teacher education reforms and tailored to the contextual realities of under-resourced schools.

3.3. Brain-Aligned Instruction and Systemic Limitations

The integration of neuroscience into educational practice has initiated a significant shift in how teaching and learning are conceptualised, particularly in classrooms that aim to foster engagement, cognitive growth, and emotional wellbeing. A review of recent literature confirms that teachers who incorporate neuroscience principles into their pedagogy often design lessons that are multisensory, interactive, and emotionally responsive (Alkhassawneh & Al Sharif, 2025; Kahise, 2025). Techniques such as cooperative learning, storytelling, kinesthetic engagement, and music integration have become widely adopted (Nayak, 2025). These strategies are rooted in neuro-scientific findings that demonstrate the connection between emotional regulation, dopamine release, and memory consolidation, which collectively enhance long-term academic outcomes (Jing, 2025; Sharma & Jain, 2025). Moreover, teachers are also increasingly prioritising the creation of emotionally secure and responsive learning environments (Geesa, et, al., 2022). This includes the deliberate implementation of practices intended to reduce learner anxiety and stress. Both of which are recognised as significant barriers to cognitive processing. Mindfulness exercises, breathing techniques and classroom rituals are some of the methods employed to enhance emotional resilience and executive functioning. Such interventions are especially beneficial for neuro-divergent learners and learners who experience elevated stress levels due to socio-economic challenges, thereby fostering improved attention, behavioural regulation, and academic persistence (Sideropoulos, 2024; Efthymiou, 2024).

The influence of neuroscience on education is further evident in the evolution of assessment practices. Increasingly, teachers are shifting away from traditional high-stakes, summative assessments towards more formative and learner-centred approaches (Zigama, 2025). These include

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retrieval practice, spaced repetition, reflective journaling, and the use of frequent low-pressure quizzes (Lipnevich, et, al., 2024). These practices align with the cognitive processes involved in memory encoding and consolidation, and they help reduce the anxiety commonly associated with assessments. Teachers who are informed by neuroscience also demonstrate a deeper understanding of metacognition (Devaki, et, al., 2025), and they promote self-regulation by embedding peer feedback, learner goal-setting, and self-assessment activities into their evaluation frameworks. This reflects a broader conceptual shift, wherein assessment is seen not merely as a tool for measuring learning outcomes but as a process that actively supports cognitive development and learner autonomy (Lamb & Little, 2016).

However, despite the promise and observed benefits of brain-aligned teaching, implementation remains uneven and constrained by systemic barriers. Many teachers, especially those in under-resourced public schools, are working within environments characterised by overcrowded classrooms, insufficient teaching materials, and rigid institutional structures (Botha, 2022). These challenges severely limit the flexibility and responsiveness required to adopt and sustain neuroscience-informed practices. Teachers often lack the institutional support, time, and professional development necessary to transform neuroscience theory into effective classroom strategies (Dubinsky, et, al., 2019).

Additionally, the absence of neuroscience-informed frameworks within national education policies compounds the implementation gap. While South African educational policies, including the Curriculum and Assessment Policy Statement (CAPS), articulate goals related to inclusivity and learner support, they do not explicitly reference cognitive neuroscience or neuroeducation. As a result, there is a persistent disconnect between emerging scientific insights into how the brain learns and the policies that govern curriculum delivery, teacher training, and assessment design. In the absence of formal policy support, teachers rely on personal initiative or informal professional networks to access neuroscience-related training..

3.4. Neuro-Responsive Classrooms and Curriculum Innovation

Recent research highlights the essential role of emotional safety in shaping classrooms that are both effective and informed by neuroscience. Teachers are becoming increasingly attuned to how chronic stress and trauma impair the regulatory function of the amygdala, which influences learners' capacity to focus, process emotions, and encode memories. As discussed by Harms, et, al., (2023) and Kelly & Li, (2019), many children experiencing toxic stress do not struggle with learning due to cognitive deficits, but rather because of disrupted neurological regulation. In response, neuroscience has become an important lens through which trauma-informed pedagogy is being developed and implemented.

Teachers working in challenging contexts, including township schools in South Africa, have introduced a range of low-cost, neurologically grounded interventions. These include mindfulness exercises, structured classroom routines, and emotional check-ins that foster a sense of safety and predictability. Udeh-Momoh, et, al., (2024) note that such interventions are not only cost-effective but also significantly enhance learners' readiness to engage with academic content. These trauma-sensitive strategies extend beyond simple behavioural interventions. Teachers are implementing calming spaces within classrooms, guiding learners through breathing techniques, and incorporating affirmation practices designed to strengthen self-regulation and reduce anxiety-related disruptions (Palmer, 2025). Waggoner, (2018), reports that these methods are particularly impactful in schools serving communities affected by poverty, displacement, or violence. In these settings, such approaches serve to restore learners' sense of agency and cognitive presence. According to Meier, (2024), the effectiveness of these strategies lies in their grounding within the science of how trauma influences areas of the brain such as the hippocampus and the prefrontal cortex, which are critical for memory, attention, and decision-making.

In tandem with these classroom interventions, neuroscience is also catalysing curriculum reform and interdisciplinary innovation. Teachers informed by neuroscience are increasingly modifying how subject content is structured and delivered. In mathematics education, for example, memory scaffolding and visualisation techniques are being used to support learners who struggle with working memory constraints. Similarly, literacy instruction is incorporating decoding strategies informed by brain-based models of comprehension and cognitive development (Spence & Mitra, 2023). These shifts mark a departure from traditional rote learning and signal a move toward pedagogy that aligns with how the brain learns naturally and efficiently.

Several studies have documented the development of interdisciplinary units that merge subject content with socio-emotional learning and executive function development. For instance, lessons on human biology have been expanded to include discussions on emotional intelligence and mental health, allowing learners to explore scientific content in ways that connect with their lived experiences. Martin, (2023) show how these integrated approaches not only improve cognitive retention but also support learner motivation and engagement. This interdisciplinary integration is further supported by the UDL framework, which promotes the use of flexible teaching methods to accommodate diverse learner needs. Balta, et, al., (2021) argue that UDL, underpinned by neuroscience, provides a powerful model for inclusive, adaptable curriculum design.

3.5. Inclusive Pedagogy through Neuroscience

Empirical studies across diverse educational contexts demonstrate that teachers are drawing upon findings from brain science to cultivate learning environments that accommodate the full spectrum of learner variability. This includes learners with Attention Deficit Hyperactivity Disorder, dyslexia, and Autism Spectrum Disorder. According Pradeep, et, al., (2024) a sound understanding of atypical neural development equips teachers with the capacity to modify instructional strategies in alignment with learners' cognitive processing styles, pace, and attentional focus. This responsiveness contributes to greater equity in the classroom, particularly for learners who are often marginalised within traditional, standardised models of teaching.

The Universal Design for Learning framework has emerged as a powerful mechanism for translating neuroscientific principles into inclusive educational practice. UDL advocates the use of multiple means of representation, engagement, and expression to ensure that instructional delivery aligns with a range of learning preferences and developmental profiles. Tsimpli, et, al., (2020) emphasise that this flexibility is essential in linguistically diverse, multicultural, and economically disadvantaged school environments. In such contexts, standardised instructional methods often serve to deepen educational exclusion. Teachers reduce cognitive overload, increase learner autonomy, and scaffold knowledge acquisition in ways that reflect both the diversity and potential of their learners, by integrating UDL principles. One of the most transformative neuroscientific concepts influencing inclusive pedagogy is neuroplasticity. This refers to the brain's innate capacity to adapt and reorganise in response to experience and intentional practice (Joshua, 2022). Teachers who internalise this principle are more inclined to cultivate growth mindsets among their learners, conveying the message that intelligence is not a static trait but rather a malleable capacity. Yang & Wang, (2022) report that learners exposed to such messaging display increased motivation, perseverance, and academic resilience. These psychological shifts are especially profound in under-resourced school settings, where learners often face external challenges that can negatively impact self-belief and academic engagement.

4. Discussion

4.1. Conceptual Depth of Neuroscience in Education

Research studies reveals that while neuroscience is increasingly recognised by teachers as an important framework for understanding learning, the conceptual clarity and depth of this understanding vary significantly among teachers (Dubinsky, et, al., 2022). Some teachers demonstrate a developed awareness of core neuro-logical processes, including memory formation, attention modulation, and emotional regulation, and are able to articulate how these processes influence learner engagement and achievement. Others, however, demonstrate only superficial familiarity, often relying on popularised terms such as "brain-friendly teaching" or "growth mindset" without clearly linking these ideas to structured pedagogical frameworks. This divergence in understanding is largely due to the limited integration of neuroscience in formal teacher education programs. Tokuhama-Espinosa, (2021) and Arslan, (2025) argue that teachers often turn to informal sources such as the internet or social media to learn about neuroscience, which can result in the internalisation of inaccurate or overly simplified ideas. To bridge this gap, studies recommend embedding neuroscience content within familiar educational models like UDL, which provides a practical scaffold for teachers to translate theory into application (Balta, et, al., 2021).

4.2. Instructional Innovation and Enhanced Learner Engagement

The findings of this conceptual study consistently indicate that teachers who draw from neuroscience-informed approaches tend to design instructional activities that are active, emotionally responsive, and cognitively engaging. Such teachers often employ strategies like storytelling, cooperative group work, music integration, and movement-based tasks to activate various sensory pathways and stimulate multiple areas of the brain. These methods are grounded in the understanding that multisensory input enhances attention and memory retention by strengthening neural connections through repeated and varied experiences (Kapoor, et, al., 2024; Duarte, et, al., 2025). Moreover, teachers also intentionally create emotionally safe classroom environments, recognising that stress, anxiety, and trauma can disrupt the functioning of the amygdala and inhibit the learning process. Larrison, (2025) report that strategies such as mindfulness, gratitude journaling, and structured classroom rituals are increasingly being used to regulate emotional states and promote executive functioning. This includes improvements in learners' working memory, self-regulation, and persistence. Therefore, these practices reflect a growing awareness that cognitive development is inseparable from emotional and social wellbeing, particularly in settings where learners are exposed to high levels of adversity.

4.3. Assessment Reform and Metacognitive Development

Another significant area of innovation linked to neuroscience is the reimagining of assessment practices. Teachers who are informed by neuroscience principles are moving away from traditional, high-stakes examinations and adopting more formative and process-oriented approaches to evaluation (Chang, et, al., 2021; Guo, 2025). These include techniques such as retrieval practice, spaced repetition, scaffolded questioning, and learner-led reflection activities. These strategies are intended not only to assess learning but also to reinforce memory consolidation and deepen conceptual understanding over time (Cotton & Ricker, 2022; Sridhar, et, al., 2023). According Harris, et, al., (2023) emphasis on frequent, low-pressure feedback reduces performance anxiety and aligns with cognitive research on the detrimental effects of stress on working memory and recall. Teachers are also promoting metacognitive awareness by encouraging learners to engage in self-assessment, goal-setting, and peer feedback. These approaches enhance executive functions such as planning, decision-making, and self-monitoring. In essence, teachers are helping learners to internalise responsibility for their own learning and to develop the cognitive flexibility needed for academic success, by reshaping assessment into an iterative and supportive process.

4.4. Trauma-Informed Practice and Emotional Regulation

The findings of this conceptual study highlight a strong link between neuroscience and trauma-informed pedagogy, particularly in socioeconomically disadvantaged schools and refugee learning environments. Teachers are increasingly aware that exposure to chronic stress, poverty, and violence disrupts the development of brain regions associated with learning, including the hippocampus and prefrontal cortex. This awareness is prompting teachers to adopt classroom practices that prioritise emotional safety, predictability, and self-regulation. Parrott, (2021) and Wheeler & Walker, (2025)

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document how teachers use strategies such as calm-down corners, emotion check-ins, breathing exercises, and affirmation circles to reduce anxiety and support cognitive readiness. These practices are not viewed as auxiliary or behavioural in nature but are seen as integral to the learning process. According to Imad, (2022), these trauma-informed strategies create a neurologically supportive climate that allows learners to access and process academic content more effectively. In communities marked by structural hardship and psychosocial instability, such approaches play a critical role in levelling the cognitive playing field and restoring learners' capacity for sustained engagement and academic growth.

4.5. Inclusive Curriculum Design and Structural Challenges

The influence of neuroscience on curriculum development is also evident in the creation of interdisciplinary and inclusive learning modules. Teachers are designing thematic units that blend content knowledge with socio-emotional learning and cognitive skill development. For instance, lessons on the human brain are being used not only to teach biology but also to explore emotional literacy, decision-making, and empathy. Mathematics instruction is being enhanced through the use of visual scaffolding to support working memory, while reading comprehension is taught using techniques grounded in cognitive load theory and metacognitive reflection (van Nooijen, et, al., 2024). These curriculum innovations reflect a move towards holistic learning that is both developmentally appropriate and neurologically aligned. However, these promising developments are often hindered by systemic constraints. The Curriculum and Assessment Policy Statement in South Africa, for example, does not explicitly reference cognitive neuroscience or neuro-education, which results in a lack of institutional support and training for teachers. As Choudhury & Wannyn, (2022) and Pardy, (2021) caution, the absence of formal policy endorsement means that the spread of neuroscience-informed pedagogy remains dependent on individual initiative rather than being driven by systemic reform. Thus, this dynamic places teachers in under-resourced schools at a particular disadvantage, as they lack the infrastructure, materials, and professional development opportunities needed to fully implement these pedagogical innovations.

5. Recommendation

5.1. Integrating Neuroscience into Teacher Education and National Policy

It is recommended that neuroscience be formally embedded within teacher education programmes and in-service training initiatives. The findings indicate that many teachers acquire neuroscience knowledge through informal sources such as social media and popular science platforms, which results in uneven understanding and risks of neuro-myths (Tokuhama-Espinosa, 2021; Arslan, 2025). Thus, incorporating neuroscience content into the curriculum of teacher training institutions, teachers would gain a scientifically grounded framework for understanding how learners think, feel, and process information.Furthermore, policy frameworks such as the CAPS should be revised to explicitly include neuro-scientific principles. Currently, CAPS does not reference neuro-education, limiting systemic support for teachers (Choudhury & Wannyn, 2022; Pardy, 2021). Integrating neuroscience into policy would align teaching practices with cognitive development and strengthen instructional planning in South Africa.

5.2. Enhancing Professional Development for Teachers in Under-Resourced Schools

The evidence shows that teachers, particularly in under-resourced schools, are eager for professional development opportunities grounded in neuroscience. However, many lack access to structured training on strategies such as scaffolding, spaced repetition, and retrieval practice (Chang et al., 2021; Cotton & Ricker, 2022). Providing contextually relevant workshops, webinars, and resource hubs can help bridge this gap. Training should be sensitive to resource limitations in rural and township schools and focus on translating cognitive science into classroom practices. Teachers

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equipped with such knowledge demonstrate stronger confidence in managing diverse learning environments and improving learner outcomes (Guo, 2025; Sridhar et al., 2023).

5.3. Fostering Trauma-Sensitive and Emotionally Safe Learning Environments

Teachers working in socioeconomically disadvantaged or high-adversity contexts require explicit support in implementing trauma-responsive pedagogy. Research highlights that chronic stress and trauma disrupt brain regions critical for learning, including the hippocampus and prefrontal cortex (Parrott, 2021; Imad, 2022; Wheeler & Walker, 2025). Professional development should therefore prioritise equipping teachers with strategies such as mindfulness activities, calm routines, breathing exercises, and emotion check-ins. These practices enhance self-regulation, working memory, and persistence, thereby improving learners' readiness to engage with academic content (Larrison, 2025). Such trauma-sensitive environments are crucial for restoring learners' capacity to succeed in cognitively demanding tasks.

5.4. Advancing Curriculum Innovation through Neuroscience-Aligned Design

Neuroscience provides valuable guidance for interdisciplinary and inclusive curriculum design. Teachers who understand how the brain processes information can integrate socio-emotional learning with cognitive skill development, using approaches such as visual scaffolding in mathematics and cognitive load-informed strategies in reading (van Nooijen et al., 2024). The Universal Design for Learning framework offers a practical model for applying these insights, supporting flexibility and inclusivity in diverse classrooms (Balta et al., 2021). However, systemic challenges such as the absence of CAPS alignment with neuroscience continue to limit teachers' ability to fully implement innovative designs (Choudhury & Wannyn, 2022). Greater institutional support is required to ensure these promising approaches are not left to individual initiative.

5.5. Aligning Assessment Strategies with Cognitive Science

It is further recommended that assessment practices move beyond high-stakes examinations towards neuroscience-informed models that reinforce learning as an iterative process. Techniques such as retrieval practice, spaced repetition, and learner-led reflection have been shown to strengthen memory consolidation and reduce test-related anxiety (Cotton & Ricker, 2022; Harris et al., 2023). By embedding low-stakes assessments, self-evaluation, and peer feedback into classroom practice, teachers foster metacognitive development and executive functions such as planning, self-monitoring, and decision-making (Chang et al., 2021; Sridhar et al., 2023). Therefore, systemic adoption of such approaches in assessment policy would better align classroom practice with cognitive science and support sustainable learner growth.

6. Conclusion

This conceptual exploration has demonstrated that educational neuroscience holds transformative potential for reimagining teaching, learning, and curriculum in inclusive and equitable ways. The findings show that teachers' understandings of neuroscience remain uneven, with some teachers demonstrating a sophisticated grasp of neural processes such as memory, attention, and emotional regulation, while others rely on popularised but superficial concepts (Dubinsky et al., 2022; Tokuhama-Espinosa, 2021; Arslan, 2025). Meaningful integration of neuroscience into pedagogy is achieved when teachers are introduced to structured frameworks such as Universal Design for Learning, which provide a scaffold for translating theory into actionable instructional practices (Balta et al., 2021; Triana & Supena, 2023; Tan & Amiel, 2022). Central to this vision is the recognition that cognitive engagement is deeply shaped by the quality of emotional experience and classroom environment, rather than by information delivery alone. Teachers who employ strategies such as mindfulness, storytelling, cooperative learning, and multisensory teaching have been shown to strengthen neural connections, promote resilience, and foster long-term academic achievement (Kapoor et al., 2024; Duarte et al., 2025; Larrison, 2025).

Equally, this study highlights the essential role of neuroscience-informed professional development in dismantling persistent neuro-myths and building teacher confidence. Structured training equips teachers to adopt evidence-based strategies such as spaced repetition, cognitive chunking, and retrieval practice, while also reshaping their understanding of learner behaviour through neurobiological insights into trauma, stress, and poverty (Matthias & Pillay, 2022; Roehrig et al., 2022; Reddy, 2025). These insights encourage shifts in classroom management from punitive approaches to empathetic, supportive practices that enhance learners' cognitive readiness. Neuroscience also informs assessment reform by promoting iterative, learner-centred evaluation methods that reduce anxiety, reinforce memory consolidation, and enhance metacognitive skills (Chang et al., 2021; Sridhar et al., 2023; Harris et al., 2023).

At the same time, the promise of neuroscience-informed pedagogy is constrained by systemic and structural barriers. Overcrowded classrooms, inadequate teaching resources, and the absence of neuroscience within national policy frameworks, such as South Africa's CAPS, impede widespread implementation (Botha, 2022; Dubinsky et al., 2019; Choudhury & Wannyn, 2022). In this context, the integration of neuroscience must extend beyond individual teacher initiative and become embedded within broader institutional reforms. In essence, recognising neuroplasticity as a foundation for learner growth and embracing inclusive frameworks such as UDL, teachers can cultivate environments that honour learner diversity and potential (Tsimpli et al., 2020; Joshua, 2022; Yang & Wang, 2022). Thus, neuroscience offers not only a scientific framework for improving teaching and learning but also a moral imperative to address equity and inclusion. The future of education depends on sustained collaboration among teachers, policymakers, and researchers to ensure that neuroscience-informed practices are both contextually relevant and systemically supported.

Declarations

Ethical Considerations: This conceptual paper did not involve direct participation of human subjects or the collection of primary empirical data. Accordingly, formal institutional ethical clearance was not required. Nevertheless, the study was guided by the principles of responsible scholarship and research integrity as stipulated in the Tshwane University of Technology Research Ethics Policy and in the ethical guidelines of the National Department of Higher Education and Training (DHET). All literature, secondary data, and policy documents used in developing this conceptual work were handled with scholarly rigor and acknowledged through appropriate citation and referencing.

Consent to Participate: Not applicable. Since this paper did not include human participants, there was no requirement for informed consent.

Consent to Publish: Not applicable. The paper does not present primary qualitative or quantitative data from participants. Only published and publicly available literature was used in the formulation of arguments.

Data Availability Statement: As this study is conceptual in nature, no original datasets were generated or analyzed. The arguments are grounded in secondary literature and policy sources, which are publicly available and cited accordingly in the reference list.

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Authors' Contributions: CCT, as the primary author, developed the conceptual framework, synthesized the literature, and drafted the manuscript. ONM, in the role of supervisor, provided intellectual guidance, critically reviewed the manuscript, and contributed to refining the arguments and theoretical positioning of the paper.

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