# INCLUSIVE EDUCATION FOR SUSTAINABLE DEVELOPMENT IN HIGHER EDUCATION TEACHER EDUCATION PROGRAMME: INTEGRATING NEUROPSYCHOLOGY AND NEUROBILOGY

**By**

**Nwachukwu, Kingsley Ezechinyere[1], Bassey, Mary Charles[2] & Sawyer. Minengibi Edmund[3]**
[123]Department of Special Needs Education, Ignatius Ajuru University
Port Harcourt Rivers State
kingsley.nwachukwu@iaue.edu.ng

**Abstract**

Inclusive education is a critical pillar for achieving equitable, high-quality learning and advancing Sustainable Development Goal 4 (SDG 4). Despite its importance, higher education teacher programmes often lack integration of neuropsychological and neurobiological insights, which limits teachers' capacity to address learner diversity effectively. This article examines the intersection of inclusive education, teacher preparation, and neuroscience, emphasizing how cognitive and neural principles can enhance instructional practice. Drawing on neuroconstructivist theory and the Universal Design for Learning framework, the study explores practical strategies for embedding neuroscience into teacher education curricula, including curriculum redesign, experiential learning, faculty professional development, and technology-enhanced instruction. The article further highlights the impacts of such integration on sustainable development, including improved learner engagement, enhanced educational equity, development of lifelong learning skills, and preparation of inclusive future educators. Challenges such as limited faculty expertise, curricular rigidity, resource constraints, and resistance to change are identified, with recommendations provided to mitigate these barriers. By bridging neuroscience and pedagogy, higher education institutions can equip teachers to implement inclusive, adaptive, and sustainable educational practices, ensuring that all learners are supported and empowered to achieve their full potential.

**Keywords:** Inclusive Education; Sustainable Development; Higher Education; Neuropsychology and Neurobiology

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## Introduction

Inclusive education is widely recognised as a fundamental component of global educational policy and an essential driver of sustainable development. Within the United Nations' Agenda 2030, Sustainable Development Goal 4 (SDG 4) emphasises the imperative to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all," positioning inclusion as a cornerstone of both educational equity and social sustainability (Crespo 2020). This sustainable development mandate necessitates that teacher education programmes in higher education not only familiarise future educators with inclusive pedagogical philosophies but also equip them with the empirical tools to support diverse learners effectively. Despite these aspirations, the complex interplay between learner diversity especially at cognitive and neurobiological levels and instructional practice remains under-addressed in many teacher training curricula (Reigosa Crespo 2019).

The fields of neuropsychology and neurobiology offer valuable insights into the cognitive and neural mechanisms that underlie learning, memory, attention, and motivation. These scientific domains illuminate how individual differences in neural development and cognitive processing influence students' responses to instruction. For instance, educational neuroscience research has demonstrated that principles such as neural plasticity and metacognitive regulation are central to learning across diverse populations (Dubinsky, Roehrig and Varma 2023). However, traditional teacher education programmes frequently lack structured content that bridges these scientific findings with pedagogical strategies, limiting teachers' capacities to translate brain-based knowledge into inclusive practice (Neuroscience Research Notes 2026). This gap underscores a broader disconnect between contemporary neuroscience and pedagogical preparation in higher education.

Integrating neuropsychological and neurobiological perspectives into teacher preparation programmes can advance inclusive education by grounding pedagogical approaches in evidence about how learners think and process information. Educational neuroscience research indicates that when educators comprehend cognitive processes such as executive function, working memory, and attentional regulation, they are better positioned to differentiate instruction and scaffold learning (Cui and Zhang 2021). Moreover, research involving pre-service teachers suggests that exposure to neuroscience in teacher training enhances understanding of instructional methods and the conceptual foundations of learning (Luzzatto, Shalom and Rusu 2024). These interdisciplinary insights enable teacher candidates to reconceptualise learners not as homogenous recipients of instruction but as individuals whose neurological and psychological profiles shape their engagement with educational content.

The integration of neuroscience into inclusive pedagogy aligns with contemporary frameworks such as Universal Design for Learning (UDL), which emphasise the need for flexible instructional environments that respond to learner variability. While studies on UDL and

neuro-inclusive curriculum design remain emergent, evidence suggests that neuroscience-informed approaches facilitate adaptive teaching strategies that accommodate diverse cognitive and neurological profiles (Reigosa Crespo 2019). Furthermore, teachers trained in educational neuroscience report enhanced empathy towards learners with diverse needs and demonstrate greater capacity to implement pedagogical adaptations that support neurodiverse students (Frei-Landau, Grobgeld and Guberman 2023). Such outcomes reflect the potential of neuropsychology and neurobiology to enrich teacher education with scientifically grounded practices that are responsive to learner differences.

This article contends that embedding neuropsychological and neurobiological principles within higher education teacher education programmes is essential for the realisation of inclusive education as a sustainable developmental goal. It explores the theoretical foundations of inclusive education, delineates current limitations in teacher preparation, and proposes practical strategies for interdisciplinary integration. By articulating how neuroscience-informed teacher education strengthens professional competencies and promotes equitable learning environments, this study contributes to scholarly and policy discussions on the role of evidence-based science in advancing inclusive and sustainable educational systems.

## Rationale for Integrating Neuropsychology and Neurobiology for Teaching Effectiveness and Learner Inclusivity

The integration of neuropsychology and neurobiology into higher education teacher programmes is increasingly recognised as a necessary innovation to enhance the efficacy of inclusive education (Schwartz 2016). Traditional teacher education curricula often emphasise pedagogical theory and classroom management while overlooking the cognitive and neurological mechanisms that underpin learning. This omission limits teachers' understanding of how students with diverse cognitive profiles, including neurodiverse learners, acquire, process, and retain knowledge (Cui and Zhang 2021). By grounding teacher preparation in neuroscientific evidence, higher education institutions can equip future educators with strategies that are responsive to learners' individual needs, thereby promoting more effective and equitable teaching practices.

Furthermore, embedding neuropsychological and neurobiological principles in teacher training aligns directly with the goals of sustainable development. Inclusive education is not only a moral and ethical imperative but also a strategic driver of social and economic progress, as it ensures access to quality learning for all individuals regardless of cognitive or neurological differences (Crespo 2020). Teachers who understand the neurocognitive bases of learning are better positioned to implement differentiated instruction, scaffold complex tasks, and foster environments that accommodate diverse learners. This scientific approach strengthens the link between pedagogical practice and sustainable development by preparing educators capable of promoting lifelong learning and reducing educational inequities (Reigosa Crespo 2019).

Finally, the rationale for integrating neuroscience into teacher education is reinforced by emerging empirical evidence demonstrating its practical benefits. Studies indicate that pre-service

teachers who engage with neuroscience-informed curricula develop enhanced skills in identifying learning challenges, applying targeted interventions, and adapting instructional strategies to accommodate individual differences (Luzzatto, Shalom and Rusu 2024). These outcomes highlight the potential for neuropsychological and neurobiological knowledge to transform teacher competencies, ensuring that higher education programmes produce educators capable of implementing inclusive practices effectively. Consequently, the integration of these disciplines is not an ancillary enrichment but a foundational requirement for advancing inclusive and sustainable educational systems (Frei-Landau, Grobgeld and Guberman 2023).

## Theoretical Framework

**Neuroconstructivist Theory:** The Neuroconstructivist Theory, advanced by Johnson, Pascual-Leone, and Karmiloff-Smith (2009), posits that cognitive development emerges from the dynamic interaction between neural structures, environmental input, and learning experiences. The theory emphasizes that the brain is highly plastic and that learning occurs through gradual construction of knowledge networks influenced by sensory, social, and cognitive stimuli. Key tenets include the idea that cognitive functions are not fixed but evolve as neural pathways are shaped by experiences, and that variability in brain development affects learning outcomes. In the context of this study, the Neuroconstructivist Theory provides a foundation for understanding how teacher education programmes can incorporate neuropsychological principles to design inclusive instructional strategies that accommodate diverse learning trajectories and cognitive profiles.

## Universal Design for Learning (UDL) Framework

The Universal Design for Learning (UDL) Framework, developed by Rose and Meyer (2002), is grounded in cognitive neuroscience and proposes that effective learning environments are those that provide multiple means of engagement, representation, and expression. The framework emphasizes flexibility in curriculum design to address learner variability, advocating for instructional strategies that are accessible to all students regardless of their cognitive or neurobiological differences. Its major tenets include providing multiple pathways to acquire knowledge, using varied teaching materials to cater to different learning modalities, and offering multiple ways for learners to demonstrate understanding. This framework relates directly to the study as it bridges neurobiological insights with inclusive education, informing teacher preparation programmes on how to design curricula that support sustainable, equitable learning outcomes in higher education contexts.

## Inclusive Education in Higher Education

Inclusive education in higher education teacher programmes refers to the deliberate preparation of future educators to recognise, accommodate, and support learners of diverse abilities, backgrounds, and needs. It goes beyond mere access to education to ensure that all students can participate meaningfully in learning experiences, irrespective of physical, cognitive, or socio-cultural differences (Ainscow, Booth and Dyson 2016). In teacher education, this

approach emphasizes equipping pre-service teachers with both theoretical knowledge and practical skills that allow them to create equitable learning environments, plan differentiated instruction, and implement adaptive assessment strategies that meet the varied needs of learners.

One of the central challenges in implementing inclusive education in teacher preparation is the gap between policy mandates and curricular practice. While global frameworks such as the UNESCO Education 2030 Agenda advocate for inclusive practices, many higher education programmes still rely heavily on traditional lecture-based methods that may not adequately prepare teacher candidates to address classroom diversity (Loreman, Deppeler and Harvey 2020). Furthermore, faculty members often lack training in inclusive pedagogy or in integrating neuropsychological and neurobiological insights, which limits the ability of teacher programmes to cultivate educators capable of applying evidence-based strategies for diverse learners (Crespo 2020).

Neuropsychological and neurobiological perspectives offer valuable guidance in addressing these gaps. Understanding cognitive processes such as attention, memory, executive function, and emotional regulation allows teacher educators to design instruction that aligns with how learners process information (Dubinsky, Roehrig and Varma 2023). For example, knowledge of neural plasticity informs strategies for scaffolding learning and supporting students with delayed cognitive development, while understanding sensory processing differences can guide classroom accommodations for neurodiverse learners (Cui and Zhang 2021). Integrating these insights ensures that inclusive education is grounded not only in moral or legal imperatives but also in empirical understanding of learning mechanisms.

Higher education teacher programmes that embrace inclusive education foster professional competencies that extend beyond academic knowledge to include empathy, adaptability, and reflective practice. Studies indicate that pre-service teachers who engage with inclusive curricula demonstrate greater awareness of learner variability, improved classroom management skills, and enhanced ability to implement differentiated instruction (Frei-Landau, Grobgeld and Guberman 2023). By incorporating practical experiences such as teaching simulations, microteaching sessions, and exposure to neurodiverse learners, teacher education programmes can strengthen these competencies and prepare educators to respond effectively to diverse classroom contexts.

In sum, inclusive education in higher education teacher programmes represents a strategic pathway toward sustainable, equitable, and high-quality learning environments. Its integration of neuropsychology and neurobiology not only enriches teacher candidates' theoretical understanding but also equips them with practical strategies for addressing learner diversity. Embedding such interdisciplinary approaches in teacher preparation is therefore essential for producing educators capable of advancing the dual objectives of inclusion and sustainable development, ensuring that all learners can achieve their full potential (Reigosa Crespo 2019).

**Neuropsychological Insights for Teaching**

Neuropsychology provides a framework for understanding how cognitive processes influence learning, offering teacher educators insights into how students perceive, process, and respond to information. Central to this perspective is the recognition that learners vary significantly in attention, memory, executive function, and emotional regulation, all of which impact classroom engagement and academic performance (Cui and Zhang 2021). For pre-service teachers, understanding these processes is critical for developing instructional strategies that accommodate diverse learning needs and promote equitable outcomes.

One major contribution of neuropsychology to inclusive teaching is the emphasis on cognitive development stages and learning variability. The theory underscores that learning is not a uniform process and that cognitive capacities evolve over time, influenced by environmental and experiential factors (Dubinsky, Roehrig and Varma 2023). This insight encourages teacher educators to adopt differentiated instruction strategies, scaffold complex tasks, and provide multiple avenues for learners to demonstrate understanding. By integrating these principles, future teachers can design lessons that are responsive to students' cognitive profiles, thereby improving engagement and learning retention.

Emotional and social aspects of learning are also highlighted by neuropsychological research, illustrating how affective states such as motivation, anxiety, and self-efficacy interact with cognitive processes to influence academic outcomes (Blair and Raver 2015). Teacher preparation programmes that incorporate these insights equip candidates with the skills to recognise and manage emotional and behavioral challenges in the classroom. Strategies such as promoting growth mindsets, using positive reinforcement, and creating supportive learning environments become essential components of inclusive education informed by neuropsychology.

Finally, neuropsychological insights extend to assessment and feedback, enabling teachers to align evaluation methods with learners' cognitive strengths and weaknesses. For example, understanding working memory limitations can guide the pacing of instruction, while knowledge of attentional processes informs the design of tasks that sustain focus and engagement (Diamond 2023). By embedding neuropsychological principles into higher education teacher programmes, institutions can ensure that future educators are prepared not only to convey content effectively but also to cultivate inclusive learning environments that respond to the full spectrum of learners' cognitive and emotional needs.

## Neurobiological Perspectives on Learning

Neurobiology provides critical insights into how the brain's structure and function underpin learning, highlighting the mechanisms through which students acquire, process, and consolidate knowledge. Understanding neural development, including synaptogenesis, neural plasticity, and the maturation of executive function, allows educators to design instructional strategies that align with learners' developmental capacities (Immordino-Yang and Damasio 2017). In teacher education, these insights equip pre-service teachers to anticipate variability in

learning readiness and adapt pedagogical approaches accordingly, fostering more inclusive classroom environments.

Neurobiological research emphasizes the importance of neural plasticity, the brain's capacity to reorganize in response to experience and learning as a foundation for inclusive teaching (Kolb and Whishaw 2025). This concept suggests that all learners, regardless of cognitive or developmental differences, can benefit from targeted instructional interventions that stimulate neural pathways. For teacher preparation programmes, incorporating these principles encourages future educators to employ differentiated instruction, repetition, and multimodal learning techniques that reinforce knowledge acquisition and cognitive growth across diverse learners.

Sensory processing and integration are additional neurobiological factors that impact classroom learning. Variations in how students perceive and respond to auditory, visual, and tactile stimuli influence attention, engagement, and comprehension (Shonkoff and Phillips 2020). By understanding these neurobiological processes, teacher candidates can implement accommodations such as varied instructional materials, structured routines, and sensory supports that enhance learning for neurodiverse students. This approach underscores the interplay between brain function and instructional design in achieving inclusive education objectives.

Finally, neurobiological insights extend to motivation, stress regulation, and memory consolidation, all of which affect educational outcomes (Goswami 2018). The interaction between affective states and neural processes indicates that optimal learning occurs when the environment supports both cognitive and emotional needs. Embedding such knowledge into higher education teacher programmes enables future educators to create classrooms that not only convey content effectively but also sustain students' engagement, resilience, and capacity to learn. Consequently, neurobiological perspectives serve as a foundational component in training teachers to implement inclusive and sustainable educational practices.

**Integration Strategies**

Integrating neuropsychology and neurobiology into higher education teacher programmes has significant implications for sustainable development, particularly in advancing inclusive and equitable quality education as outlined in Sustainable Development Goal 4 (SDG 4). By equipping future educators with a scientific understanding of cognitive and neural processes, teacher preparation programmes can foster learning environments that accommodate diverse abilities, promote learner engagement, and reduce educational disparities. Such integration not only enhances instructional effectiveness but also contributes to long-term societal benefits, including increased social equity, economic participation, and lifelong learning opportunities. In this context, neuro-informed inclusive pedagogy emerges as a critical lever for achieving sustainable educational outcomes and ensuring that higher education systems produce graduates capable of supporting diverse learners and promoting equitable knowledge access (Crespo 2020; Reigosa Crespo 2019).

1. **Curriculum Redesign for Interdisciplinary Learning**: Higher education teacher programmes should revise curricula to integrate neuropsychological and neurobiological principles alongside core pedagogical courses. This approach enables pre-service teachers to connect theoretical knowledge of learning processes with practical teaching strategies. For example, modules on cognitive development, neural plasticity, and memory consolidation can be embedded into educational psychology courses, allowing candidates to understand how brain function influences learning outcomes (Dubinsky, Roehrig and Varma 2023).

2. **Practical Teaching Simulations and Microteaching**: Simulated classroom experiences allow pre-service teachers to apply neuroscience-informed strategies in controlled environments. Through microteaching sessions, candidates can experiment with differentiated instruction, scaffolding, and sensory accommodations, receiving feedback that enhances their ability to adapt teaching for diverse learners. Such practical integration bridges theory and practice while fostering reflective and adaptive teaching skills (Frei-Landau, Grobgeld and Guberman 2023).

3. **Professional Development Workshops for Educators**: Faculty and teacher trainers should engage in ongoing professional development to build competence in neuro-inclusive pedagogy. Workshops can focus on translating neuroscience research into actionable classroom strategies, using case studies and evidence-based practices to demonstrate how cognitive and neurobiological insights improve learning outcomes. This ensures that teacher educators themselves model inclusive practices (Cui and Zhang 2021).

4. **Use of Technology-Enhanced Learning Tools**: Incorporating digital platforms, learning analytics, and adaptive learning software allows pre-service teachers to implement personalized learning strategies informed by neuropsychology. Such tools can help monitor students' cognitive engagement, attention, and progress, providing data to inform differentiated instruction. Technology thus operationalizes neuroscience-informed pedagogy in practical, scalable ways (Luzzatto, Shalom and Rusu 2024).

5. **Collaborative Learning and Peer Mentoring:** Embedding collaborative projects and peer mentoring in teacher education programmes promotes understanding of social and emotional aspects of learning, which are strongly linked to neuropsychological functioning. Group activities and peer feedback help candidates develop empathy, communication skills, and awareness of learner diversity, reinforcing inclusive practices in real-world teaching contexts (Blair and Raver 2015).

## Impact on Sustainable Development

Integrating neuropsychology and neurobiology into higher education teacher programmes directly supports sustainable development by promoting inclusive and equitable quality education, as emphasized in Sustainable Development Goal 4 (SDG 4). By grounding teacher preparation in scientific insights about cognitive, emotional, and neural processes, educators are better equipped to address learner diversity, implement evidence-based instructional strategies, and foster environments where all students can thrive. Such an approach not only enhances educational

outcomes but also contributes to broader societal goals, including social equity, lifelong learning, and the development of skills essential for economic and civic participation (Crespo 2020).

**Impacts:**

1. **Enhanced Educational Equity:** Teachers trained in neuro-informed inclusive practices can recognize and accommodate diverse learning needs, ensuring that students with cognitive, emotional, or sensory differences receive equitable support. This reduces disparities in access and achievement, enabling all learners to benefit from quality education (Ainscow, Booth and Dyson 2016).
2. **Improved Learner Engagement and Retention:** By applying neuropsychological and neurobiological insights, educators can design instruction that aligns with students' cognitive capacities and learning preferences, increasing motivation, attention, and persistence. This leads to higher engagement and reduced dropout rates, contributing to sustainable learning outcomes (Blair and Raver 2015).
3. **Promotion of Lifelong Learning Skills:** Understanding how the brain processes and retains information enables teachers to foster critical thinking, problem-solving, and self-regulated learning skills in students. These competencies are essential for continued personal and professional development, supporting sustainable societal growth (Diamond 2013).
4. **Preparation of Inclusive Future Educators:** Embedding neuroscience-informed pedagogy in teacher programmes develops professional competencies among pre-service teachers, including empathy, adaptability, and reflective practice. Graduates are thus prepared to lead inclusive classrooms that support sustainable educational practices over time (Frei-Landau, Grobgeld and Guberman 2023).
5. **Contribution to Social and Economic Development:** Inclusive education informed by neuropsychology and neurobiology equips all learners with knowledge and skills necessary for active participation in society and the workforce. This reduces educational inequalities and fosters social cohesion, economic productivity, and community development, aligning with the broader goals of sustainable development (Crespo 2020).

**Challenges of Implementation**

Integrating neuropsychology and neurobiology into higher education teacher programmes, while beneficial for promoting inclusive education and sustainable development, presents several practical and conceptual challenges. These challenges arise from institutional, curricular, and pedagogical constraints that can limit the effectiveness of implementing neuroscience-informed strategies. Understanding these barriers is essential for designing realistic, evidence-based interventions that enhance teacher preparation and ensure that inclusive practices are sustainable over time (Reigosa Crespo 2019).

1. **Limited Faculty Expertise:** Many teacher educators lack formal training in neuroscience or neuropsychology, making it difficult to translate complex scientific concepts into

practical classroom strategies. Without targeted professional development, faculty may struggle to incorporate brain-based approaches into curricula effectively (Cui and Zhang 2021).

2. **Curricular Constraints:** Teacher education programmes often have rigid curricula with limited flexibility for interdisciplinary content. Integrating neuropsychology and neurobiology requires redesigning courses, which may face resistance due to accreditation standards, time limitations, or competing course requirements (Loreman, Deppeler and Harvey 2020).

3. **Resource Limitations:** Implementing neuroscience-informed practices often requires specialized materials, technology-enhanced learning tools, and access to research databases. Institutions with limited funding or infrastructure may be unable to provide these resources, constraining the scope of integration (Luzzatto, Shalom and Rusu 2024).

4. **Complexity of Translating Research into Practice:** Neuropsychological and neurobiological research can be highly technical, and the evidence does not always directly translate to classroom strategies. Teacher candidates may find it challenging to apply abstract findings to concrete instructional decisions without ongoing guidance and mentorship (Dubinsky, Roehrig and Varma 2023).

5. **Resistance to Change:** Institutional culture and entrenched teaching practices can inhibit the adoption of new approaches. Faculty and students accustomed to traditional pedagogy may be reluctant to embrace interdisciplinary or neuroscience-informed methods, slowing the integration process (Crespo 2019).

**Conclusion**

Integrating neuropsychology and neurobiology into higher education teacher programmes represents a transformative strategy for advancing inclusive education and achieving sustainable development goals. By grounding teacher preparation in scientific insights about cognitive, emotional, and neural processes, future educators are better equipped to design equitable, responsive, and adaptive learning environments that accommodate diverse learner needs. Despite challenges related to faculty expertise, curricular rigidity, and resource constraints, the adoption of neuroscience-informed pedagogy fosters enhanced professional competencies, promotes learner engagement, and contributes to broader societal benefits such as social equity and lifelong learning. Ultimately, embedding these interdisciplinary approaches within teacher education not only strengthens instructional practice but also ensures that higher education institutions play a pivotal role in producing educators capable of sustaining inclusive, high-quality, and equitable educational systems.

**Recommendations**

This work recommends the following:

1. Higher education institutions should embed neuropsychology and neurobiology modules into teacher preparation programmes to provide pre-service teachers with evidence-based knowledge of cognitive and neural learning processes.
2. Universities should organize ongoing training and workshops for teacher educators to enhance their competence in translating neuroscience research into practical, inclusive teaching strategies.
3. Teacher programmes should include microteaching, classroom simulations, and exposure to neurodiverse learners, enabling candidates to apply neuro-informed strategies in real-world teaching contexts.
4. Institutions should adopt adaptive learning tools, digital platforms, and assessment technologies to support differentiated instruction and monitor student engagement, learning progress, and cognitive development.
5. Higher education institutions should promote collaboration among educators, neuroscientists, and curriculum designers to develop sustainable, inclusive teaching practices while addressing resistance to change and institutional barriers.

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