

**Teachers' Understanding of Educational Neuroscience: A Mixed-Method Approach to
Understanding Knowledge, Attitudes and Application**

By

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Thank you all!

Declaration

I, Yasin Arslan, confirm that the work presented in my thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

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Abstract

This thesis investigated the integration of educational neuroscience into UK teacher training programmes, addressing gaps in teachers' understanding and limitations in current training. It is conducted in the context of what Initial Teacher Training (ITT) and the Early Career Framework (ECF) currently provide regarding educational neuroscience, particularly its implications for Special Educational Needs (SEN).

The research comprises three interconnected studies. Study 1 explored teachers' knowledge of educational neuroscience and the factors influencing it. Results revealed limited knowledge among teachers, with findings indicating that formal educational neuroscience training was associated with significantly higher knowledge scores than exposure through CPD or informal sources (e.g., blogs).

Study 2 examined teachers' views on the value of educational neuroscience in teaching practice and perceived challenges in accessing knowledge and training in the field. While teachers perceived educational neuroscience knowledge to be valuable and relevant in teaching practice, they identified time constraints, financial limitations, and a lack of accessible, practical resources as barriers to accessing this knowledge.

In Study 3, a short educational neuroscience training programme was designed, delivered and evaluated for its effectiveness in improving educational neuroscience knowledge in practising teachers. Participation in the programmes led to significant improvements in the teachers' knowledge compared to those who did not take the course.

Findings from this thesis highlight the need for and potential effectiveness of structured training in educational neuroscience for teachers. Further studies with larger and more diverse teacher populations are needed to support these findings further and assess their long-term influence on teaching practices and student outcomes. Additionally, future

research should explore how these training programmes can be adapted and scaled effectively to ensure their accessibility, feasibility, and sustainability across different educational settings.

Impact Statement

This thesis highlights the value of integrating educational neuroscience into teacher training programmes in the UK by emphasising its potential to cultivate a workforce resistant to non-evidence-based practices that can waste time and money, which are precious school resources. Equipping teachers with research-based knowledge and strategies ensures that resources are effectively deployed. The research highlights the appetite among teachers for embedding educational neuroscience within Initial Teacher Training (ITT) programmes and the potential benefit to teaching practice and improved student outcomes. Through actionable recommendations, it demonstrates the potential for educational neuroscience to transform curriculum design, instructional strategies, and teacher career frameworks.

Collaborations with leading international institutions, such as Vanderbilt University, Columbia University, and the Karolinska Institute, have amplified this research's academic relevance and practical impact, facilitating knowledge exchange and advanced interdisciplinary dialogue. These efforts have led to resource development and a graduate-level educational neuroscience programme for US teachers.

The research has already demonstrated significant practical applications, particularly for diverse learners, including those with Special Educational Needs (SEN). Study 3 of this thesis introduced a structured educational neuroscience course, which received high praise from participating teachers for its practical focus and accessibility. Teachers highlighted its relevance for classroom application, particularly in SEN settings, and noted its scalability as a model for future professional development. This course addresses the challenges of packed ITT programmes and teachers' limited time, offering a feasible solution for integrating educational neuroscience into teacher training in the UK and beyond.

The outcomes of this research have direct and long-term implications for educational practice, policy, and society. Dissemination efforts have been planned to maximise the research's impact. Two peer-reviewed journal publications, crafted in an accessible format and language, have already garnered citations and engaged a broad audience, particularly educational practitioners. A seminar at the London Centre for Educational Neuroscience attracted over 100 participants, including teachers and academics, leading to productive discussions and requests for additional resources. Presentations at major conferences, such as those hosted by the British Educational Research Association (BERA), the European Educational Research Association (EERA), and the International Mind, Brain, and Education Society (IMBES), have further promoted dialogue among diverse stakeholders and encouraged interdisciplinary knowledge exchange. These activities have promoted valuable feedback and laid the groundwork for international collaborations.

The long-term impact of this work lies in its potential to influence educational policy and establish systematic, high-quality educational neuroscience training within ITT and Continuous Professional Development (CPD) programmes. By advocating for evidence-informed practices, this thesis emphasises equipping teachers with the skills necessary for the dialogue between research and classroom practice. Furthermore, it builds the foundation for future research into how evidence-informed teaching impacts student outcomes, potentially leading to sustainable advancements in education policy.

Ultimately, this research aims to contribute to discussions on evidence-informed practice in education by examining teachers' engagement with educational neuroscience and their perceptions of its relevance. By investigating teachers' knowledge levels, barriers to engagement, and training experiences, this thesis provides insights that can inform future

professional development initiatives and policies to integrate educational neuroscience more effectively into teacher training and practice.

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List of Abbreviations

ADHD	Attention Deficit Hyperactivity Disorder
AERA	American Educational Research Association
ASD	Autism Spectrum Disorder
BERA	British Educational Research Association
CEN	London Centre for Educational Neuroscience
CPD	Continuing Professional Development
ECF	Early Career Framework
ECT	Early Career Teacher
EERA	European Educational Research Association
ENKT	Educational Neuroscience Knowledge Test
GCF	General Cognitive Function
GPA	Grade Point Average
IMBES	International Mind, Brain, and Education Society
ITT	Initial Teacher Training
ITTECF	Initial Teacher Training and Early Career Framework
MBE	Mind, Brain and Education
PGCE	Postgraduate Certificate in Education
PGDE	Postgraduate Diploma in Education
QTS	Qualified Teacher Status
SEN	Special Educational Needs
UCL	University College London
UK	United Kingdom

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Chapter 1
General Introduction

General Introduction

Teachers in the UK are required to complete a degree and an Initial Teacher Training (ITT) programme to gain Qualified Teacher Status (QTS). The Department for Education provides statutory guidance that accredited Initial Teacher Training providers must follow when performing their ITT-related duties (Department for Education, 2024a, 2024b). The department also provides Teachers' Standards, which is a guidance for school leaders, school staff and governing bodies (Department for Education, 2021).

ITT programme delivery routes are complex in the UK, and they are delivered via various routes, such as school-led and university-led (Department for Education, 2024a). Unlike many school-led teacher training courses, university-led programmes, such as those offering postgraduate certificates in education (PGCE), emphasise teaching as autonomous and often include master's degree credits (la Velle et al., 2020).

ITT programmes aim to equip teachers with the essential skills and knowledge for effective teaching in schools. Teachers could benefit greatly from these programmes since they offer training on key aspects such as understanding the curriculum, lesson planning, teaching methods, assessment and feedback, behaviour management, and Special Educational Needs (SEN) (Department for Education, 2023) (in recent years, the term Special Educational Needs and Disabilities (SEND) has become more prevalent in policy frameworks, such as the Initial Teacher Training Core Content Framework (ITTECF). However, Special Educational Needs (SEN) remains widely used in academic literature and educational discourse. For consistency with the sources referenced in this thesis, the term SEN is used throughout, while acknowledging the concurrent use of SEND in policy contexts).

In addition to this content, there is increasing evidence that understanding the brain systems and processes involved in learning can assist and influence teachers in developing optimal teaching practices (Brick et al., 2021; Dubinsky et al., 2019; Howard-Jones et al., 2020; Privitera, 2021; Rogers & Thomas, 2022; Thomas & Arslan, 2024; Tokuhamma-Espinosa & Borja, 2023; Tokuhamma-Espinosa & Nouri, 2023; Walker et al., 2019). This understanding is particularly pertinent for those working with children with Special Educational Needs (henceforth, SEN), as it helps gain a deeper insight into their unique requirements (Papadatou-Pastou et al., 2017; Rogers & Thomas, 2022; Thomas et al., 2019).

Given the considerable cognitive processes involved in learning and their influence on performance differences across age groups and abilities (Jin et al., 2019; Liu & Nesbit, 2023), it is reasonable that teachers might benefit from learning more about such processes to optimise their classroom practice (Dubinsky et al., 2019; Schwartz et al., 2019; Tan & Amiel, 2022; Thomas & Arslan, 2024; Weisberg et al., 2008).

Due to the growing importance and interest in cognitive science (Im et al., 2018; Pickering & Howard-Jones, 2007; Wilcox et al., 2021; Zambo & Zambo, 2011), various initiatives aim to enhance the content within ITT programmes (Tokuhamma-Espinosa, 2008, 2017; Tokuhamma-Espinosa & Nouri, 2023). For instance, the UK's recently updated Initial Teacher Training and Early Career Framework ('ITTECF', Department for Education, 2024a) emphasises the importance of incorporating related content, such as understanding working memory and the practice of breaking down material into smaller steps, into ITT programmes.

However, while trainee teachers are required to engage with this framework to gain QTS, such frameworks are not extensive and often lack depth in addressing the neurocognitive mechanisms of learning (McMahon et al., 2019; Thomas & Arslan, 2024;

Tokuhamma-Espinosa, 2008, 2017; Tokuhamma-Espinosa & Nouri, 2023). As a result, ITT programmes in the UK and many other countries still provide very little content in this area (Arslan et al., 2022; Blanchette Sarrasin et al., 2019; Privitera, 2021; Thomas & Arslan, 2024; Tokuhamma-Espinosa, 2017; Tokuhamma-Espinosa & Borja, 2023; Willingham, 2017).

Educational neuroscience, also known as the ‘science of learning’ or ‘mind, brain and education’, is the formal field of research investigating the interplay between neurocognitive systems and processes that underpin learning and educational practice (Feiler & Stabio, 2018; Mareschal et al., 2013; Rogers & Thomas, 2022; Thomas et al., 2020; Van Herwegen et al., 2022). This field also aims to create a dialogue between researchers and practitioners (Butterworth & Tolmie, 2013; Fischer, 2009) so that professionals from both aspects can better engage with the research evidence in this area. If this subject area was fully included as part of the curriculum for ITT programmes, it could provide teachers with the knowledge they require to understand the neurocognitive systems and processes involved in learning before entering into the profession (Thomas & Arslan, 2024).

However, the extent to which this knowledge is effectively translated into practice often depends on the quality and credibility of the training provided. This is important because there is evidence that a lack of understanding of educational neuroscience leaves teachers less aware of ways they can engage with and understand related research evidence to optimise their teaching (Arslan et al., 2022; Feiler & Stabio, 2018; Torrijos-Muelas et al., 2021). More importantly, the absence of knowledge about the neurocognitive mechanisms of learning can lead to adopting unscientific teaching methods (Tardif et al., 2015) and beliefs in ‘neuromyths’ (Arslan et al., 2022; Gini et al., 2021; Privitera, 2021; Torrijos-Muelas et al., 2021; Van Herwegen et al., 2022).

Neuromyths are pervasive and enduring misconceptions and misinterpretations concerning the functioning of the human brain, commonly observed within diverse educational settings (Torrijos-Muelas et al., 2021). These misbeliefs are notably prominent in SEN contexts, including those associated with neurodevelopmental disorders (Gini et al., 2021; Macdonald et al., 2017). Training in educational neuroscience shows promise in dispelling and preventing the application of neuromyths and promoting more evidence-based teaching practices (Arslan et al., 2022; Ferreira & Rodríguez, 2022; Rousseau, 2021; Tokuhamma-Espinosa & Borja, 2023; Tokuhamma-Espinosa & Nouri, 2023).

This chapter examines the evolution of educational neuroscience as a distinct research field, alongside evidence of the benefits of educational neuroscience and ongoing debates regarding its relevance and usefulness in the classroom. The discussion extends to the application of educational neuroscience within the UK education contexts, particularly in ITT (Department for Education, 2021, 2024a). The chapter explores how educational neuroscience can be applied in teaching and teacher training and delves into the complexities of translating research evidence into effective classroom practices, especially from educational neuroscience. Moreover, it examines the rise of neuromyths, considering their potential effects in educational environments and their influence on understanding and using research evidence within the sphere of teacher education and training, particularly in SEN contexts. The rationale for the research in this thesis, the research questions, and an overview of the methodologies employed in three distinct studies designed to address these research questions are also provided.

Key Functions in Children's Learning

Learning is a complex process that involves multiple cognitive mechanisms. Among these, memory, attention, executive function, and neuroplasticity are particularly crucial

(Brookman, 2016; Chen et al., 2022; Constantinidis et al., 2023; Diamond, 2013; Hopkins et al., 2016; Keller et al., 2020; Okano et al., 2000; Posner et al., 2009; Ritter et al., 2014; Trumble et al., 2024).

Memory refers to how information is encoded, stored, and retrieved (Sridhar et al., 2023). It is a complex and dynamic cognitive function (Cutsuridis & Yoshida, 2017; Gerard, 1953) that underpins our ability to learn, adapt, and function in our daily lives. It consists of various types, including sensory memory, short-term memory, and long-term memory (Casey & Kelly, 2019; Cowan, 2008; Squire, 1992), under which they are further divided. Briefly, short-term memory holds information temporarily for processing, and long-term memory stores information indefinitely (Cowan, 2008; Jonides et al., 2008).

Attention is the focused mental engagement on learning tasks or materials. It is a complex process involving internal (e.g., memory, executive function) and external (e.g., sensory perception) components and can be directed towards or away from the topic at hand (Keller et al., 2020; Martínez-Pérez & Salvador-Bertone, 2019). Effective learning requires students to maintain on-topic attention (Chen et al., 2022), which can be challenging given the natural fluctuations in attention (Keller et al., 2020). Attention can be divided into bottom-up attention, which is automatic and involuntary, and top-down attention, which is effortful and voluntary. Briefly, bottom-up attention occurs when something automatically captures our focus, while top-down attention involves deliberate allocation based on internal factors such as interests or task demands (Buschman & Miller, 2007; Ciaramelli et al., 2010; Katsuki & Constantinidis, 2014).

Executive function refers to a set of higher-order cognitive processes essential for goal-directed behaviour. These processes include planning, focusing, shifting attention, managing time, and remembering instructions (Diamond, 2013). Core aspects of executive

function include inhibitory control, task switching, and working memory. These functions help filter out irrelevant information, adapt to changing conditions, and hold information temporarily while processing tasks (Best & Miller, 2010; Diamond, 2014).

Neuroplasticity is the brain's ability to change and adapt in response to new information, sensory stimulation, development, damage, or dysfunction (Marzola et al., 2023). Learning exemplifies how the brain adapts and develops through new connections between neurons.

Neuroplasticity plays a vital role in learning by enabling the brain to adapt to new information and experiences. For instance, during the learning process, repetitive activation of specific neural pathways strengthens the synaptic connections within those pathways, facilitating more efficient information processing and retrieval. This adaptability is essential for developing and maintaining cognitive functions throughout life (Cramer et al., 2011).

SEN Contexts

Although cognitive difficulties are not limited to specific diagnoses, they can occur across the range of cognitive abilities in children with SEN. Children with SEN often exhibit impairments in various cognitive functions, including memory, attention, executive functions, and neuroplasticity. These impairments can significantly impact their learning processes. For example, studies have indicated that *working memory* deficits are prevalent among children with dyscalculia and other learning disabilities (Kroesbergen et al., 2023), contributing to academic and behavioural difficulties (Winkel & Zipperle, 2023).

Attention deficits are commonly observed in children with SEN, particularly in those with attention deficit hyperactivity disorder (ADHD) and autism spectrum disorders (ASD). Such attention impairments are directly linked to academic challenges, as sustained

attention is essential for learning and performing well in school (May et al., 2013; McConaughy et al., 2011).

Research on *executive function* dysfunctions highlights that children with dyslexia (Farah et al., 2021) and ADHD (Willcutt et al., 2005) frequently experience deficits in working memory, cognitive flexibility, inhibitory control, and planning. These executive function deficits can contribute to the inattentive and hyperactive/impulsive symptoms of ADHD, leading to difficulties in sustaining attention, filtering out distractions, and regulating behaviour. This is important since these deficits are closely related to learning, poorer academic performance and social functioning (Paananen et al., 2018; Willcutt et al., 2005).

The complex cognitive processes underlying learning and their impact on performance variations across age groups and abilities (Jin et al., 2019; Liu & Nesbit, 2023) highlight the value of equipping teachers with knowledge in this area to enhance their classroom practices (Tan & Amiel, 2022; Weisberg et al., 2008). However, despite its importance, most ITT programmes globally, including those in the UK, provide limited coverage of educational neuroscience (Arslan et al., 2022; Blanchette Sarrasin et al., 2019; Privitera, 2021; Tokuhamma-Espinosa, 2017; Tokuhamma-Espinosa & Borja, 2023; Willingham, 2017). This leads us to explore the historical development and current state of educational neuroscience.

Educational Neuroscience: A Brief History

Technological advancements in the late 20th century made it possible to examine neural activation in vivo and better understand the organisation of cognitive function in specific brain regions (Molitor, 2009). This led to the emergence of cognitive neuroscience (Albright et al., 2000), which was then followed by the extension of its fundamental principles to specialised areas like social cognitive neuroscience and developmental

neuroscience (Tolmie, 2015). Neuroimaging research has gained momentum thanks to these developments, especially since the 'Decade of the Brain' (i.e. 1990s, Jones & Mendell, 1999). The term 'Decade of the Brain,' introduced by the US Congress (Dekker et al., 2012; Geake, 2004; Goldstein, 1994; Jones & Mendell, 1999), refers to a coordinated initiative to enhance research and technological development in brain sciences, with a particular focus on advancing neuroimaging techniques (Düvel et al., 2017; Thomas & Ansari, 2020). These advancements, such as the development of functional magnetic resonance imaging (fMRI) for studying brain activity during cognitive tasks (Kwong et al., 1992; Ogawa et al., 1992), led people to ask if the same approach could generate a deeper understanding of learning processes, which could then be used to optimise teaching (Butterworth & Tolmie, 2013; Tokuhamma-Espinosa, 2012; Tolmie, 2015). One outcome of this was the emergence of what was variously called Mind, Brain and Education (MBE), Science of Learning and Educational Neuroscience.

In its early stages, educational neuroscience often appeared to function as a unidirectional endeavour, primarily because researchers initially focused on disseminating neuroscientific evidence to inform teaching practices. This approach, shaped by uncertainty about how to engage with teachers effectively, faced significant critique in the field's early development (Carey et al., 2020; Fischer, 2009). For example, Bruer (1997) argued that this model was unrealistic without additional "bridges" between neuroscience and education, mainly through cognitive psychology. He cautioned that without these connections, neuroscience findings were at risk of being misinterpreted or misapplied in teaching methodologies.

However, this unidirectional appearance did not reflect an intentional exclusion of collaboration. Instead, it stemmed from the limitations of researchers' existing methods,

often placing the burden of translating findings entirely on practitioners. This dynamic increased the likelihood of misinterpretations and misapplications in educational contexts (Fischer et al., 2010; Goswami, 2006; Pickering & Howard-Jones, 2007). Bruer's (1997) "bridge" metaphor underscores the importance of reciprocal exchange between neuroscience and education, emphasising that bidirectional collaboration was always envisioned as a fundamental goal.

Over time, researchers in this field gradually navigated ways of building a collaborative and eclectic approach. This new direction involved both researchers and practitioners in educational neuroscience, drawing from various theoretical foundations and integrating elements from established systems in education, cognitive science, psychology, and neuroscience (Tokuhamma-Espinosa & Nouri, 2023). The goal was to develop a comprehensive system of understanding the interplay between these systems with practical applications (Howard-Jones et al., 2016; Mareschal et al., 2013). This approach aimed to promote constructive dialogues and establish a shared research agenda capable of directly informing practice, all within a 'non-reductionist framework' (Butterworth & Tolmie, 2013; Fischer, 2009; Thomas et al., 2020; Thomas & Arslan, 2024; Tokuhamma-Espinosa & Nouri, 2023). In essence, the field's purpose evolved into establishing a bidirectional link between science and practice (Katzir & Pare-Blagoev, 2006). Some argue that, via this collaborative exchange, neuroscience not only shapes educational practices but also allows practitioners to engage with researchers by shaping research questions and methodologies (Fischer, 2009; Mason, 2009). Some researchers have likened this to interdependence observed in fields such as engineering, which relies on a community of physicists and manufacturers (Tolmie, 2015), and in medicine, where biologists and medical practitioners collaborate to address medical and health-related issues (Fischer, 2009).

The first decade of this century marked a pivotal shift in the field of educational neuroscience as the field gained more acceptance (Tandon & Singh, 2016; Wilcox et al., 2021). This included transitioning from theoretical explorations to more concrete conceptualisations and research objectives, such as strategies to improve reading skills based on neuroscience-informed methods (Fischer et al., 2007).

This rapid expansion of educational neuroscience was accompanied by challenges defining the field and integrating diverse perspectives (Feiler & Stabio, 2018). Following this, researchers recognised the need for close interdisciplinary collaboration and coordination between psychologists, neuroscientists, and educators to be able to integrate such diverse perspectives to inform education (Wilcox et al., 2021).

From the close of the first decade of this century, however, concerted efforts were made to systematise the rapid growth of educational neuroscience. These efforts included organising numerous international conferences and offering professional development opportunities to bring various professionals and academics together to discuss issues and present ideas (Privitera, 2021). Additionally, formal initiatives were introduced to foster dialogue and facilitate a meaningful exchange between researchers and practitioners through organisations like the International Mind, Brain, and Education Society (IMBES), the London Centre for Educational Neuroscience (CEN), as well as special interest groups within the American Educational Research Association (AERA) and the European Association for Research in Learning and Instruction (EARLI). Academic journals such as "Mind, Brain and Education" and "Trends in Neuroscience and Education" began publishing scholarly work related to educational neuroscience in 2007 and 2012, respectively, which led to more credibility (Zadina, 2015). Furthermore, formal educational programmes, including master's and PhD programmes in educational neuroscience in the United States and the United

Kingdom, emerged subsequently, catering to both teachers' and researchers' demands (Tokuhamma-Espinosa, 2012; Zadina, 2015).

Evidence of the Benefits of Educational Neuroscience

Recognition that education can significantly benefit from evidence-based practices, informed by educational neuroscience research, has gained momentum over the last decade (Serpanti & Loughan, 2012; Sigman et al., 2014; Tan & Amiel, 2022). Today, there is strong evidence that educational neuroscience can provide significant benefits for teaching and learning. Notable examples involve leveraging our understanding of key cognitive mechanisms, especially the ones discussed in the 'Key Functions in Children's Learning' section. The following paragraphs map back to these mechanisms, highlighting the importance of learning about these for teachers.

Memory

Research has consistently shown that specific techniques, such as spaced learning and retrieval practice, can significantly improve students' long-term memory and information retention (Trumble et al., 2024). Spaced learning, for example, involves breaking learning sessions into shorter intervals with gaps of unrelated activities in between, allowing the brain time to consolidate the learned material. This technique leverages the brain's natural consolidation processes, where memories are strengthened during periods of rest or unrelated cognitive activity (Kelley & Watson, 2013). These gaps are crucial because they prevent cognitive overload and help transition information from short-term to long-term memory (K. Feng et al., 2019; Martin et al., 2017; Naqib et al., 2012).

Neuroscientific evidence highlights that spaced learning exploits the brain's neuroplasticity, promoting the repeated activation and strengthening of synaptic

connections (K. Feng et al., 2019; Martin et al., 2017), particularly in regions associated with memory, such as the hippocampus (Lindsey et al., 2014). Studies suggest that the repetition and spacing of information allow for more durable encoding, making the retrieval of that information easier and more efficient over time (Rawson et al., 2013). This has significant implications for curriculum design, as structuring learning in this way supports deeper retention and reduces the risk of information being forgotten after a single, intensive session.

Moreover, retrieval practice, which involves actively recalling information rather than passively reviewing it (Roediger & Butler, 2011), complements spaced learning by reinforcing neural pathways. This dual strategy aligns with findings highlighting the brain's preference for active engagement in the learning process to form robust and accessible memory traces (Karpicke & Blunt, 2011).

These studies collectively highlight the value of these techniques for teachers in enhancing students' long-term memory and information retention. By understanding how the brain encodes and consolidates memories, teachers can design more effective learning activities that align with these neuroscientific principles and support memory development in children (Posner et al., 2009). For example, incorporating multiple opportunities for retrieval spaced out over time or breaking information into smaller chunks can enhance students' ability to recall information.

Attention

Neuroscientific research has revealed that attention operates through two primary mechanisms: top-down and bottom-up attention. Top-down attention is goal-directed and effortful, guided by internal objectives or expectations, such as focusing on a teacher's instructions during a lesson (Gibson et al., 2023; Katsuki & Constantinidis, 2014). In contrast,

bottom-up attention is automatic and stimulus-driven, triggered by external factors like a loud noise or sudden movement (Katsuki & Constantinidis, 2014).

Research has shown that distinct but interconnected neural systems mediate these two types of attention (Buschman & Miller, 2007; Katsuki & Constantinidis, 2014). Top-down attention relies on cognitive control processes originating in the prefrontal cortex, which allow individuals to sustain focus and ignore distractions. Bottom-up attention, on the other hand, involves sensory-driven processing in regions such as the parietal and occipital lobes, automatically redirecting attention to unexpected stimuli.

Understanding the interplay between top-down and bottom-up attention has important implications for classroom practice. Given young children's limited attention spans (Ebert et al., 2024; Hallez & Droit-Volet, 2017; Kannass et al., 2010), strategies like using novelty, movement, and engaging materials can help teachers capture and sustain their attention. However, adolescents, whose prefrontal cortex is more developed, may benefit from strategies that strengthen sustained attention through structured, goal-directed activities. Once engaged, structured tasks and clear instructions can encourage top-down attention to sustain their focus on learning objectives. Teachers can also manage classroom environments to minimise unnecessary bottom-up distractions, such as reducing background noise or organising seating arrangements to limit visual clutter.

Neuroscientific evidence further highlights that attention is not a fixed capacity but can be trained and improved. For instance, mindfulness practices and structured attention-training exercises have been shown to enhance top-down attentional control by strengthening connections between the prefrontal cortex and other cognitive regions (Tang et al., 2015).

Swingler et al. (2015) found that targeted exercises designed to improve attention could modify neural pathways, leading to enhanced focus and better task performance. However, their study focused on early childhood, specifically infants and toddlers, highlighting the role of caregiver interactions in shaping attention skills. This suggests that strategies designed to support attention need to be age-appropriate, considering the neural differences between early childhood, middle childhood, and adolescence (Swingler et al., 2015).

By understanding how the brain processes attention through top-down and bottom-up mechanisms, teachers can develop strategies to optimise attentional engagement. Structuring lessons to balance these two mechanisms ensures students remain focused, reducing cognitive overload and enhancing learning outcomes (Immordino-Yang et al., 2018). For younger children (e.g., those in early primary school), short, engaging activities interspersed with breaks may be more effective, while older children (e.g., adolescents) may benefit from explicit training in targeted strategies to sustain attention on complex tasks.

Executive Function

Executive function skills, which are regulated by the prefrontal cortex of the brain, are crucial skills for maintaining mental and physical health, promoting cognitive, social, and psychological development (Diamond, 2013), and improving academic success and learning in the classroom (Friedman & Robbins, 2022; Moriguchi & Hiraki, 2013). Deficits in these functions are closely related to poorer academic performance and social functioning (Paananen et al., 2018; Willcutt et al., 2005).

Executive function skills like planning, organisation, impulse control, and working memory can be improved through targeted cognitive training and classroom strategies (Martínez-Pérez & Salvador-Bertone, 2019). Moreover, providing teachers with training on

how to develop these skills in students has been shown to improve student performance on measures of higher-order cognition and academic achievement (Gamino et al., 2022).

Thorell et al. (2009) examined the effects of executive function training on language and reading skills in preschool children. The study found that training in executive functions, such as working memory and inhibitory control, significantly improved language and reading skills in these children. However, such findings should be interpreted cautiously, given that transfer effects from generic executive function training are often limited. Research increasingly emphasises that the effectiveness of executive function training depends on embedding these skills within the specific contexts where they are required, as opposed to relying solely on generic training approaches (Gunzenhauser & Nückles, 2021; Roy et al., 2019; UnLocke, 2019). Embedding these skills within the learning context (e.g., UnLocke, 2019) may yield more consistent and meaningful outcomes.

Overall, the research contributes to the broader understanding of the role of executive functions in learning and cognitive development. Understanding these functions is essential for teachers, as children often face demanding tasks that require following instructions and retaining information for classroom activities. Effective, context-specific interventions can equip students with the cognitive tools needed to succeed, demonstrating the practical implications of integrating neuroscience principles into education.

Neuroplasticity

Neuroplasticity, the brain's ability to reorganise itself by forming new neural connections, is fundamental to the learning process. It underpins changes in both behaviour and the nervous system (Voss et al., 2017) and is shaped by various factors such as genetic predispositions, experiences, and the brain's state prior to learning (Posner et al., 2009).

This understanding can provide a biological foundation for educational practices and help optimise teaching methods to improve learning outcomes (Tovar-Moll & Lent, 2016).

Research in educational neuroscience has provided compelling evidence of neuroplasticity in action. For example, Rivera et al. (2005) used functional magnetic resonance imaging (fMRI), a non-invasive neuroimaging technique, to examine brain activity in individuals aged 8-19 as they solved arithmetic problems. Findings from this study revealed age-related differences in brain activation patterns. Older children exhibited heightened activity in the left parietal cortex, a region associated with mathematical processing (Friedrich & Friederici, 2013; Menon et al., 2000), whereas younger children relied more on the prefrontal cortex, which is linked to working memory and attention (Panichello & Buschman, 2021). These findings illustrate neuroplasticity by demonstrating how the brain shifts reliance on different regions as cognitive tasks are practised and refined with age and experience. Such insights highlight the developmental transition in how arithmetic tasks are approached, suggesting that older children optimise neural pathways for efficiency while younger children engage more heavily in cognitive resources like working memory and attention.

This developmental shift suggests that younger children depend more on cognitive control and working memory when solving arithmetic problems, whereas older children, having had more practice, exhibit more efficient and automated neural processing. Considering these age-related differences, for example, younger children might benefit from explicit scaffolding and working memory support, whereas older students may require tasks that challenge and strengthen their mathematical reasoning abilities.

Building on this evidence, teaching strategies can be tailored to align with age-specific neural development. For example, teachers might focus on nurturing mathematical

reasoning skills in adolescents, given their increased reliance on specialised brain regions for mathematical processing. Conversely, for younger children, instructional methods could emphasise enhancing working memory and attention to support foundational learning processes (Peters, 2020).

Neuroplasticity also plays a critical role in responding to environmental stressors, such as sleep deprivation, which is prevalent among adolescents due to early school start times. Studies have shown that insufficient sleep can lead to structural changes in brain regions such as the hippocampus, orbitofrontal cortex, and frontal and temporal gyri (Sung et al., 2020). Additionally, adolescents are more fatigued in the early mornings than in the evenings, reflecting how chronic sleep deprivation influences brain function and adaptation (Hagenauer et al., 2009). The findings of a review of literature on adolescent sleep patterns consistently demonstrate that early school start times are associated with reduced sleep duration, poorer sleep quality, increased daytime sleepiness, and negative impacts on academic performance, health, and behaviour among adolescents (Alfonsi et al., 2020).

Interventions like delaying school start times have demonstrated positive outcomes. Studies indicate that later start times improve sleep duration and quality, enhance academic performance, and reduce symptoms of depression (Alfonsi et al., 2020; Dunster et al., 2018; Gradisar et al., 2022; Minges & Redeker, 2016; Wahlstrom, 2002). For example, Lewin et al. (2017) and Owens et al. (2017) found that increased sleep duration resulting from delayed start times led to significant improvements in emotional regulation and reduced depressive symptoms, further exemplifying neuroplasticity as the brain reorganises to optimise cognitive and emotional functioning with adequate rest. These findings have influenced policies. For example, California State enacted a senate bill mandating later school start times for high schools, requiring them to start no earlier than 8:30 AM, and for middle

schools, no earlier than 8:00 AM (State of California, LCB, 2019). While similar policies are less widespread in the UK, a few schools have trialled later start times. However, UK schools generally start later than the mandated times in California, making it less clear what adjustments would be most beneficial. This lack of clarity, combined with teacher resistance and logistical challenges, has hindered broader adoption or large-scale trials to assess the feasibility and effects of delayed school start times within the UK educational context (Barratt, 2022).

Understanding neuroplasticity's role in learning extends beyond specific interventions. Research demonstrates that abilities, intelligence, and talents are not static but can be cultivated through effort, resilience, and dedication (Draganski et al., 2004; Scholz et al., 2009). Teachers can apply this understanding to create a positive learning environment emphasising effort, resilience, and learning from mistakes. Such an environment promotes a) a culture of continuous improvement and perseverance, helping students to develop a more robust and adaptive approach to learning (Blackwell et al., 2007; Yeager & Dweck, 2012), b) collaboration and mutual support (Hamre & Pianta, 2005), and c) providing opportunities for students to engage in challenging, meaningful tasks that promote learning (Vygotsky, 1978). Practical strategies include providing constructive feedback, setting incremental goals, and celebrating progress to reinforce the belief that effort is a critical component of success (Rattan et al., 2012).

These findings highlight that educational neuroscience research shows compelling evidence on age-specific differences, which can be useful for considering age-related differences when training teachers in educational neuroscience. It can be insufficient to provide a 'one-size-fits-all' approach to applying educational neuroscience in the classroom. Instead, teacher training should equip teachers with age-specific insights into neural

development, helping them tailor their instructional strategies accordingly. By incorporating these distinctions into ITT and CPD programmes, teachers can make more informed decisions about applying neuroscientific principles to diverse classroom contexts.

SEN-related Benefits

Educational neuroscience has also been shown to be of particular value in SEN contexts, especially when explaining deficits and related needs in children with SEN to support these children proactively (Goswami, 2004, 2006; Pérez, 2020). For example, studies have identified atypical neural connectivity patterns in children with autism that may underlie their difficulties with social cognition and emotional processing (Leung et al., 2014; Liloia et al., 2024; Safar et al., 2021). Similarly, children with ADHD exhibit atypical patterns of brain activation, particularly in regions associated with attention and executive functions (Cortese et al., 2012; Rubia et al., 2014).

Neuroimaging studies have also revealed distinct brain activation patterns in infants at risk for dyslexia, even shortly after birth, compared to infants not at risk (Guttorm et al., 2001). These differences have also been observed in preschool children at risk for dyslexia (Kuhl et al., 2020) and are consistent with findings in children formally diagnosed with dyslexia compared to their non-dyslexic peers (Blau et al., 2010).

The primary advantage of these enhanced insights into the neurocognitive aspects of SEN lies in the potential development of early interventions for these children, especially those with dyslexia (D'Mello & Gabrieli, 2018). For example, Kearns et al. (2019) highlight that understanding the neurobiology of dyslexia can provide insights into how the brain changes with reading intervention, informing the development of effective interventions tailored to students' cognitive profiles. Moreover, research on altered brain connectivity and impaired processing of time-dependent information in dyslexia could lead to new

therapies and pedagogical practices, emphasising the importance of non-specific tools like musical or rhythmic interventions (Habib, 2021).

Without sufficient knowledge of educational neuroscience, teachers may be in danger of perceiving students' special needs insufficiently. There is substantial evidence to suggest that teachers tend to perceive dyslexia as a stereotypical behavioural condition that only impacts skills related to reading, writing, and spelling (e.g., Bell et al., 2011; Washburn et al., 2014). To illustrate, a comprehensive study involving 2,570 teachers in England and Wales examined their understanding of dyslexia and assessed the extent to which ITT programmes equipped them with adequate knowledge about dyslexia (Knight, 2018). The findings revealed a noticeable deficiency in the participants' understanding of the neurocognitive and biological underpinnings of dyslexia, despite their role in teaching children with dyslexia. Specifically, a substantial majority (79.5%) of the participants characterised dyslexia primarily in terms of its behavioural aspects, such as reading, writing, and spelling, while overlooking its biological dimensions, encompassing neurological distinctions, and cognitive aspects, including processing differences and memory. Furthermore, 71.8% of the participants expressed dissatisfaction with their ITT programmes, citing a lack of comprehensive information on dyslexia.

It is essential to recognise that dyslexia extends beyond behavioural aspects and necessitates a multi-level understanding encompassing neurocognitive functions (Frith, 1995, 1999; Willingham, 2009). A deeper understanding of the neuroscience underlying dyslexia not only prevents teachers from lowering their expectations of children with dyslexia regarding their academic performance (Knight, 2018) but also equips them with the ability to identify those at risk for early assessment and diagnosis (D'Mello & Gabrieli, 2018; Gabrieli, 2016).

Moving forward, the evidence highlights the profound benefits of educational neuroscience in teaching practices, enhancing learning outcomes through a deeper understanding of cognitive functions. This foundation also holds significant promise for SEN contexts. Thus, equipping teachers with accurate and evidence-based knowledge of educational neuroscience is crucial to bridge the gap between scientific research and classroom practice. This comprehensive understanding ensures that teachers can support all aspects of a child's development, leading to better educational outcomes for students with SEN. Given the substantial benefits highlighted, integrating educational neuroscience into classroom practices is imperative.

Educational Neuroscience in the Classroom

Educational neuroscience training can be particularly beneficial for teachers and pre-service teachers (Tardif et al., 2015), providing them with the skills to select optimal pedagogical approaches (Cui & Zhang, 2021), strategise lesson planning, make real-time classroom decisions (Chang et al., 2021), and shape student perspectives (Dubinsky et al., 2022). Moreover, it can help reduce teachers' susceptibility to neuromyths (Ansari & Coch, 2006; Arslan et al., 2022; Coch, 2018; Macdonald et al., 2017; Privitera, 2021; Ruhaak & Cook, 2018), which are misconceptions about brain function and learning processes. It can also enhance teachers' capacity to benefit from research evidence, ensuring they use evidence-based practices and improve their ability to make informed decisions (MacNabb et al., 2006; Rato et al., 2013). This, in turn, can promote a productive exchange of ideas and insights between researchers and teachers.

Within the context of SEN, increasing evidence suggests that an improved grasp of educational neuroscience among special education teachers can be particularly instrumental in enhancing their understanding of the learning needs of children with

neurodevelopmental disorders (Gini et al., 2021; Papadatou-Pastou et al., 2017) and in guiding the development of tailored teaching strategies.

However, despite the expectations and recommendations for teachers to evaluate and use evidence-based materials and practices in their classrooms (Haberfellner & Fenzl, 2017), this endeavour poses a considerable challenge for teachers. Implementing research findings into teaching requires teachers to understand research evidence, skills to apply it effectively, and self-efficacy to believe that they can employ it in the classroom (Georgiou et al., 2020). Educational neuroscience training initiatives have been established to address these gaps.

As an illustrative example, the benefits of educational neuroscience training were assessed in the context of teacher workshops (the 'BrainU' workshops, Dubinsky et al., 2013). Over a span of three years, these workshops introduced 107 high school biology teachers to compact neuroscience concepts, which were initially disseminated by the Society for Neuroscience in 2008 (recently updated, BrainFacts, 2022). The content encompassed topics such as neuronal structure, neuroplasticity, and synaptic function. To illustrate, the concept of neuroplasticity was taught through inquiry-based lessons wherein teachers engaged in an exercise of tossing beanbags at a target while wearing prism goggles that altered their vision to a certain degree. Teachers learned by experiencing how quickly their brains adapted to a changed vision.

When assessed using an 11-question multiple-choice neuroscience knowledge pre-post-test, teachers' neuroscience knowledge increased up to a degree of 20% where teachers answered more than 80% of the questions correctly. Furthermore, classroom observations were conducted to ascertain whether the workshop influenced teachers' adoption of student-centred pedagogical practices, in comparison to those who did not

participate in the workshop. As measured by the Standards of Authentic Classroom Instruction, which is a framework designed to promote various characteristics of classroom engagement and student thinking (Newmann & Wehlage, 1993), three broad characteristics exhibited significant enhancements among teachers who received the workshop. These characteristics are higher-order thinking, substantive conversations, and connections to world, which explain classroom engagement and student thinking.

In a more recent study, Schwartz et al. (2019) examined the neuroscience knowledge of non-science teachers, as well as their confidence in applying this knowledge to their pedagogical practices. Fourteen teachers underwent training in educational neuroscience concepts, including general brain structure, neuroplasticity, memory, emotions and stress (as presented in BrainFacts, 2022; Dubinsky et al., 2013). A pre-post-test approach was employed to evaluate teachers' understanding of these concepts, which included a) eight multiple choice questions about neurons and the brain, b) drawing and labelling two connected neurons. Following the training, the results indicated a significant improvement in both neuroscience knowledge ($t(13) = 2.86, p < .05$) and the ability to draw neurons ($t(12) = 5.87, p < .001$). Additionally, the training led to a substantial increase in the teachers' confidence levels concerning their ability to apply learned neuroscience concepts to the process of lesson planning ($t(13) = 4.08, p < .01$).

A recent scoping review on educational neuroscience training for teachers (Privitera, 2021) examined the extent to which neuroscience training influences teachers' pedagogy. Findings from ten studies suggest that such training is efficacious in (a) enhancing neuroscience content knowledge and (b) increasing teachers' confidence in applying these concepts in practice. However, the review also highlighted the diversity in training formats and durations, suggesting that the structure and delivery of training significantly influence

its effectiveness. This highlights the need for further research into the design and implementation of neuroscience training for teachers.

These studies discussed here highlight educational neuroscience's potential influence on teaching practice. In the current model of educational neuroscience, which emphasises fostering dialogue between researchers and practitioners, the effective role of educational neuroscience primarily relies on practitioners (Fischer, 2009), particularly teachers, who possess a robust knowledge of educational neuroscience and its research evidence.

Challenges in Implementing Educational Neuroscience Training

While the benefits of educational neuroscience training are well-documented, its effectiveness can be significantly influenced by the quality and reliability of the training provided. Training that lacks rigorous oversight or is delivered by unverified sources can oversimplify complex concepts, propagating neuromyths and hindering evidence-based practice (Fischer, 2009; Grospietsch & Mayer, 2020; Jones, 2021; Tardif et al., 2015). For example, informal workshops or online non-peer-reviewed resources may inadvertently lead to misinterpretations or inappropriate classroom applications.

Moreover, the dissemination of neuroscience knowledge is fraught with potential pitfalls, particularly the widespread prevalence of neuromyths. These misconceptions often stem from various factors, including the lack of high-quality educational neuroscience training. Neuromyths can undermine the application of evidence-based educational practices and be particularly detrimental in addressing the needs of SEN students. Therefore, exploring the risks associated with neuromyths and their impact on educational settings is essential.

The Risk of Neuromyths

Neuromyths were initially described as misconceptions or unscientific ideas about the brain (Crockard, 1996, as cited in Howard-Jones, 2010). In educational contexts, neuromyths have been defined as “misconception[s] generated by a misunderstanding, a misreading or a misquoting of facts scientifically established (by brain research) to make a case for use of brain research, in education and other contexts.” (OECD, 2002, p. 111). For instance, a frequently identified and widely endorsed neuromyth is the notion of “learning styles”, which posits that individuals possess a ‘dominant’ cognitive learning modality (e.g., verbal, auditory, or kinaesthetic, Torrijos-Muelas et al., 2021) and that educational materials and instructional methods should be tailored to these preferences to enhance learning outcomes. However, empirical evidence does not support the effectiveness of tailoring instruction based on individual learning styles, and there is even considerable doubt about the existence of such styles as distinct, reliable cognitive traits (Rogowsky et al., 2020). This concept has attracted substantial criticism due to the dearth of empirical substantiation for its pedagogical benefits (i.e., Cuevas & Dawson, 2018; Dekker & Kim, 2022; Dündar & Gündüz, 2016; Newton & Salvi, 2020; Papadatou-Pastou et al., 2021; Pashler et al., 2008; Rogowsky et al., 2020).

Prevalence of Neuromyths

Distinguishing between neuromyths and evidence-based scientific statements (i.e., *neuro-facts*) is a widely employed method for evaluating teachers' knowledge of educational neuroscience (Torrijos-Muelas et al., 2021). This approach offers an index of the understanding necessary for educational neuroscience to function effectively. In a study by Dekker et al. (2012), this methodology was used to investigate the prevalence of and factors leading to neuromyth endorsement among teachers in the United Kingdom and the

Netherlands. A questionnaire, encompassing 15 neuromyths and 17 neuro-facts, was administered to 242 teachers who were then asked to indicate their agreement or disagreement with these statements.

The surveyed teachers shared an interest in neuroscience, a deliberate selection made on the premise that such individuals might be more inclined to implement neuromyths into their teaching practices due to a potential lack of previous exposure to research evidence and tools to evaluate such evidence. The findings revealed that teachers endorsed nearly half (49%) of the presented neuromyths, with three of them enjoying notable prevalence, as they were affirmed by 80% of the participants. These prominent neuromyths included beliefs in learning styles, the notion of left brain/right brain dominance for particular tasks, and the perceived effectiveness of brain training apps, such as Brain Gym.

This questionnaire underwent numerous revisions and was administered in diverse educational settings across various countries, including Turkey (Dündar & Gündüz, 2016; Karakus et al., 2015); Latin America (Gleichgerricht et al., 2015); Greece (Papadatou-Pastou et al., 2017); Australia (Hughes et al., 2021); Morocco (Janati Idrissi et al., 2020); Spain (Ferrero et al., 2016); USA (van Dijk & Lane, 2020); and Germany (Grospietsch & Mayer, 2019). Consistently, these studies demonstrated the prevalence of neuromyths across various educational settings, encompassing teachers with diverse experiences, including primary, secondary, and pre-service teachers. A summary of neuromyth beliefs from these studies, as well as others, is provided in Table 1.

Table 1. *Neuromyth Beliefs in Different Countries*

Administered in (Study)	Sample size	Neuromyths	Neuro-facts	Neuromyth belief (%)
UK & Netherlands (Dekker et al., 2012)	242	15	17	49%
Turkey (Karakus et al., 2015)	278	15	17	53%
Latin America (Gleichgerrcht et al., 2015)	3451	12	20	51%
Spain (Ferrero et al., 2016)	284	12	19	49%
Greece (Papadatou-Pastou et al., 2017)	573	22	48	44%
Germany (Grospietsch & Mayer, 2019)	550	11	11	51%
Morocco (Janati Idrissi et al., 2020)	330	12	20	67%
USA (van Dijk & Lane, 2020)	213	15	18	64%
Australia (Hughes et al., 2021)	228	15	17	51%
Trinidad & Tobago (Bissessar & Youssef, 2021)	338	17	13	40%

Note. Latin America: Argentina, Peri and other countries.

More recently, a comprehensive systematic review conducted by Torrijos-Muelas et al. (2021) has shed light on the extent of neuromyth endorsement within diverse sample groups across 24 distinct studies. These sample groups included in-service teachers (N = 13; 54.17%), pre-service teachers (N = 7; 29.17%), educators of unspecified categories (N = 2; 8.33%), and head teachers (N = 1; 4.17%). The review found that each group persistently displayed a propensity to endorse various neuromyths, with the concept of learning styles ranking as the most prevalent among them.

Furthermore, a separate systematic review addressing teachers' endorsement of the learning styles neuromyth found that this particular misconception is highly pervasive, with 89.1% of a substantial cohort of 15,045 teachers endorsing it (Newton & Salvi, 2020). Additionally, the review uncovered no discernible decline in the prevalence of this belief over a period spanning from 2009 to 2020. Notably, there is also a considerable proportion of teachers who actively integrate this neuromyth into their classroom practices. These systematic reviews collectively highlight that the endorsement of neuromyths does not substantially vary based on teachers' levels of professional experience. Given that evidence also suggests neuromyths are prevalent within SEN settings (Gini et al., 2021; Papadatou-Pastou et al., 2017), analysing the presence of neuromyths in the context of SEN can pave the way for future research initiatives and foster a constructive dialogue between professionals from the realms of research and practice.

Neuromyths in Special Educational Needs (SEN)

Inclusive education typically refers to an educational environment in which children with SEN are taught with their typically developing peers, with reasonable accommodations made to optimise their learning outcomes within mainstream classroom settings. Today, there is an increasing number of pupils with SEN taught in mainstream classrooms

(Department for Education, 2022; Krämer et al., 2021). Given this escalating trend, it can be tentatively inferred that a significant proportion of teachers have experience in teaching students with SEN (Holmqvist & Lelling, 2021), thus earning the designation of ‘teachers of children with SEN’ (Broomhead, 2013).

The examination of neuromyths within the context of SEN has been a relatively underexplored area, often receiving limited attention in research (Gini et al., 2021; Papadatou-Pastou et al., 2017; Van Herwegen et al., 2022). A recent study by Gini et al. (2021) sought to address this gap by investigating the prevalence of neuromyths in SEN among both the general public and individuals working in the field of education, with a total sample size of 569 participants. The study specifically focused on ASD, ADHD, and Down Syndrome.

To assess the endorsement of neuromyths, participants were presented with an online questionnaire featuring a range of neuromyths and neuro-facts related to neurodevelopmental disorders. Respondents rated neuromyths on a 4-point Likert scale where lower scores indicated greater belief in neuromyths. The findings revealed that the endorsement of neuromyths related to neurodevelopmental disorders ($M = 3.12$) was more prevalent than those associated with general cognitive function ($M = 3.22$). Notably, despite the wealth of neurobiological and neurocognitive findings on dyslexia, the misconception that dyslexia is primarily caused by letter reversals (or backward reading) remains widespread (Anderson et al., 2020). These findings emphasise the heightened susceptibility of teachers working in SEN contexts to the endorsement of neuromyths specifically related to SEN, shedding light on a critical area of concern.

Potential Cost of Neuromyths in Educational Settings

As delineated in the preceding sections, the absence of formal and structured training in educational neuroscience can engender challenges for teachers in discerning between neuromyths and neuro-facts. Consequently, this difficulty may result in the adoption of unscientific and inefficient pedagogical methods and strategies within the classroom (Jones, 2021; Tardif et al., 2015).

For example, there have been instances where marketers have introduced purported 'neuro-didactic' (Grospietsch & Mayer, 2020) or 'brain-based' educational programmes. These programs may inappropriately incorporate neuroscientific concepts, resulting in an oversimplification or misunderstanding of critical concepts, including the learning styles neuromyth (Fischer, 2009).

There is evidence that many schools implement various types of educational programmes and interventions, although the supporting evidence of these interventions is limited (Pegram et al., 2022). For example, one educational approach that is based on a neuromyth that purposeful and deliberate bodily movements are conducive to optimal learning outcomes (Brain Gym, 2022) is the 'Brain Gym' approach. It implies, for instance, that the deliberate movement of the left arm to the right leg at a slow pace enhances mental coordination and attention while concurrently reducing stress levels. A review showed that many schools implement this approach in their classrooms, despite the absence of empirical evidence validating its effectiveness (Spaulding et al., 2010).

Regarding another frequently endorsed neuromyth, that of learning styles, applying this neuromyth to teaching practices can result in teachers and schools using the budget, resources and time on activities that are not evidence-based (Dekker et al., 2012; Grospietsch & Lins, 2021; Papadatou-Pastou et al., 2017; Privitera, 2021; van Dijk & Lane,

2020). Franklin (2006) contends that the adoption of a learning style framework in the classroom can lead teachers to label students rather than helping teachers to create more constructive learning environments through a better understanding of the learning processes. Such constrained approaches can also affect teachers' expectations of students (Education Endowment Foundation, 2021), which in turn influence student performance (i.e., Andersen, 2018; Good & Nichols, 2001; Jahan & Mehrafzoon, 2019; Szumski & Karwowski, 2019).

Nevertheless, there exists no consensus on the impact of neuromyths on students' learning (Gini et al., 2021; Hughes et al., 2021; Krammer et al., 2021), as the body of literature on this subject presents a complex and diverse range of findings. For instance, Krammer et al. (2021) investigated the relationship between the academic performance of pre-service teachers and their endorsement of neuromyths. Student teachers' academic achievement by grade points (GPAs) was collected throughout a 3-year Bachelor's programme. Neuromyth beliefs were subsequently assessed in the final year of their programme. While certain neuromyths, such as the learning styles, were highly endorsed, no significant association was observed between neuromyth beliefs and the GPAs of student teachers. In other words, the level of endorsement of neuromyths had no impact on the academic achievement of pre-service teachers. Similarly, Horvath et al. (2018) found that high-performing and award-winning teachers had similar neuromyths endorsement scores to trainee and non-award-winning teachers. The absence of consensus regarding the impact of neuromyths on student learning can be attributed to the limited number of empirical studies exploring and elucidating the underlying constructs and structures of neuromyths. This is a pivotal consideration, given that neuromyths often stem from misinterpretations and oversimplifications of evidence-based research (Geake, 2008; Grospietsch & Mayer,

2018, 2019; Im et al., 2018). While the indirect costs of neuromyths are clear, their prevalence highlights the need for a deeper understanding of the factors influencing their beliefs.

Factors Potentially Influencing Neuromyth Beliefs

Examining the factors that may influence neuromyth beliefs is instrumental in gaining a better understanding of the effects of these factors and in determining the necessary measures to address and rectify such beliefs (Hughes et al., 2020). This section examines the available evidence pertaining to three factors that have been reported as potential determinants of teachers' likelihood to believe in neuromyths. These factors include, a) years of teaching experience, b) engagement with educational or professional materials related to educational neuroscience, such as blogs, magazines, or podcasts, and c) exposure to educational neuroscience training.

The influence of these three factors on neuromyth beliefs have been examined in the literature (i.e., Arslan et al., 2022; Bissessar & Youssef, 2021; Tovazzi et al., 2020; Zhang et al., 2019). However, the findings within this body of research are mixed for these factors (Hughes et al., 2020). This is likely because studies in the literature generally examine neuromyth and neuro-fact scores separately. For instance, certain studies reveal no discernible relationship between years of teaching experience and either neuromyth scores (Horvath et al., 2018; Rato et al., 2013) or neuro-fact scores (Ferrero et al., 2016). In contrast, others report a significant positive relationship between years of teaching experience and neuro-fact scores (Gleichgerrcht et al., 2015).

Similarly, the connection between teachers' levels of understanding and engagement with educational or professional materials related to educational neuroscience, such as blogs, magazines, or podcasts, exhibits variability in the literature. Some studies

suggest that individuals engaging with such materials tend to manifest lower levels of neuromyth endorsement (Gleichgerricht et al., 2015), while others report no substantial association with neuromyths but note higher neuro-fact scores (Dekker et al., 2012).

The relationship between educational neuroscience training and teachers' levels of neuromyth endorsement is equally complex and varied. Research indicates that high levels of neuromyth endorsement can occur regardless of whether teachers have limited (van Dijk & Lane, 2020) or extensive training in educational neuroscience (Ferrero et al., 2016; Im et al., 2018). A critical factor influencing this variability is the quality of the training received. Teachers who depend on informal or unstructured sources, such as non-peer-reviewed online content, social media, or workshops led by unqualified individuals, can be at a heightened risk of endorsing neuromyths (Grospietsch & Mayer, 2020; Privitera, 2021; Tardif et al., 2015; Torrijos-Muelas et al., 2021). These sources often lack the scientific rigour necessary to differentiate between validated research findings and misconceptions, thereby increasing the likelihood of misinterpretation (Fischer, 2009; Jones, 2021; Privitera, 2021). As such, the impact of educational neuroscience training depends not only on its extent but also on the quality and credibility of its sources and methodologies.

By contrast, structured training from reputable institutions, such as accredited universities or professional development organisations, can help equip teachers with the skills to critically evaluate evidence. Such training can bridge the gap between research and practice, promoting confidence and mitigating the risks posed by pseudoscientific content. Addressing this issue is pivotal to creating a foundation of evidence-based teaching practices (Department for Education, 2024a; Fischer, 2009; Privitera, 2021; Tokuhamma-Espinosa & Nouri, 2023).

Additionally, teachers often start their careers with inadequate knowledge about SEN (Arslan et al., 2022; Crispel & Kasperski, 2021; L. Feng & Sass, 2013; Van Herwegen et al., 2022; Wall et al., 2019; Warnes et al., 2022). In some instances, this can result in teachers developing specialised teaching skills via trial and error (Oliver et al., 2018). Such a learning path can also render teachers susceptible to neuromyths, particularly those related to SEN.

Educational neuroscience training has been identified as a predictor for higher general knowledge about the brain (Papadatou-Pastou et al., 2017), which may help reduce neuromyth beliefs. Furthermore, various types of educational neuroscience training, from one-off sessions (McMahon et al., 2019) to extended three-year professional development programmes (Dubinsky et al., 2013), have proven effective in improving various teacher-related outcomes.

Considering the benefits of educational neuroscience training, it is essential to provide teachers with accurate and reliable knowledge of this field. A set of guidelines and frameworks are needed for the practical application of educational neuroscience training in the classroom. The following section delves into the practical application of educational neuroscience, guided by key findings from various reports (e.g., Tokuhamma-Espinosa, 2008, 2017; Tokuhamma-Espinosa & Nouri, 2023) and the current frameworks in place (e.g., Department for Education, 2021, 2024a) while emphasising the necessity of a structured approach to incorporating these insights into ITT.

Standards and Principles of Educational Neuroscience Training

Gola et al. (2022) assert that neuroscientific studies examining learning mechanisms should ideally be a collaborative effort between neuroscientists and pedagogists, aiming to closely relate to the dynamics inherent in classroom settings. Moreover, while it is crucial to

specify the methodological intricacies and procedures employed in such studies, it is equally essential to render the resulting evidence accessible and applicable, allowing educators, specifically teachers, to fully comprehend and adeptly implement the insights generated by these studies. This highlights the necessity for a harmonious synergy between neuroscience and education to enhance teaching practice (Pickering & Howard-Jones, 2007).

Sigman et al. (2014) propose that to enhance the exchange between researchers and practitioners, the basic conceptual knowledge required by teachers should be systematically organised and disseminated in a coordinated and formal manner. Regarding this essential conceptual knowledge for teachers, Tokuhamma-Espinosa (2008) aimed to establish internationally recognised standards and principles for educational neuroscience training. She also investigated how well ITT programmes equip teachers with fundamental conceptual knowledge of this field. The study used the Delphi method, which involves distributing a series of questionnaires to a panel of experts who provide anonymous input on pertinent issues (Crisp et al., 1997). This methodology was crucial in identifying the core knowledge of educational neuroscience necessary for teachers

The Delphi panel engaged in discussions on various topics, including optimal learning strategies, methods to enhance the learning outcomes for all students, and the influential risk and protective factors affecting learning potential. The outcome of these discussions was the development of a comprehensive list detailing the conceptual knowledge about the brain and learning science that teachers should possess (Tokuhamma-Espinosa, 2008). This list highlighted the necessity for educators to manage the basic vocabulary of the field and be familiar with the major principles, tenets, and instructional guidelines of educational neuroscience (or, *Mind, Brain and Education Science*, as the authors state) (Tokuhamma-Espinosa, 2008).

A decade later, a follow-up Delphi panel further refined this list. The 2017 Delphi panel, which included a more diverse group of 40 experts from 11 countries, confirmed many of the previous findings while also addressing new advancements and ongoing challenges in the field (Tokuhamma-Espinosa, 2017). This second Delphi study sought to update the macro vision of the field of educational neuroscience, identify key baseline knowledge for teachers, and re-energise the field with a more organised and evidence-based structure. The panel identified several core principles that apply to all human learning, which are crucial for teachers to understand. These principles include the uniqueness and organisational variability of each brain, the complex and dynamic nature of the brain, the innate search for meaning in human nature, and the high degree of brain plasticity throughout the lifespan (Tokuhamma-Espinosa, 2017).

In addition to establishing these principles, the panel also recognised the importance of context and psychosocial factors, such as socioeconomic status, parental education levels, and intellectually stimulating environments, which interact with biological influences on learning (Tokuhamma-Espinosa, 2017). The findings emphasised the need for teachers to be aware of these factors and incorporate this understanding into their teaching practices to support diverse learning needs effectively.

The quality and credibility of educational neuroscience training are equally important for its success. Poorly designed or unstructured training, especially from unverified sources, could undermine these principles and risk perpetuating misinformation, which can hinder teachers' ability to apply evidence-based practices in their classrooms. Conversely, educational neuroscience training designed and delivered by credible institutions, such as universities or accredited professional organisations with experts with a robust understanding of educational neuroscience, is more likely to equip teachers with

accurate, evidence-based knowledge. For example, university-led programmes or government-backed initiatives can provide a higher level of scrutiny and quality assurance, reducing the likelihood of perpetuating myths or pseudo-scientific practices.

The Delphi method's iterative process allowed for a thorough examination and consensus-building among experts, ensuring that the resulting guidelines were both scientifically grounded and practically applicable in educational settings. This comprehensive approach underscores the importance of integrating neuroscience, psychology, and education to enhance teaching and learning practices.

Building on these foundations, Tokuhamma-Espinosa and Nouri (2023) aimed to test the validity of the 2017 International Delphi Panel (Tokuhamma-Espinosa, 2017) and to identify and systematically compile essential knowledge of educational neuroscience for teachers into a comprehensive list of core topics. The list of experts in educational neuroscience invited to participate in the survey included 358 people from 30 different countries. Of the 358 invitations sent, 112 people completed the survey.

Participants were presented with 11 statements, which members of the 2017 Delphi Panel initially identified. They were asked to evaluate the importance of these statements for teachers. The initial statements were refined based on the experts' evaluations and their feedback. Ultimately, the experts affirmed nine out of the 11 statements as crucial areas of knowledge of educational neuroscience for teachers. In light of the additional comments provided, nine new statements were generated. The results of this survey yielded a consensus on 18 key concepts for basic teacher knowledge, categorised into six areas (see Table 2 for details).

Table 2. *Eighteen Concepts for Educational Neuroscience Teacher Literacy*

Categories	Concepts
Prerequisite knowledge	The nature and goals of *MBE as a field of study
	Educating the whole child
	Neuromyths
Cognitive and metacognitive functions	Attention
	Memory
	Executive functions
Human development across the life span	Brain development
	Nature-nurture interaction
	Neuroplasticity
	Individual differences
	Neurodevelopmental disorders
	Development of intelligence
Affect and cognition	Embodied cognition
	Socio-cultural context
	Emotional thought
Classroom applications of *MBE knowledge	Neurobiological processes underpinning learning in different areas of the school curriculum
	Pedagogical practices
*MBE research methodology	Educational neurotechnology

Notes. MBE: Mind, Brain and Education. Adapted from “Teachers’ Mind, Brain, and Education Literacy: A Survey of Scientists’ Views.”, by Tokuhamma-Espinosa, T., & Nouri, A., 2023, *Mind, Brain, and Education*, 17(3), p.172. <https://doi.org/10.1111/mbe.12377>.

*Refers to educational neuroscience

These 18 concepts include understanding general cognitive domains such as executive functions, attention, and memory systems, as well as neuroplasticity, the

malleability of intelligence, improvements in attention networks through training, debunking neuromyths, and the interaction between mind, body, and environment in embodied cognition (Tokuhamma-Espinosa & Nouri, 2023). The findings emphasise the importance of integrating these concepts into basic teacher training programmes to ensure that teachers are well-equipped to support diverse learning needs effectively. The study underscores the continued evolution of educational neuroscience and highlights the necessity of ongoing research and collaboration to bridge the gap between neuroscience and education. The intention is to give teachers a profound understanding of the neurocognitive systems and processes underpinning learning, as Felier and Stabio (2018) suggested.

In conclusion, knowledge of educational neuroscience could equip teachers with the terminology necessary to engage effectively with other professionals and empower them to critically assess existing educational practices while actively contributing to developing new, applicable knowledge (Tokuhamma-Espinosa & Nouri, 2023). This knowledge can enable teachers to tailor their approaches to meet the diverse needs of their students more effectively (Brick et al., 2021; Dubinsky et al., 2019; Howard-Jones et al., 2020; Privitera, 2021; Walker et al., 2019), thereby promoting an inclusive and supportive learning environment, especially in SEN contexts (Thomas et al., 2019). While aspects of neurocognitive mechanisms, such as attention and memory, are covered to some extent in ITTECF (Department for Education, 2024), this coverage is limited. Studies on the standards and principles of educational neuroscience (Tokuhamma-Espinosa, 2008, 2017; Tokuhamma-Espinosa & Nouri, 2023) have significantly contributed to defining the essential conceptual knowledge of educational neuroscience that teachers need. They provide a robust

framework for ITT programmes, aiming to bridge the gap between evidence-based research and educational practice, ultimately improving educational outcomes for all students.

Following these studies and the increased interest in educational neuroscience (Im et al., 2018; Pickering & Howard-Jones, 2007; Thomas et al., 2024; Wilcox et al., 2021; Zambo & Zambo, 2011), it is important to understand how current teacher training frameworks incorporate these essential topics. The Initial Teacher Training and Early Career Framework ('ITTECF', Department for Education, 2024a) provides a structured approach to developing the core pedagogical knowledge and skills necessary for teachers, combining and refining previous frameworks in the UK (e.g., Department for Education, 2019b, 2019a) to better address contemporary educational needs in the UK context.

Educational Neuroscience in the UK: Application in the Initial Teacher Training and Early Career Framework (ITTECF)

In the UK, the Department for Education sets out frameworks and content for ITT programmes. The Early Career Framework (2019a) and Initial Teacher Training Core Content Framework (2019b) were introduced to set teacher standards and enhance teachers' knowledge. The ECF specifies what early career teachers should learn and practice as they begin their careers, while the CCF details the minimum content all trainee teachers should receive based on the best available evidence. It outlines the essential content that ITT providers and their partnerships must incorporate when designing and delivering their ITT programmes.

In March 2023, the Department for Education (2023) issued a call for evidence to gather recent, relevant, and high-quality research to inform the revision of the initial ITT Core Content Framework and the Early Career Framework (ECF). The aim was to combine these frameworks into a cohesive document that outlines the essential knowledge and skills

for trainee and early career teachers. The call for evidence invited contributions from academic researchers, education experts, and organisations with expertise in various fields, including SEN.

The collected evidence was reviewed by the Department for Education and appraised by the Education Endowment Foundation (EEF) to ensure the incorporation of robust and relevant research into the updated framework. This collaborative effort culminated in the Initial Teacher Training and Early Career Framework (ITTECF) publication in January 2024, which integrates and updates the previous ITT Core Content Framework and ECF (Department for Education, 2024a).

The ITTECF includes updates on supporting pupils with SEN, high-quality oral language (oracy), and early cognitive development. A new statement on evidence literacy has also been added, highlighting the importance of teachers' engagement with evidence.

The current ITTECF (Department for Education, 2024a) covers a broad range of topics designed to prepare new teachers effectively. Supporting the earlier section in this document, 'evidence for the benefits of educational neuroscience', specific examples within the ITTECF highlight the incorporation of neuroscientific concepts:

1. **Memory:** The framework stresses the need for teachers to understand the limits of working memory and strategies to avoid overload, such as breaking complex material into smaller steps and reducing distractions (p. 14).
2. **Attention:** It acknowledges that attention can be improved through training, emphasising the role of structured practice and retrieval tasks to enhance learning (p. 14).

While the framework includes key concepts of educational neuroscience (Gordon et al., 2024; e.g., Tokuhamma-Espinosa, 2008, 2017; Tokuhamma-Espinosa & Nouri, 2023), the

crowded ITT curriculum often limits the depth of coverage. Moreover, these concepts are introduced primarily during early career induction once teachers are in practice rather than as foundational knowledge during their initial training. For example, the framework's "How Pupils Learn" section emphasises understanding working memory, long-term memory, and processes that enhance memory retention and learning outcomes (pp. 13-14). However, the practical application and deeper integration of these concepts are left for development during the early career induction period.

In summary, foundational knowledge of educational neuroscience can empower teachers to optimise their pedagogical practices, leading to improvement in the educational outcomes of students (Tan & Amiel, 2022) and fostering more productive interactions between researchers and practitioners. Although the ITTECF aligns with this knowledge, the crowded curriculum often limits thorough coverage. A more comprehensive initial exposure to foundational knowledge and principles of educational neuroscience during the initial stages of teacher training would ensure that teachers have a robust understanding of these concepts and are well-equipped to apply these insights effectively before they enter the classroom. Moreover, this could help teachers better understand empirical evidence and discern what is reliable and valuable throughout their careers. This could have a profound impact on educational outcomes. This suggests a clear need for a structured and systematic approach to embedding educational neuroscience in ITT, justifying further research into how these essential concepts can be more effectively integrated into teacher training programmes.

Rationale

The findings in this chapter have shed light on the inadequacy of ITT programmes in providing teachers with knowledge about the neurocognitive mechanisms of learning to an

adequate standard for informing teaching practice. Knowledge of educational neuroscience is predominantly acquired through informal and unstructured channels, such as in-service teacher training (Pickering & Howard-Jones, 2007) and internet-based sources of uncertain reliability. Most of these informal and unstructured training approaches predominantly aim at creating a one-way translation of neuroscientific knowledge to classroom practice (Privitera, 2021), aligning with Bruer's transmissional model (1997) rather than fostering a reciprocal exchange between researchers and practitioners.

In addition, the quality and source of educational neuroscience training can be critical to its effectiveness. Poorly designed or unstructured training from unreliable sources could risk perpetuating unscientific practices, hindering teachers' ability to engage with evidence effectively. For instance, training lacking rigorous oversight or delivered by unverified sources may oversimplify complex concepts, propagating neuromyths and hindering evidence-based practice. Conversely, structured training designed and delivered by reputable sources, such as universities or professional organisations, is more likely to provide teachers with accurate, evidence-based knowledge and practical tools. Addressing these gaps through systematic and high-quality training could mitigate wasted resources and improve teachers' ability to engage with evidence effectively, promoting evidence-based practices. While Privitera (2021) reviewed various neuroscience training programmes and noted their positive effects on teachers' knowledge and confidence, it also highlighted the diversity in training formats and durations, suggesting that the effectiveness of such training depends on its structure and delivery.

It is apparent that teachers do not receive structured and consistent formal educational neuroscience training and evidence-based practice as part of their teacher training (Blanchette Sarrasin et al., 2019; Carey et al., 2020; Privitera, 2021; Tokuham-

Espinosa, 2008, 2017; Tokuhamma-Espinosa & Borja, 2023; Tokuhamma-Espinosa & Nouri, 2023; Willingham, 2017). Even when teachers encounter such content in the course of their careers through informal training paths, there is evidence that they find it challenging to understand and effectively engage with the research evidence (Schwartz et al., 2019; Tan & Amiel, 2022). These gaps in structured and consistent training call for a deeper examination of the types and quality of training teachers receive to identify best practices for bridging the gap between research and classroom application.

As teachers struggle to effectively engage with evidence-based educational neuroscience findings to proactively support students, especially those with SEN (Carey et al., 2020; Gabrieli, 2016; Papadatou-Pastou et al., 2017), this is a barrier even for those teachers who have a genuine interest in this field (Dekker et al., 2012; Thomas et al., 2024; Thomas & Arslan, 2024). Adding to this, a lack of effective engagement with and understanding of educational neuroscience research evidence might leave teachers susceptible to embracing neuromyths (Dekker et al., 2012; Gini et al., 2021; Privitera, 2021; Torrijos-Muelas et al., 2021), thus leading to ineffective, or even damaging, teaching methods in their classrooms (Tardif et al., 2015).

In order to mitigate this, teachers require knowledge of educational neuroscience and skills that enable them to evaluate and digest research evidence. The current research adopted a novel approach to systematically examine teachers' knowledge of educational neuroscience and aimed to find better ways of improving their performance on these related indices.

Current Thesis

Research Questions

The current research has addressed the following research questions:

1. To what extent do UK teachers' knowledge of educational neuroscience vary according to their professional background and prior training in educational neuroscience?
2. What are the key predictors of teachers' knowledge of educational neuroscience, and how do these predictors interact?
3. What are teachers' views on the value of educational neuroscience in teaching practice and the challenges they face in accessing resources and training in this field?
4. What is the impact of a structured educational neuroscience training programme on teachers' knowledge and perceptions of educational neuroscience?

General methods

This research adopted a systematic and multi-stage approach to investigate teachers' knowledge of educational neuroscience, the factors influencing this knowledge, and the potential of structured training to address gaps in understanding and practice.

Three studies have been designed to address the research questions.

In the first study, teachers' knowledge of educational neuroscience was assessed, and factors influencing this knowledge were identified using the Educational Neuroscience Knowledge Test (ENKT), a tool developed for this study.

The second study involved a follow-up qualitative investigation using focus groups and dyadic and individual interviews, which provided an in-depth examination of teachers' perceptions of their knowledge, the perceived value of educational neuroscience, and the

barriers and challenges they face in accessing educational neuroscience training, materials and resources.

The third study built on the findings of the first two. A structured educational neuroscience training programme was developed, focusing on key educational neuroscience principles, such as memory, attention, executive function, and neuroplasticity, with a particular focus on SEN contexts and relevant topics. The effectiveness of the training on teachers' knowledge of educational neuroscience was evaluated using a pre-post-test experimental design with a control group. Quantitative and qualitative measures assessed changes in teachers' knowledge.

This systematic approach ensured a comprehensive understanding of teachers' knowledge of educational neuroscience and the development of accessible, time-efficient, and evidence-based programmes to address gaps. Details about these studies are given in relevant chapters.

Chapter 2

Teachers' Knowledge of Educational Neuroscience (Study 1)

Teachers' Knowledge of Educational Neuroscience (Study 1)

Rationale

Given the considerable cognitive processes involved in learning and their influence on performance differences across age groups and abilities (Jin et al., 2019; Liu & Nesbit, 2023), it is reasonable that teachers might benefit from learning more about such processes to optimise their classroom practice (Dubinsky et al., 2019; Schwartz et al., 2019; Tan & Amiel, 2022; Thomas & Arslan, 2024; Weisberg et al., 2008).

Due to the growing importance and interest in cognitive science (Im et al., 2018; Pickering & Howard-Jones, 2007; Wilcox et al., 2021; Zambo & Zambo, 2011), various initiatives aim to enhance the content within Initial Teacher Training (ITT) programmes (Tokuhamma-Espinosa, 2008, 2017; Tokuhamma-Espinosa & Nouri, 2023). For instance, the UK's recently updated Initial Teacher Training and Early Career Framework ('ITTECF', Department for Education, 2024a) highlights incorporating related content, such as understanding working memory and the practice of breaking down material into smaller steps, into ITT programmes.

However, while trainee teachers are required to engage with this framework to gain Qualified Teacher Status (QTS) in the UK, such frameworks are not extensive and often lack depth in addressing the neurocognitive mechanisms of learning (McMahon et al., 2019; Thomas & Arslan, 2024; Tokuhamma-Espinosa, 2008, 2017; Tokuhamma-Espinosa & Nouri, 2023). Consequently, ITT programmes in the UK, as well as in many other countries, offer minimal content in this area (Arslan et al., 2022; Blanchette Sarrasin et al., 2019; Privitera, 2021; Thomas & Arslan, 2024; Tokuhamma-Espinosa, 2017; Tokuhamma-Espinosa & Borja, 2023; Willingham, 2017). As a result, teachers, particularly those with a strong interest in

educational neuroscience, often turn to informal and unstructured channels to expand their knowledge (Thomas & Arslan, 2024).

Training lacking rigorous oversight or delivered by unverified sources can oversimplify complex concepts and hinder evidence-based practice (Fischer, 2009; Grospietsch & Mayer, 2020; Jones, 2021; Tardif et al., 2015). For example, informal workshops or online non-peer-reviewed resources may inadvertently lead to misinterpretations or inappropriate classroom applications. Moreover, the dissemination of neuroscience knowledge is fraught with potential pitfalls, particularly the widespread prevalence of neuromyths (Privitera, 2021; Tokuhamma-Espinosa, 2017, 2018; Tokuhamma-Espinosa & Nouri, 2023).

Neuromyths are pervasive and enduring misconceptions and misinterpretations concerning the functioning of the human brain, commonly observed within diverse educational settings (Tokuhamma-Espinosa, 2018; Torrijos-Muelas et al., 2021). These misconceptions often stem from various factors, including the lack of high-quality educational neuroscience training.

Years of teaching experience can significantly influence teachers' beliefs in neuromyths. Research suggests that neuromyth beliefs are resilient and difficult to correct (Grospietsch & Lins, 2021; Torrijos-Muelas et al., 2021). However, the prevalence of these beliefs among experienced teachers may not necessarily indicate a greater susceptibility to neuromyths. Instead, it could reflect a lack of exposure to educational neuroscience concepts during their initial training or professional development. Many experienced teachers began their careers at a time when educational neuroscience-informed teacher training was less widespread, leaving them with limited opportunities to learn and apply validated educational neuroscience principles (Privitera, 2021; Tokuhamma-Espinosa & Borja,

2023). In contrast, newer teachers, who have fewer years of teaching experience, are more likely to have encountered educational neuroscience concepts during their training, likely due to a growing emphasis on incorporating educational neuroscience into teacher training programmes (Thomas & Arslan, 2024).

Moreover, there are various means of exposure to educational neuroscience for teachers throughout their careers. These include formal and structured training, Continuing Professional Development (CPD) courses, and engagement with professional or educational materials such as videos, blogs, books and magazines. These types of exposure require different levels of teacher engagement. Some can be mandatory and delivered through schools; some may be self-paced online. These types may also vary significantly in quality and structure depending on the type of training. Thus, it is reasonable to propose that they can lead to different levels of neuromyth beliefs.

Specific to the types of educational neuroscience training, formal, structured programmes provide a more comprehensive and systematic understanding of educational neuroscience concepts (Betts et al., 2019; Tokuhamas-Espinosa & Nouri, 2020). This could also influence neuromyth beliefs (McMahon et al., 2019; Papadatou-Pastou et al., 2017). Thus, it can be argued that formal training would equip teachers with a deeper understanding of educational neuroscience principles, which can reduce neuromyth beliefs.

Neuromyths can undermine the application of evidence-based educational practices and be particularly detrimental in addressing the needs of SEN students because these misbeliefs are notably prominent in SEN contexts, including those associated with neurodevelopmental disorders (Gini et al., 2021; Macdonald et al., 2017).

Beliefs in neuromyths can be useful indicators for assessing teachers' knowledge of educational neuroscience, as they reveal teachers' ability to distinguish incorrect scientific

information from correct scientific information about educational neuroscience (i.e., neuro-facts). Neuro-facts are well-supported and evidence-based findings about how the brain learns. While prior studies have often assessed neuromyths and neuro-facts independently, this study argues that considering them together provides a more robust measure of knowledge of educational neuroscience.

Endorsing a neuro-fact demonstrates that a teacher understands established scientific principles and findings in educational neuroscience, suggesting foundational knowledge of validated information. Rejecting a neuromyth, however, reflects critical evaluation skills—the ability to identify misinformation or pseudoscience and to avoid the pitfalls of misconceptions that may undermine teaching practices. This dual capability is particularly important because neuromyths are often presented in ways that sound scientifically plausible, making it challenging to distinguish them from genuine facts without sufficient training.

Together, these two measures—endorsing neuro-facts and rejecting neuromyths—provide complementary insights into a teacher's knowledge. By combining these two measures into a single assessment, researchers can capture both dimensions of knowledge: the depth of understanding and the capacity for critical discernment. Understanding neuro-facts shows what teachers know, but their ability to reject neuromyths highlights how effectively they can apply that knowledge to filter and critique information. In this sense, the rejection of neuromyths represents an active demonstration of critical thinking skills rather than a passive recall of factual information.

Moreover, endorsing a neuro-fact does not necessarily imply the rejection of a neuromyth, as knowledge of accurate information does not automatically confer the ability to identify and discredit incorrect claims. This lack of automatic correlation highlights the

importance of assessing both skills together, as both should ideally be present in a teacher's knowledge and skill set. Teachers need not only to grasp established scientific concepts but also to distinguish them from unsupported or misleading claims (Tokuhamma-Espinosa & Nouri, 2020, 2023; Torrijos-Muelas et al., 2021). For example, a teacher may understand that "Sleep is important for consolidating knowledge" (a neuro-fact) yet still believe in the neuromyth that "Humans only use 10% of their brain at any one time," indicating a gap in their critical evaluation skills.

The current study assessed teachers' knowledge of educational neuroscience and explored factors influencing this knowledge, including teachers' years of experience and exposure to educational neuroscience training through formal, CPD or informal sources. The Educational Neuroscience Knowledge Test (ENKT) was developed for this study. The ENKT is a dual measure of knowledge that not only gauges teachers' grasp of evidence-based statements but also reflects their critical evaluation skills. To ensure a comprehensive evaluation, the ENKT included categories for general cognitive functions (GCF) and special educational needs (SEN). This approach builds on prior discussions about the importance of understanding universal cognitive processes like memory and attention, which benefit all learners, alongside SEN-specific challenges, such as neurodevelopmental conditions like dyslexia or ADHD.

Through these aims, the study seeks to illuminate the current state of knowledge of educational neuroscience among teachers in the UK and the potential for targeted training to enhance their understanding of educational neuroscience.

Research Questions and Hypotheses

1. To what extent do UK teachers' knowledge of educational neuroscience vary according to their professional background and prior training in educational neuroscience?
2. What are the key predictors of teachers' knowledge of educational neuroscience, and how do these predictors interact?

To address these research questions, two hypotheses were formulated:

Hypothesis 1: Teachers' years of teaching experience would be negatively correlated with knowledge of educational neuroscience.

Hypothesis 2: Exposure to formal educational neuroscience training would lead to higher knowledge of educational neuroscience compared to other identified forms of educational neuroscience training (i.e., CPD courses, informal exposure through self-directed materials, or no exposure).

Methods

This study employed a questionnaire design, which was chosen to assess knowledge of educational neuroscience across a large and diverse sample of teachers. This approach maximised the likelihood of including participants with varying years of teaching experience and different levels of exposure to educational neuroscience training. For this study, “knowledge of educational neuroscience” refers to a composite measure combining teachers' understanding of neuro-facts and their ability to identify and reject neuromyths correctly. This dual knowledge measure reflects accurate educational neuroscience understanding and critical evaluation skills.

Participants

The study received full ethical approval from the UCL Institute of Education Ethics Committee (Appendix A). Participants included teachers legally qualified to teach in the UK, along with Early Career Teachers (ECTs) in their induction period. Recruitment employed a multi-channel approach to reach a diverse group of educators. Each recruitment method included a brief description of the study, eligibility criteria, and a link directing potential participants to an online platform (Qualtrics) where they could read the information sheet (Appendix B), give informed consent, and complete the questionnaire. For the email invitations, schools were contacted directly, and permission was sought from school administrators to forward the study details to staff. Social media posts on platforms popular among educators, such as LinkedIn and Facebook, used targeted hashtags to attract those who might find the study interesting. Study flyers were also distributed in both physical and digital formats to reach participants in various educational settings (Appendix C).

A total of 533 participants accessed the online questionnaire, with 375 completing it. Nine responses were excluded due to incomplete data, lack of teaching experience or qualifications, or teaching outside the UK, resulting in 366 complete responses for analysis. This sample (78.7% female) mirrored the gender distribution in the UK teaching workforce (Department for Education, 2024c).

Age was recorded using categorical age groups. The mean age of participants was calculated by assigning midpoints to each group (e.g., 21.5 for 18-25, 28 for 26-30). Each midpoint was multiplied by the frequency of participants in that age group to create a weighted sum, which was then divided by the total number of participants. This method produced an approximate mean age of 42.39 years ($SD = 10.7$).

Materials

Questionnaire: The Educational Neuroscience Knowledge Test (ENKT)

The Educational Neuroscience Knowledge Test (ENKT) was developed to assess teachers' ability to discern neuromyths from neuro-facts (Appendix D). As explained in the introduction, this was used as an assessment tool to identify teachers' knowledge of educational neuroscience since it incorporated a holistic approach by using neuromyths and neuro-facts together.

The ENKT was divided into four sections, outlined in Table 3.

Table 3. *Educational Neuroscience Knowledge Test (ENKT) Sections and Details*

Section	Details
Demographic Information and Qualifications	Gender, age, types of degrees and teaching certifications earned.
Teaching Experiences and Roles	General years of teaching experience, years of teaching experience with children with SEN, SEN categories taught.
Exposure to Educational Neuroscience Materials and Training	Types of educational neuroscience materials accessed, types of training received in educational neuroscience.
Core Neuromyths and Neuro-facts	Participants' ability to distinguish neuromyths and neuro-facts.

Note. ENKT = Educational Neuroscience Knowledge Test

This study also recognised the relevance of SEN teaching experience to teachers' knowledge of educational neuroscience. Thus, the ENKT included distinct categories of statements addressing general cognitive function (GCF) and SEN.

The core neuromyths were drawn and adapted from previous studies (e.g., Dekker et al., 2012; Gini et al., 2021; Macdonald et al., 2017). SEN-related neuromyths were drawn based on their prevalence (e.g., Gini et al., 2021; Macdonald et al., 2017; Moats, 2009). The evidence-based neuro-facts were taken from established findings from neuroscience and

educational neuroscience (e.g., Betts et al., 2019; Centre for Educational Neuroscience, 2021; Parvizi et al., 2012; Tokuhamma-Espinosa, 2018).

SEN items included specific neuromyths and neuro-facts about neurodevelopmental disorders, including dyslexia, ASD, and ADHD, as well as other SEN categories, such as deaf/hard of hearing. GCF items did not include any specific statements related to SEN but included general knowledge about the brain, such as “sleep is important for consolidating knowledge.” All ENKT statements can be seen in Appendix D.

For all statements, participants were asked to what extent they agreed or disagreed with the statements on a 5-point Likert scale from 1 (strongly agree) to 5 (strongly disagree). Earlier studies (e.g., Dekker et al., 2012; Gleichgerricht et al., 2015; Dündar & Gündüz, 2016) employed binary response options ("correct," "incorrect," "do not know"). However, as the participants might be reluctant to provide definitive answers for all statements (Gini et al., 2021), more recent studies, such as Grospietsch and Mayer (2019) and Gini et al. (2021), adopted Likert scales to capture the strength of beliefs more precisely, as suggested by Macdonald et al. (2017). This shift provided greater granularity, enabled more sophisticated statistical analyses, and allowed researchers to assess ambivalence.

While responses are collected on a Likert scale, this does not mean that only opinions are being measured. The ENKT assesses participants’ ability to differentiate between neuro-facts and neuromyths, thereby reflecting both factual knowledge and critical evaluation skills. Prior research (e.g., Grospietsch & Mayer, 2019; Gini et al., 2021) has demonstrated that Likert-scale measures effectively capture degrees of belief in scientific concepts, which is particularly important when assessing misconceptions. Additionally, while some participants may possess knowledge but still express disagreement, this does not invalidate the measure; rather, it highlights the complexities of

knowledge acquisition and belief formation. This approach ensures a more nuanced evaluation of teachers' knowledge, rather than a simple recall of information.

Participants' neuromyth and neuro-fact beliefs were then used together to assess their overall knowledge of educational neuroscience. To calculate this, each participant's neuro-fact score was subtracted from their neuromyth score, creating a differentiation score. This score range was from -72 to 72, with higher, more positive scores indicating better differentiation between correct and incorrect information. This score was used as an index for participants' knowledge of educational neuroscience.

Additionally, two sub-indexes were calculated. The first measured knowledge of educational neuroscience specifically related to SEN by focusing on SEN-related neuromyths and neuro-facts (*SEN knowledge*). The second index focused on GCF, denoted by the non-SEN questions (*GCF knowledge*). Table 4 shows the distribution of neuromyths and neuro-facts by GCF and SEN categories.

Table 4. *Distribution of Statements and Range of Possible Scores for the ENKT*

Index	Statements (N)		Theoretical Minimum Score	Theoretical Maximum Score
	Neuromyths	Neuro-facts		
Overall Knowledge	18	18	-72	72
SEN Knowledge	8	8	-32	32
GCF Knowledge	10	10	-40	40

Note. ENKT = Educational Neuroscience Knowledge Test

Piloting the Questionnaire. Before the study commenced, the questionnaire was piloted to ensure clarity and functionality. Seven teachers and three PhD students in

education participated in this pilot. The primary aim of this process was to identify and resolve any potential problems, such as the clarity and ease of understanding of the questions, the appropriateness of the language used, and the logical progression and coherence of the questionnaire sections. This included ensuring that participants could navigate through the survey smoothly, that the sequence of questions was intuitive, and that there were no abrupt transitions or ambiguities that might hinder comprehension or completion.

Based on the pilot, no further changes were needed for the neuromyths and neuro-facts section. The only update made was enabling participants to select multiple options for their current roles, recognising that they might hold dual positions, such as being both a classroom teacher and a subject lead.

Procedure

Once consent was received, participants could begin the questionnaire. The online survey was accessible across multiple devices, allowing participants to complete it at their convenience. The eighteen neuromyths and eighteen neuro-facts were presented in a mixed, randomised order (i.e., not grouped as all neuromyths first followed by all neuro-facts). This approach was used to prevent any bias that might occur if similar types of statements were clustered together.

At the end of the questionnaire, participants were asked whether they would be willing to participate in follow-up research and a course in educational neuroscience. The questionnaire remained open for 16 weeks on Qualtrics. The mean completion time across participants was 15 minutes.

Data Analysis

Statistical analyses were conducted using IBM SPSS Statistics v29 software. The alpha for inferential statistics was set at .05.

Research Question 1: To What Extent do UK Teachers' Knowledge of Educational Neuroscience Vary According to Their Professional Background and Prior Training in Educational Neuroscience?

To determine whether teachers' knowledge of educational neuroscience was significantly different from chance, one-sample *t*-tests were conducted for the three differentiation indexes: overall knowledge, GCF knowledge and SEN knowledge. These tests used a baseline score of zero to represent chance-level performance.

Research Question 2: What are the Key Predictors of Teachers' Knowledge of Educational Neuroscience, and How do These Predictors Interact?

The specific levels of educational neuroscience training (formal, CPD, informal, and no exposure) are detailed in the Results section for clarity. Correlation coefficients were calculated to assess the relationships between knowledge of educational neuroscience, years of teaching experience, and educational neuroscience training levels. A two-way factorial ANOVA was conducted to test the individual and interactive effects of years of teaching experience and educational neuroscience training on knowledge of educational neuroscience. Post-hoc Bonferroni tests were used to identify significant differences among the training levels.

The internal consistency of the questionnaire was measured using Cronbach's alpha. Normality was assessed with the Shapiro-Wilk test, and the assumption of homogeneity of variances was tested with Levene's test.

Results

Distribution and reliability

Boxplots revealed no outliers, and histograms indicated a normal distribution of knowledge of educational neuroscience across the 366 participants (Appendix E). Based on a Shapiro-Wilk test, normality was assumed for educational neuroscience training and years of teaching experience groups. Internal consistency was good for the whole questionnaire ($\alpha = 0.8$) and the 18 neuromyths ($\alpha = 0.79$), but moderate for the 18 neuro-facts ($\alpha = 0.68$).

Descriptive statistics

As highlighted, many teachers work with students with SEN (Department for Education, 2022; Holmqvist & Lelinge, 2021; Krämer et al., 2021), and we anticipated that most participants would have some SEN experience, reflecting the general UK teaching population (Department for Education, 2024d). This expectation was further confirmed, with 96.4% of participants reporting SEN classroom experience.

The current study categorised educational neuroscience training into four distinct levels based on teachers' previous training experiences:

1. Formal educational neuroscience: undergraduate or postgraduate level educational neuroscience training,
2. CPD: continuing professional development level, but no formal educational neuroscience training,
3. Informal exposure: engagement with professional or educational materials related to educational neuroscience, but neither formal educational neuroscience nor CPD training,
4. No exposure to any identified educational neuroscience training.

These levels are distinct and non-overlapping. For example, individuals at the CPD level should not have received formal educational neuroscience training.

Of the 366 participants, 109 had formal or CPD training in educational neuroscience, while 196 reported using educational neuroscience-related materials in their teaching. Table 5 presents the distribution of educational neuroscience training levels among participants and the mean knowledge of educational neuroscience scores across training categories and years of teaching experience.

Table 5. *Descriptive Statistics for Knowledge of Educational Neuroscience by Training Levels and Years of Teaching Experience*

Educational Neuroscience Training Level	Years of Teaching Experience Group	<i>n</i>	%	<i>M</i>	<i>SD</i>
Formal	2 or less	3		19.33	10.21
	3-5 years	3		30	8
	6 or more years	23		29.43	11.74
	Total	29	7.9	28.45	11.41
CPD	2 or less	9		23.22	10.15
	3-5 years	8		19.5	9.49
	6 or more years	63		20.54	8.23
	Total	80	21.9	20.74	8.51
Informal	2 or less	5		12.6	15.09
	3-5 years	14		20.07	7.3
	6 or more years	99		21.05	9.27
	Total	118	32.2	20.58	9.42
No exposure	2 or less	15		17.07	6.17
	3-5 years	19		19.58	9.22
	6 or more years	105		15.39	8.31
	Total	139	38	16.14	8.32

Note. *M* = mean; *SD* = standard deviation.

Research Question 1: To What Extent do UK Teachers' Knowledge of Educational Neuroscience Vary According to Their Professional Background and Prior Training in Educational Neuroscience?

One-sample *t*-tests were conducted on each of the three differentiation indexes (overall, GCF and SEN) to determine whether teachers' knowledge of educational neuroscience significantly differed from chance levels (baseline). The baseline in this analysis was zero, representing the score expected if participants were simply guessing without meaningful knowledge. Results indicated that teachers performed significantly better than this baseline across all items ($t(365) = 39.08, p < .001$), GCF items ($t(365) = 30.59, p < .001$), and SEN-related items ($t(365) = 35.54, p < .001$). However, the mean knowledge of educational neuroscience score of 19.55 ($N = 366, SD = 9.57$) indicated that while teachers were above the chance level, their knowledge of educational neuroscience was not substantially higher than this baseline. This means that although teachers demonstrated some understanding of educational neuroscience concepts by scoring above the level expected by random guessing, their overall knowledge was still relatively low. Specifically, the mean knowledge of educational neuroscience score of 19.55 suggests that teachers, on average, possess limited proficiency in accurately distinguishing neuro-facts from neuromyths.

Research Question 2: What are the Key Predictors of Teachers' Knowledge of Educational Neuroscience, and how do These Predictors Interact?

The second research question examined factors influencing teachers' knowledge of educational neuroscience, specifically the impact of years of teaching experience and exposure to different levels of educational neuroscience training.

To investigate whether there was a relationship between teachers' knowledge of educational neuroscience and their years of teaching experience, a non-parametric correlation analysis (Spearman) was conducted. According to G*Power analysis (V3.1) (Faul et al., 2009), a sample size of 258 participants was required to detect a correlation coefficient of $r = .3$ with 95% power ($\alpha = 0.001$, two-tailed). Given that the study included 366 participants, this study was substantially more than adequately powered to detect relationships between variables.

This analysis revealed no significant correlation between knowledge of educational neuroscience and years of teaching experience ($r = -.01$, $p = .91$), indicating that the length of teaching experience does not appear to predict differences in knowledge of educational neuroscience in this sample.

Binary variables were created for each educational neuroscience training level (formal, CPD, informal, and no exposure) to investigate their association with knowledge of educational neuroscience. Only formal educational neuroscience training significantly correlated with knowledge of educational neuroscience ($r = .23$, $p < 0.001$). Table 6 shows all correlations.

Table 6. *Correlations Between Years of Teaching Experience and Knowledge of Educational Neuroscience Across Training Levels*

Variables	1	2	3	4	5
1 Knowledge of educational neuroscience	1				
2 Years of teaching experience	-.01	1			
3 Formal educational neuroscience	.23*	.00	1		
4 CPD-level educational neuroscience	.08	-.03	-.16*	1	
5 Informal-level educational neuroscience	.09	.10	-.20*	-.36*	1

*Correlation is significant at the 0.001 level (two-tailed)

Factorial ANOVA

A two-way factorial ANOVA was conducted to test the individual and interactive effects of years of teaching experience and educational neuroscience training on knowledge of educational neuroscience. For this analysis, years of teaching experience were divided into three categories, while educational neuroscience training was divided into four separate levels. The decision to categorise years of teaching experience was made for logistical ease of access for participants and to minimise potential input errors (e.g., entering '22' instead of '2' years). Keeping the experience levels as categories also helped account for broader trends in educational neuroscience training opportunities, which have expanded significantly in recent years. As previously highlighted, newly qualified teachers and those with only a few years of experience may have had greater exposure to educational neuroscience content than those who completed their training six or more years ago, when such opportunities were less available.

The assumption of homogeneity of variance was met based on Levene's test ($F(14, 351) = 1.01, p = .48$), suggesting that the error variance of the knowledge of educational

neuroscience is equal across groups. This result means that the spread of scores (variance) in each group is similar enough to confidently proceed with our analysis. The means and standard deviations for knowledge of educational neuroscience across these groups are presented in Table 5 under the descriptive statistics heading.

Results showed that there was no significant main effect for years of teaching experience, $F(2, 354) = 1.76, p = .17$), nor was there a significant interaction between years of teaching experience and educational neuroscience training, $F(6, 354) = 1.86, p = .09$). However, there was a significant main effect for educational neuroscience training on knowledge of educational neuroscience, $F(3, 354) = 4.38, p < .05$).

In order to identify which specific training levels differed from each other (second hypothesis), post hoc testing using Bonferroni indicated that knowledge of educational neuroscience was significantly higher for formal educational neuroscience training ($M = 28.45, SD = 11.41$) than they were for CPD training ($M = 20.74, SD = 8.51$), ($p < .001$), informal training ($M = 20.58, SD = 9.42$), ($p < .001$), and no exposure ($M = 19.58, SD = 9.22$), ($p < .001$). This suggests that the formal educational neuroscience training level was better able to distinguish neuromyths from neuro-facts compared to the CPD, informal and no exposure levels. Multiple comparison results are shown in Table 7.

Table 7. *Post Hoc Comparisons Across Educational Neuroscience Training Levels (Bonferroni)*

Comparison	<i>M</i> Difference	<i>SE</i>	<i>p</i>
Formal vs. CPD	7.71*	1.938	<.001
Formal vs. Informal exposure	7.87*	1.853	<.001
Formal vs. No exposure	12.3*	1.825	<.001
CPD vs. Informal	0.16	1.295	1
CPD vs. No exposure	4.59*	1.255	.002
Informal exposure vs. No exposure	4.43*	1.119	.001

Notes. *M* = Mean; *SE* = Standard Error.

*Result is significant at the 0.05 level.

Discussion

This study investigated the level of teachers' knowledge of educational neuroscience in the UK and examined the factors influencing this knowledge. Using a novel test (i.e. the ENKT), teachers' ability to discriminate between neuromyths and neuro-facts was assessed in relation to years of teaching experience and levels of educational neuroscience training. The findings suggest that formal educational neuroscience training is the most effective way to enhance teachers' knowledge, as it significantly improves their ability to distinguish between neuromyths and neuro-facts. CPD and informal exposure led to higher scores than having no exposure, but these forms of training were still less effective than formal training. Importantly, years of teaching experience did not predict teachers' knowledge of educational neuroscience, indicating that without structured learning opportunities, experience alone does not lead to improved understanding in this field.

A central contribution of this study is its demonstration that, despite the increasing recognition of educational neuroscience in education policy, structured and formalised

training in this area remains largely absent from ITT in the UK. While the recently introduced ITTECF (Department for Education, 2024a) incorporates some cognitive science principles, it does not provide teachers with a structured understanding of the neurocognitive mechanisms underlying learning. Consequently, teachers and schools are left to independently navigate and interpret educational neuroscience concepts, leading to inconsistencies in understanding and application.

This study provides evidence that formal educational neuroscience training is the most reliable means of developing teachers' knowledge in this field. Given that ITT programmes currently lack mandatory educational neuroscience components, these findings highlight the need for such content to become an integral part of teacher training. If educational neuroscience training remains fragmented across different sources, teachers will continue to experience uneven access to essential knowledge, increasing their susceptibility to neuromyths and limiting their ability to apply neuroscience-informed strategies in their teaching. This supports existing literature advocating for structured educational neuroscience programmes, as they provide a comprehensive understanding of neurocognitive mechanisms and critical evaluation skills (Betts et al., 2019; Papadatou-Pastou et al., 2017; Tokuhamma-Espinosa, 2018). The persistence of neuromyths, as identified in this study, highlights formal training as an effective way to combat these misconceptions, which can undermine evidence-based teaching practices if not addressed systematically (Torrijos-Muelas et al., 2021).

The study found no significant relationship between years of teaching and knowledge of educational neuroscience. This suggests that teaching experience alone does not influence the development of knowledge of educational neuroscience. This finding aligns with prior research indicating that many teachers may still perceive the need for

exposure to educational neuroscience throughout their careers (Privitera, 2021; Tokuhamas-Espinosa & Borja, 2023), particularly those trained before its integration into teacher training programmes. While these programmes previously omitted such content, recent but insufficient efforts have attempted to incorporate educational neuroscience principles (Department for Education, 2024a; Tokuhamas-Espinosa & Nouri, 2023). This highlights the need for interventions that address knowledge gaps across all career stages. Importantly, this finding highlights that even experienced teachers may endorse neuromyths, emphasising that misconceptions persist without targeted efforts to address them.

These findings highlight two key pathways for improving knowledge of educational neuroscience: ITT and CPD. Incorporating educational neuroscience content into ITT programmes would ensure that new teachers begin their careers with a strong foundation in evidence-based practices. For example, structured ITT courses could cover topics such as memory consolidation, executive function, and neuroplasticity, equipping teachers to design effective learning strategies for all students, including those with SEN. Additionally, ITT programmes should emphasise critical evaluation skills to enable teachers to identify and reject pseudoscientific claims, reducing the prevalence of neuromyth beliefs early in their careers.

As ITT programmes, such as the UK's recent ITTECF (Department for Education, 2024a), are relatively structured and formalised compared to less standardised and informal opportunities (Burton, 2020), the most effective way to provide formalised educational neuroscience training could be to incorporate this content into ITT programmes. This would enable teachers to begin their careers with a strong foundation of knowledge and skills in educational neuroscience. This foundational knowledge could then be reinforced and

expanded through CPD sessions throughout their careers, addressing the need for knowledge in teachers already practising.

However, as this study and prior research highlight, CPD often lacks the depth and consistency of formal training and may vary significantly in quality (M. M. Kennedy, 2016; Opfer & Pedder, 2011). Short-term or fragmented sessions may not adequately address the complexity of educational neuroscience concepts or provide teachers with the tools to evaluate misinformation critically. To maximise impact, CPD programmes should be designed as part of a coordinated, long-term strategy to reinforce and build upon the foundational knowledge acquired during ITT. For experienced teachers, such programmes could also help bridge gaps in understanding created by earlier, less comprehensive teacher training frameworks.

This dual approach of integrating educational neuroscience into ITT and CPD programmes aligns with broader calls for evidence-based teaching practices in education (Georgiou et al., 2020; Slavin, 2020). By systematically embedding educational neuroscience training across career stages, teachers can be better equipped to apply neurocognitive principles in diverse classroom settings. For instance, understanding the neurocognitive challenges faced by students with SEN, such as dyslexia or ADHD, allows teachers to implement tailored interventions that enhance learning outcomes (Howard-Jones et al., 2020; Thomas et al., 2019). Moreover, promoting a deeper understanding of general cognitive functions, such as attention and memory, enables teachers to design instructional strategies that benefit all students. By incorporating distinct categories of general cognitive function and SEN, the current study provides an in-depth evaluation of how knowledge of educational neuroscience manifests in diverse teaching contexts. This approach advances the research base by offering a new tool, the ENKT, for assessing knowledge of educational

neuroscience. It extends understanding by exploring the specific impact of different training levels, such as formal, CPD, informal, or no exposure, on teachers' ability to evaluate neuroscience concepts critically.

The study also points to the need for coordination and oversight in the dissemination of knowledge of educational neuroscience. Informal materials, while accessible, can perpetuate misconceptions or oversimplify complex concepts if not rigorously vetted. Teachers relying solely on these resources may lack the critical skills to distinguish between valid neuroscience principles and pseudoscience, leading to inconsistent classroom application. Formal and structured training, whether in ITT or CPD, can address this issue by providing teachers with credible, evidence-based knowledge and the ability to evaluate new information critically.

Implications

The findings of this study emphasise the importance of formal educational neuroscience training in improving teachers' knowledge of educational neuroscience. Educational institutions and policymakers should prioritise integrating educational neuroscience content into ITT programmes, ensuring that all new teachers graduate with a foundational understanding of neurocognitive principles. Well-structured CPD programmes should complement this by offering opportunities for ongoing learning, particularly for experienced teachers who may lack exposure to educational neuroscience content.

By adopting a dual strategy incorporating educational neuroscience into ITT and CPD, educational systems can create a more consistent and evidence-based approach to teaching. This would enhance teachers' ability to support diverse learners and promote the critical evaluation of new and emerging educational trends, promoting a culture of lifelong learning among teachers.

Limitations and future research

Although this study provides valuable insights into the factors influencing knowledge of educational neuroscience, it is essential to acknowledge some limitations. The relatively small number of participants with formal educational neuroscience training may limit the generalisability of findings related to this group. Future research should aim to include a larger, more representative sample of teachers across different educational neuroscience training levels to validate and expand upon these results. In particular, further validation with more diverse samples, preferably ensuring a balanced representation across different levels of educational neuroscience training, is necessary to enhance the robustness of the findings. Employing a controlled sampling approach can also be helpful for this aspect to ensure a more systematic representation of participants. Additionally, while collecting years of teaching experience using categorical variable allowed for clearer comparisons across distinct teaching career stages, it also resulted in some loss of statistical power and precision. Although no relationship was found between knowledge of educational neuroscience and years of teaching experience, future research may benefit from analysing teaching experience as a continuous measure to capture more nuanced relationships between teaching experience and knowledge of educational neuroscience.

While the differentiation index used in the ENKT offers a novel approach to assessing knowledge of educational neuroscience, further refinement of this tool could improve its reliability and validity as a widely accepted assessment tool. The ENKT was developed for this study, but further research should examine its psychometric properties to ensure reliability and validity across diverse teacher populations. Future studies should seek to validate and refine such tools to strengthen their applicability in research and practice. Future research could also explore alternative methods to assess teachers' knowledge of

educational neuroscience more effectively. For example, incorporating vignettes, which are realistic and context-specific scenarios, could enhance ecological validity. This method would evaluate how teachers apply educational neuroscience principles in practical situations. Such an approach could provide richer insights into their ability to distinguish neuromyths from neuro-facts and how they translate this knowledge into classroom practices. Longitudinal studies would also be valuable in exploring how this knowledge develops over time and the long-term impact of different training levels.

Finally, future research should investigate the specific components of formal educational neuroscience training that are most effective in reducing neuromyth beliefs and enhancing evidence-based practices. Identifying these elements could inform the design of more impactful training programmes, ensuring all teachers have the knowledge and skills necessary to support their students' learning and development.

Conclusion

This study highlights the critical role of formal educational neuroscience training in improving teachers' knowledge of educational neuroscience. While years of teaching experience were not a significant predictor of knowledge of educational neuroscience, formal training emerged as a key factor, emphasising the need for systematic and coordinated approaches to teacher training. Integrating educational neuroscience content into ITT programmes and providing structured, high-quality CPD opportunities throughout teachers' careers would address current gaps in knowledge and promote evidence-informed teaching practices. Such efforts have the potential to improve educational outcomes for all students, particularly those with SEN, and to promote a more informed and reflective teaching workforce.

Chapter 3

Teachers' Views on Educational Neuroscience (Study 2)

Teachers' Views on Educational Neuroscience (Study 2)

Rationale and Research Questions

As already noted, educational neuroscience is a field of research with significant potential to inform and enhance educational practices (Dubinsky et al., 2022; Gini et al., 2021; Howard-Jones et al., 2020; Thomas et al., 2019). Teachers are increasingly interested in learning about this field (Thomas et al., 2024), engaging through various means such as formal and structured training, Continuing Professional Development (CPD) courses, and engagement with professional or educational materials such as videos, blogs, books and magazines. Study 1 of this project revealed that these different types of engagement are linked with varying levels of knowledge of educational neuroscience (Arslan et al., 2022). Understanding these diverse engagement pathways is crucial for fostering effective application of educational neuroscience concepts in education.

Given the field's potential and teachers' growing interest, it is crucial to explore teachers' attitudes towards educational neuroscience and identify barriers or opportunities for engaging with its training and materials. Teachers' perceptions provide valuable insights into how educational neuroscience concepts are understood, valued, and practically implemented in educational contexts. Understanding these attitudes is particularly significant because perceptions often shape behaviours, influencing the likelihood of engaging with educational neuroscience training and applying its principles in the classroom. By examining these attitudes, researchers can pinpoint specific challenges that hinder the adoption of educational neuroscience-informed practices, especially in supporting students with special educational needs (SEN). A deeper understanding of neurocognitive mechanisms is critical for effectively addressing SEN (Howard-Jones et al., 2020; Rogers & Thomas, 2022; Thomas et al., 2019), and systematic integration of

educational neuroscience principles into teacher training and development can provide educators with evidence-based tools to enhance learning outcomes (Privitera, 2021; Privitera et al., 2023; Tokuhamma-Espinosa, 2008; Tokuhamma-Espinosa & Nouri, 2023).

Addressing these barriers can significantly enhance the adoption and application of educational neuroscience within classroom practices (Ching et al., 2020; Dubinsky et al., 2019). By systematically integrating educational neuroscience training into Initial Teacher Training (ITT) and CPD, teachers can build foundational knowledge about neurocognitive mechanisms such as memory, attention, and executive function, which are essential for effective learning. For instance, embedding educational neuroscience principles into Initial Teacher Training curricula, as suggested in the literature review, provides teachers with tools to understand cognitive diversity better and optimise teaching methods for all learners, including those with SEN. This integration not only equips educators with evidence-based strategies but also reduces the prevalence of neuromyths, promoting a more scientifically informed teaching workforce.

Creating supportive environments also ensures equitable access to reliable educational neuroscience resources and structured training. Efforts to collaborate between researchers and educators, such as those highlighted in frameworks by Tokuhamma-Espinosa and Nouri (2023), can bridge the gap between theory and practice. For example, curated educational resources and platforms can make research findings accessible and actionable for teachers. These initiatives promote a culture of continuous professional growth, where teachers feel empowered to adapt educational neuroscience insights to diverse classroom needs. By addressing financial, time, and knowledge barriers through institutional support, educators can move from fragmented and informal educational neuroscience exposure to a cohesive and practical understanding of its principles.

Furthermore, enhancing educational neuroscience-focused training and collaboration can strengthen interdisciplinary dialogue, enabling educators to co-create research agendas that address classroom realities. This reciprocal relationship ensures that educational neuroscience research remains relevant and directly applicable, supporting teachers in implementing tailored strategies to improve learning outcomes. These efforts collectively nurture an ecosystem where continuous learning is the norm, and educational neuroscience becomes a cornerstone of modern pedagogical practices, particularly in supporting SEN students.

This study employed a qualitative approach to explore teachers' views on the perceived value, challenges, and benefits of educational neuroscience in classroom practice, including those related to training and professional development. This investigation addresses the third main research question: "What are teachers' views on the value of educational neuroscience in teaching practice and the challenges they face in accessing resources and training in this field?" To thoroughly address this question and ensure a comprehensive understanding of the various aspects of teachers' perspectives on educational neuroscience, four more specific and connected research questions were formulated:

1. How do teachers perceive their own knowledge of educational neuroscience?
2. How do teachers perceive the value of educational neuroscience as part of the teaching profession?
3. What barriers, if any, do teachers perceive regarding training in educational neuroscience?
4. What barriers, if any, do teachers perceive regarding accessing materials and resources related to educational neuroscience?

The underlying principles guiding data collection were derived from naturalistic inquiry (Lincoln & Guba, 1985), a theoretical framework often associated with an inductive and flexible research design. This approach, which captures insights directly from individuals undergoing a particular experience, allows researchers to explore participants' perspectives without imposing preconceived categories or theories (Moustakas, 1990).

The study aimed to gather insights from teachers with varying levels of exposure to educational neuroscience to gain a comprehensive understanding of views on it. Four educational neuroscience training levels were targeted: formal, CPD, informal, and no exposure. These were the training levels identified in Study 1 (see the *Descriptive Statistics* section of Chapter 2 for details of these levels). A series of focus groups were employed to leverage discussion and group dynamics to augment in-depth information gathering (A. Bowling, 2014). This method also facilitates the identification of common themes and understanding of the complex interplay between teachers' beliefs and classroom practices by leveraging group dynamics and encouraging open discussions where participants build on each other's responses. This process allows for a richer exploration of shared experiences and diverse perspectives, which may not emerge in individual interviews (Hook & Farah, 2013). However, based on the number of available participants and their schedules, participants were allocated to focus groups with three or more participants, dyadic interviews with two participants, or individual interviews. This adaptation was necessary to accommodate the pressures on teachers' time and ensure that meaningful data could still be collected.

Although focus groups, dyadic interviews, and individual interviews have distinct features, these methods share commonalities, facilitating participant-researcher interaction for exploring complex issues and gathering diverse perspectives (Adams, 2015; Longhurst,

2009; Morgan et al., 2013; Wilson, 2014). These methods also provide opportunities for participants to raise new issues and for the researcher to use probes and spontaneous questions to deepen understanding and clarify responses (Adams, 2015; Longhurst, 2009; Wilson, 2014).

Data were collected online. Online data collection has become increasingly prevalent, particularly since the COVID-19 pandemic, and this method is versatile and practical and produces results similar to those of offline methods (Nugraha & Susilastuti, 2021; Zhang et al., 2022). Online data collection methods, such as Teams and Zoom, are interactive and valid tools, and educators have also adapted to using these platforms for teaching and learning (Adipat, 2021). Since participants were from schools in different parts of the United Kingdom, this method enabled us to gather input from not just one catchment area but regions across the United Kingdom.

Methods

Participants

Participants for this study were drawn from those involved in Study 1 and selected from those who had agreed at that point to participate in future research of this PhD project. Initially, email invitations were sent to 160 potential participants, and 32 responded with interest.

As discussed in the rationale, this study aimed to gather insights from teachers with varying levels of exposure to educational neuroscience. The plan was to organise one focus group per educational neuroscience training level, each consisting of six participants. This number was deemed sufficient based on qualitative research practices, which suggest that focus groups with 4-6 participants allow for in-depth discussion and effective group dynamics while ensuring all participants have the opportunity to contribute (Hennink et al.,

2019; Krueger & Casey, 2015; Morgan, 1996, 1997). Furthermore, the aim was to balance the need for manageable group sizes with the practical constraints of participant availability.

To achieve the desired number of participants, six individuals per educational neuroscience level were targeted for contact, with additional participants kept as backups to account for potential dropouts. However, at the formal educational neuroscience level, only four participants expressed interest. Consequently, all four were contacted and offered time slots. These participants were from the primary school sector. For the other three levels, six participants were contacted for each level, with a balance between primary and secondary school teachers (three each) to ensure diversity.

In total, this approach resulted in 22 participants being initially contacted with focus group time slots, while an additional 10 participants were designated as backups in case of dropouts. From the initial pool of 22 participants, 10 did not respond to follow-up communications, and three dropped out before the sessions commenced. Attempts were made to contact the 10 backup participants to fill these vacancies; however, no responses were received. As a result, the final number of participants was nine (8 female).

Age data was available in categories. As done in Study 1, the mean age of participants was estimated by assigning a midpoint to each age group (e.g., 21.5 for 18-25, 28 for 26-30, and so on). Each midpoint was multiplied by the frequency of participants in that age group to create a weighted sum, which was then divided by the total number of participants. This method produced an approximate mean age of 46.17 years ($SD = .87$), providing a general estimate in cases where individual ages are unavailable.

Materials

Before data collection, measures were undertaken to ensure the integrity of the content, structure and approach. These safeguards involved a two-step process: obtaining

feedback on the discussion topics and focus group structure and conducting a pilot test on the discussion topics to assess language suitability.

Firstly, the discussion topics were forwarded to two UK-based primary school teachers, one from an SEN and one from a mainstream school, both having experience with SEN. The intended question sequence was: a) introduction and general discussion, b) experiences and perspectives on educational neuroscience training and materials, and c) willingness, preferences, and recommendations in educational neuroscience engagement. Subsequently, the following revisions were made to the discussion topics based on the piloting outcomes.

The first question, “If I say educational neuroscience, what is your reaction to that?” was deemed overly broad. Therefore, follow-up prompts, such as “Do you know what it is?”, were introduced to enhance clarity and steer the discussion. Additionally, specific prompts were added to gather more detailed responses about educational neuroscience training and their influence on classroom practice. Example prompts included, “What sort of training was it?”, “Where did you find the training that you underwent?” and “How has this training impacted your approach to teaching?”

Following the refinement of the discussion topics, a full-length in-person pilot session was conducted with a primary-school mathematics teacher and an educational psychologist pursuing PhDs in education and educational psychology, respectively, with some exposure to educational neuroscience training. They were instructed to pause the facilitator if they encountered any unclear points, provide feedback, and resume. Although no points were found unclear, the pilot participants informed the facilitator that some prompts were discussed more quickly than anticipated, leaving insufficient time to respond to specific discussion topics. Timing guidelines were therefore included in the Facilitator

Guidelines and Session document (please refer to the following paragraphs for detailed information). Towards the conclusion of the pilot session, participants were asked to provide general feedback on how much they felt engaged in a natural conversation. Due to real-time feedback provided by participants through pauses and at the end of the session, the pilot took 68 minutes to complete.

The discussion questions used in the focus groups and interviews were carefully crafted to serve two main purposes: to gather specific information about the participants' educational neuroscience training history, and to elicit more open-ended, reflective responses that explored participants' thoughts, emotions, motivations, and feelings regarding their educational neuroscience training experience.

A structured approach, commencing with overarching and broad inquiries followed by progressively more specific points, was adopted for a detailed exploration of participants' perspectives and to ensure a nuanced understanding of their experiences.

For each method (i.e. interview, dyadic, or focus group), the questions were divided into three main topics: a) introduction and general discussion, b) experiences and perspectives on educational neuroscience training and materials, and c) willingness, preferences, and recommendations in educational neuroscience engagement. Participants from each method received the same pre-defined questions. Although slight variations in follow-up questions occurred during the sessions, the core discussion topics remained consistent across the three methods.

As there were four distinct educational neuroscience training levels, each with differing levels of educational neuroscience exposure, some follow-up prompts did not apply to certain educational neuroscience training levels. Therefore, two documents outlining revised discussion questions based on these levels were created. Both documents

included the first (introduction and general discussion) and third (willingness, preferences, and recommendations in educational neuroscience engagement) discussion topics. Follow-up prompts were adjusted for the second discussion topics (experiences and perspectives on educational neuroscience training and materials) to suit the specific levels of educational neuroscience training. This ensured the discussion was relevant and aligned with the participants' prior experiences or lack thereof.

The first document, for the formal and CPD levels, includes detailed follow-up prompts about the types of educational neuroscience training participants received, their motivations for and barriers to undertaking the training, and the impact of the training on their teaching practices (e.g., "What sort of training was it?" and "How has this training impacted your approach to teaching?").

The second document, for the informal and no-exposure level, excluded follow-up prompts concerning previous exposure to educational neuroscience training, as they had reported no prior training in this field. Instead, they were prompted to discuss the absence of training and the reasons for it, focusing on their general perceptions of educational neuroscience, barriers to receiving educational neuroscience training, and their views on the accessibility and impact of educational neuroscience materials (e.g., "You mentioned in the initial questionnaire that you did not have any training in educational neuroscience; can you just tell me a bit more about this?" and "What type of materials in educational neuroscience do you know of?").

The following paragraphs provide detailed information on the three main discussion topics used across all methods (i.e., interview, dyadic, or focus group): 1) Introduction and General Discussion, 2) Experiences and Perspectives on Educational Neuroscience Training

and Materials, and 3) Willingness, Preferences, and Recommendations in Educational Neuroscience Engagement.

Introduction and General Discussion.

The aim of this section was to understand participants' perspectives on educational neuroscience, irrespective of their prior exposure to related training or materials. The following questions and prompts were used.

Initial Reactions to Educational Neuroscience. Participants were asked to provide their spontaneous reactions to the term "educational neuroscience." The purpose of this was to capture initial thoughts and feelings. Prompts for clarification were given, if required, to encourage discussion. Example prompts included "Do you know what it is?" and "How do these words, educational neuroscience, make you feel?"

Clarifying Educational Neuroscience. After participants shared their initial reactions to the term "educational neuroscience" and explained their understanding, they were provided with a standard definition to ensure a shared frame of reference for subsequent discussions. This step was included to address potential variations in participants' interpretations of the term, which could otherwise lead to misunderstandings during the session.

Participants were informed that educational neuroscience refers to a broad concept encompassing the study of the learning brain and the cognitive mechanisms involved in learning. To support understanding and facilitate discussion, examples of key topics within educational neuroscience, such as attention, memory, and executive function, were shared.

Prompts were used to guide this portion of the discussion and encourage participants to reflect on the concept. Examples of prompts included: "Explain knowledge of educational neuroscience: for example, having knowledge about attention and memory".

This helped ensure that each participant clearly understood what the term educational neuroscience meant in the sessions, which helped the facilitator to continue the following discussion topics based on this general definition. This served as a starting point for participants to reflect on their understanding or experiences related to these cognitive mechanisms. Following the prompt, participants were encouraged to elaborate, share their interpretations, or discuss any familiarity with the concepts mentioned.

Views on the Value of Knowledge of Educational Neuroscience in Classrooms.

Participants were asked for their perspectives on the value of knowledge of educational neuroscience. Prompts were used to guide discussions, and participants were invited to explore the potential benefits of integrating knowledge of educational neuroscience into teaching practices. Participants were also prompted to consider potential benefits related to SEN resulting from increased knowledge of educational neuroscience. Example prompts included, "How do you think learning about this [e.g., attention, memory, or executive function as cognitive mechanisms involved in learning] can be beneficial for teachers?" and "How do you think this can improve teaching practices in the classroom?"

Experiences and Perspectives on Educational Neuroscience Training and Materials

This section focused on the participants' experiences with educational neuroscience training and materials. The goal was to understand their motivation to engage with such training and materials, identify potential barriers or challenges to these training and materials, and understand the impact of such training and materials on their teaching practices.

This section was divided into two sub-sections for clarity: a) perspectives on educational neuroscience training, such as those related to courses and CPD sessions, which primarily applied to formal/CPD level participants, with adjustments made for informal and

no-exposure participants to reflect their lack of prior educational neuroscience training, and
b) perspectives on educational neuroscience materials, such as videos, books, and
magazines, which were relevant across all participant groups.

Perspectives on Educational Neuroscience Training. Participants were prompted to share the motivations driving their engagement in educational neuroscience training. This aimed to uncover personal incentives or perceived professional benefits that encouraged their participation. This was followed by insights into participants' reactions during and after training, including positive and negative aspects encountered. Example prompts included, "What sort of training was it?" "Where did you find the training that you underwent?" "What did motivate you to take this training?" "Tell me your reaction to the training while you were doing it and after you had done it." If they talked very much about the design of their previous course and not about their engagement, additional prompts included, "How do you feel about this training or exposure?" "What did you like about it?" "What did you dislike about it?".

Participants were then asked to reflect on how their training influenced their overall teaching approach, as well as their approach to teaching children with SEN. Specific emphasis was placed on whether the training led to any tangible changes in classroom practices. They were then encouraged to share instances where their educational neuroscience training was directly applicable to real-life teaching scenarios. Potential scenarios included understanding individual differences in learning, optimising learning environments, and managing cognitive load.

Perspectives on Educational Neuroscience Materials. Participants were prompted to discuss the types of educational neuroscience materials they were familiar with and the ease of acquiring these materials. Example prompts included, "What type of materials in

educational neuroscience do you know of?", "Can you describe any experiences you have had with educational materials? " and "What has your experience been like in accessing these materials?" Participants were then prompted to reflect on how their exposure to educational neuroscience materials impacted their teaching approach. Example prompts included, "How do you feel your teaching approach has been influenced by the materials you have read or used?" and "In what ways do you think exposure to various types of these materials impacts your teaching practices, especially for students with special educational needs?"

Willingness, Preferences, and Recommendations in Educational Neuroscience

Engagement

This section aimed to understand the factors influencing teachers' preferences and willingness to engage with educational neuroscience training and materials. Participants were asked about their willingness to undergo free, school-encouraged (but not mandated) educational neuroscience training. Example prompts included: "If there was an ideal world where you could take educational neuroscience-related training for free and your school encourages but does not mandate it, would you take it?" "If you wanted to learn more about educational neuroscience, what strategies would you use?" and "How likely would you recommend this type of exposure to other teachers? Why or why not?"

Facilitator Guidelines and Session Protocols

To ensure consistency across sessions, a detailed 'facilitator guidelines and session protocols' document was created. This document delineated the procedures to be followed before, during, and after each discussion session and provided clear guidance for the facilitator. The document was divided into three sub-sections: a) Preparation, Introduction, and Welcome; b) the Session; and c) General Rules.

Preparation, Introduction, and Welcome. Before the discussions commenced, all necessary steps were taken. This included reminders for equipment testing, such as ensuring the functionality of the recording option on Zoom. Participant attendance and their informed consent were confirmed in this section.

Detailed procedures were followed to ensure smooth communication. This included verifying participants' internet connections and ensuring the visibility of participants' names to each other. A welcoming message and brief session outline were provided to promote an inclusive and collaborative environment. Participants were assured of the confidentiality of their contributions, emphasising that there were no right or wrong answers. Information was given regarding session recordings and the secure storage of collected data in alignment with GDPR and UCL Ethics Guidelines.

General Rules. Throughout the sessions, specific guidelines for conduct and engagement were adhered to. Each discussion topic was covered without skipping any or dwelling excessively on one. Instead, a natural flow of conversation was maintained, participants' levels of interest and engagement were identified, and examples from their own experiences were encouraged. Time was kept using a clock to ensure that discussions did not overrun excessively. Every 10 minutes, it was checked whether a discussion topic had been explored adequately, aiming to limit each theme to a maximum of 10 minutes to prevent participant boredom. Efforts were made to conclude within an hour to avoid dissatisfaction among participants, though ending earlier was acceptable.

Furthermore, since participant contributions were valued, they were allowed to lead the session. Measures were taken to prevent anyone from monopolising the conversation by using polite prompts to redirect the discussion when necessary. Examples of probes included silent/affirmative probes (e.g., "uh huh, I see"), echo probes (e.g., repeating back

the last thing they said), and challenging probes (e.g., "why, please explain"). These probes were used to encourage further discussion, clarify points, and delve deeper into topics of interest.

Procedure

Participants were initially contacted using email addresses provided in Study 1 for further involvement in our research. They were invited to engage further and informed about the transition to the next phase via a research information sheet (Appendix F). This clearly outlined the inclusion/exclusion criteria for participants, provided details about the purpose of the study, explained the voluntary nature of participation, assured confidentiality and data security, and informed participants that the data collection method would depend on participant numbers (e.g., focus groups, dyadic, or individual interviews).

Participants were asked to complete a short online questionnaire as part of their response to the invitation. In Study 1, participants were given the option to provide their email addresses if they were interested in participating in future research, including the current Study 2. However, their email addresses were not linked to their Study 1 responses, which had been anonymised. To address this, the online questionnaire for Study 2 was designed to collect updated demographic information, teaching experience, and prior exposure to educational neuroscience training. This allowed participants to be appropriately grouped for the focus groups while maintaining the confidentiality of their original responses in Study 1.

Moreover, at the end of the questionnaire, participants were presented with the Educational Neuroscience Knowledge Test (ENKT), which had been developed in Study 1. The ENKT assess the ability to distinguish neuromyths from scientifically accurate information (neuro-facts). Detailed information on the ENKT's development, structure, and

scoring is provided in Study 1 (Chapter 2). Including ENKT in Study 2 served a logistical purpose for the planning of Study 3. Study 3 involved an educational neuroscience course with a true experimental design, including treatment and control groups, and was planned to include pre-test and post-testing. By administering the ENKT at the Study 2 stage, pre-test scores for Study 3 could be obtained well in advance of the course, ensuring a long interval between the pre-test and post-test phases. The Study 2 research information sheet informed participants that they would be contacted later for the final phase of the research (Study 3) as well.

Each participant received a unique questionnaire link to link their email addresses to their responses automatically.

Following the initial invitation emails, timeslots for focus groups were sent to the 32 participants who responded. Considering busy teaching schedules and the varying availability of participants, they were provided with a range of time slots over two weeks and two weekend days with morning and evening slots. They were notified that the sessions would be conducted via Zoom. Participants were asked to reply within two weeks, selecting as many suitable time slots as possible to facilitate scheduling. They were informed they would receive an Amazon gift card to the value of £15 as a token of appreciation for their time.

Once suitable times were arranged, participants received a Zoom link with the confirmed date and time for the group discussion, along with a consent form (Appendix G). Nine participants (8 female) took part due to scheduling constraints and limited responses from backup participants (see *Participants* section for details). All sessions were conducted upon completion of the consent forms.

The equipment and internet connections were checked to ensure the quality of the recording, and the discussion sessions began with a welcome and gratitude message. For the purposes of the recording, the facilitator stated the date of the session, and the number and names of the participants present. As part of the welcome and warm-up, participants were informed that they would introduce each other one by one with names, their connecting locations, and the schools where they worked. To initiate conversations, the facilitator shared details about himself and invited others. During this phase, the facilitator took notes about participants' schools and their locations, enabling reference to specific points later in the session.

Once the introductions were completed and the facilitator ensured that everyone could see each other's names, an outline of the session was provided. Participants were informed that the discussion would revolve around the role of educational neuroscience for teachers in the UK. They were also informed that the facilitator might occasionally refer to his notebook to take notes to follow the discussion better.

At the end of the sessions, participants were given the opportunity to share any additional thoughts or comments they deemed relevant to the discussion. They were then invited to our free online course in educational neuroscience (Study 3), and their preferred contact method (e.g., email, mobile phones) was asked for ease of communication regarding the course, with assurances of privacy. Amazon gift cards were sent to all participants upon completion of all sessions. The average session length was approximately 40 minutes, ranging from 31 to 49 minutes. This duration primarily depended on the number of participants and the lengths of their answers. All sessions were completed within three weeks, from mid-November to early December 2023.

Ethics and Sampling

The UCL Institute of Education Ethics Committee granted full ethical approval for the study (Appendix A).

Official UCL Ethics Guidelines suggest that Microsoft Teams is UCL's preferred option for research data collection over Zoom. This is because when using Microsoft Teams, the data is processed through UCL servers, and data in Teams is held in Microsoft Data Centres in Europe, which are compliant with GDPR. Therefore, researchers and participants can be assured that the data remains more secure. However, this is not the case when using Zoom, as though Zoom have servers in multiple countries to ensure a good quality of service is maintained, the data itself is stored in the United States of America. Therefore, when a session is recorded via Zoom, the data is processed by Zoom, meaning the data is sent to the US servers before being sent back to the UK to UCL servers, which means that a data transfer to the US has been made. However, Zoom was given as an alternative if the researchers considered the Microsoft Teams option and do not feel it works for their research project (www.ucl.ac.uk/dataprotection/covid-19-data-protection-faqs).

Consequently, while the Microsoft Teams option was considered as the online data collection method, Zoom was selected over Microsoft Teams since it would be a more accessible option for teacher participants than Microsoft Teams. This is because our teacher participants would be more familiar with using Zoom as an education tool in their schools, especially since the beginning of the pandemic (Adipat, 2021; Nugraha & Susilastuti, 2021; Zhang et al., 2022).

Data analysis

The data analysis approach selected for this study was reflexive thematic analysis ('RTA', Braun & Clarke, 2006, 2022), a qualitative method for systematically identifying,

analysing, and interpreting patterns or themes within data. This iterative and flexible method allows researchers to refine insights through familiarisation, coding, and theme development cycles, making it particularly suitable for exploring the nuanced perspectives of teachers. RTA was chosen for its alignment with the study's objectives, providing a robust framework for examining the interplay between teachers' professional backgrounds, training experiences, and classroom practices and for generating themes that directly address the research questions (Braun et al., 2014; Braun & Clarke, 2019).

Given the diverse contexts in which participating teachers work, RTA's adaptability ensures the analysis captures each participant's specific settings and circumstances. This approach was instrumental in uncovering educational neuroscience's perceived challenges and benefits, teachers' knowledge of educational neuroscience, and the barriers to accessing relevant training and resources (Terry et al., 2017). The method also supported the generation of actionable insights to inform the design of future educational neuroscience training programmes, enhancing teachers' ability to apply knowledge of educational neuroscience effectively.

NVivo 14.23.3 for Windows was used to organise data. As proposed by Braun and Clarke (2006, 2022), a six-step process was systematically followed:

1. **Familiarisation with the Data:** To initiate this step, all data were transcribed without making any changes to the extracted data, including repetitive words and sentences. The researcher then started reading the transcripts to become familiar with the content. This step aimed to gain a sense of the breadth and depth of the material in relation to the research questions and develop a preliminary understanding of potential patterns, codes and themes.

2. **Generating Initial Codes:** In this step, initial codes were systematically generated to label data features related to the research questions. These included line-by-line coding and breaking content down into meaningful segments. In the initial stage of this step, fifty-six codes were generated. These codes represented the most basic segments of the data that were relevant to the research questions. A hybrid process of inductive and deductive coding was used to analyse data. The deductive initiation of coding involved using pre-existing concepts or categories derived from the research questions, such as "teachers' knowledge of educational neuroscience" or "barriers to educational neuroscience training," to guide the initial coding process, which was then complemented by the inductive generation of new codes through iterative refinement as the researcher sifted through the data.
3. **Generating Initial Themes (Candidate Themes):** The initial codes were categorised into potential themes by grouping codes relevant to the research questions. All codes and linked data were revised to identify possible combinations of codes based on shared meanings, facilitating the formation of themes and sub-themes. Themes represented higher-level concepts or patterns that emerge from the coded data. They addressed this study's research aims by highlighting the nature of teachers' attitudes towards and engagement with educational neuroscience.
4. **Reviewing Potential Themes:** Once the themes were generated, they were examined and refined by reviewing and checking them against the coded extracts and the entire dataset. This step ensured that each theme was internally coherent and distinct from others. The themes' overall story and relevance to the research questions were considered at this stage.

5. **Defining and Naming Themes:** At this stage, themes were clearly defined and named, each representing a coherent and recognisable pattern within the data.
6. **Producing the Report:** The final stage involved writing the report and presenting the findings in a coherent narrative. Quotations from the data were included to illustrate each theme, ensuring the report conveyed a clear and compelling analysis story.

Reliability and Validity.

Once the themes were generated based on the relevant codes, all coded data, codes, themes, and sub-themes were subjected to the evaluation of an experienced qualitative researcher as part of the quality control process. This evaluation involved reviewing the coding process and the generated themes to ensure that they accurately represented the data and were consistent with the research questions. The qualitative researcher independently assessed the codes' appropriateness, the themes' coherence, and the alignment between the coded data and the identified themes.

Additionally, the researcher provided critical feedback on the refinement of the themes, ensuring that they were not only representative of the data but also distinct and non-overlapping. Through this external review, the credibility of the findings was strengthened, ensuring that the analysis process remained transparent and grounded in the data.

To further enhance reliability, teacher opinions emerging from discussion sessions were supported by relevant quotes that captured the essence of each code. This approach ensures that the data presented is reflective of the participants' true perspectives and experiences. Careful documentation and the use of unaltered quotations are critical practices in qualitative research, as they help to maintain the authenticity and richness of the data, thereby strengthening the study's reliability (Büyüköztürk et al., 2017; Lingard &

Watling, 2021; Shenton, 2004). By presenting direct quotes, the study not only illustrates the themes identified but also allows readers to see the direct linkage between the data and the conclusions drawn, enhancing the findings' validity. This method is particularly important in addressing potential subjectivity and scepticism, as it provides a transparent account of how interpretations are grounded in the data.

Results

Participants represented varying levels of educational neuroscience exposure: one from the formal level, three from the CPD level, two from the informal level, and three from the no-exposure level. Despite efforts to fill the vacancies from the initial pool of backups, the final number was constrained by time limitations and participant availability.

Overall, all participants had more than six years of teaching experience. All participants reported having more than six years of classroom teaching experience with SEN, except for one having 3-5 years of teaching experience with SEN. In addition to main teaching roles in schools, all participants had additional roles, such as subject lead and headteacher. Pseudonyms were assigned to each participant and are used throughout the results section when presenting excerpts from the discussion sessions. These pseudonyms, participant demographic details, educational neuroscience training levels, and interview types, are displayed in Table 8.

Table 8. Educational Neuroscience Training by Participant Demographics, Teaching Roles and Qualifications

Educational Neuroscience Training	Age Group (G)	Main Role	Additional Role	Highest Qual	Interview Type	Pseudonym
Formal	55-64 (F)	Primary	Headteacher /Head of School/Acting Head	Bachelor's	Individual Interview	Alice
CPD	35-44 (F)	Primary	Subject Lead	PGCE or PGDE	Individual Interview	Beth
	55-64 (F)	Primary	Headteacher /Head of School/Acting Head	Bachelor's	Dyadic	Caroline
	45-54 (F)	Primary	Deputy or Assistant Head	Bachelor's	Dyadic	Diana
Informal	35-44 (F)	SEN	Subject Lead	Bachelor's	Individual Interview	Emma
	35-44 (F)	SEN	Deputy or Assistant Head	Master's	Individual Interview	Fiona
No Exposure	35-44 (F)	Secondary	Subject Lead	Master's	Focus Group	Grace
	45-54 (M)	Secondary	Subject Lead	Master's	Focus Group	Henry
	35-44 (F)	Secondary	Head of Sixth Form	Master's	Focus Group	Ivy

Notes. G = Gender; Qual = Qualification. Formal = undergraduate or postgraduate level; CPD = Continuing Professional Development level, but no formal educational neuroscience level; Informal = engagement with professional or educational materials related to educational neuroscience, but neither formal educational neuroscience nor CPD level; No Exposure = No exposure to any identified educational neuroscience training.

Based on the number of participants, the formal level had one individual interview with one participant. The CPD level included one dyadic interview with two participants and

one additional individual interview with one participant. The informal exposure level involved two separate interviews, each with one participant. Finally, the no-exposure level consisted of one focus group with three participants.

As noted earlier in the chapter, the decision regarding individual, dyadic, or focus group interviews was based on participant availability. While the CPD group had three participants, a scheduling conflict with one prevented conducting a focus group. Consequently, a dyadic interview was held with the two available participants, and an individual interview was conducted with the third. As group discussions were preferred whenever possible, as they allow participants to engage in dialogue and build on each other's responses, which may enhance data richness, conducting three individual interviews was not the preferred approach.

The analysis resulted in the identification of three main themes: (1) Teacher Perceptions of Knowledge of Educational Neuroscience, (2) the Role and Value of Educational Neuroscience in Teaching, and (3) Barriers to Incorporating Educational Neuroscience in the Classroom. These themes included six related sub-themes. A miscellaneous theme was generated for seven codes that did not fit the themes. Table 9 illustrates these themes and their sub-themes, and the following paragraphs explain each identified theme and sub-theme with the related insights that were identified in the data. For a visual representation of the themes and sub-themes are also illustrated in Figure 2.

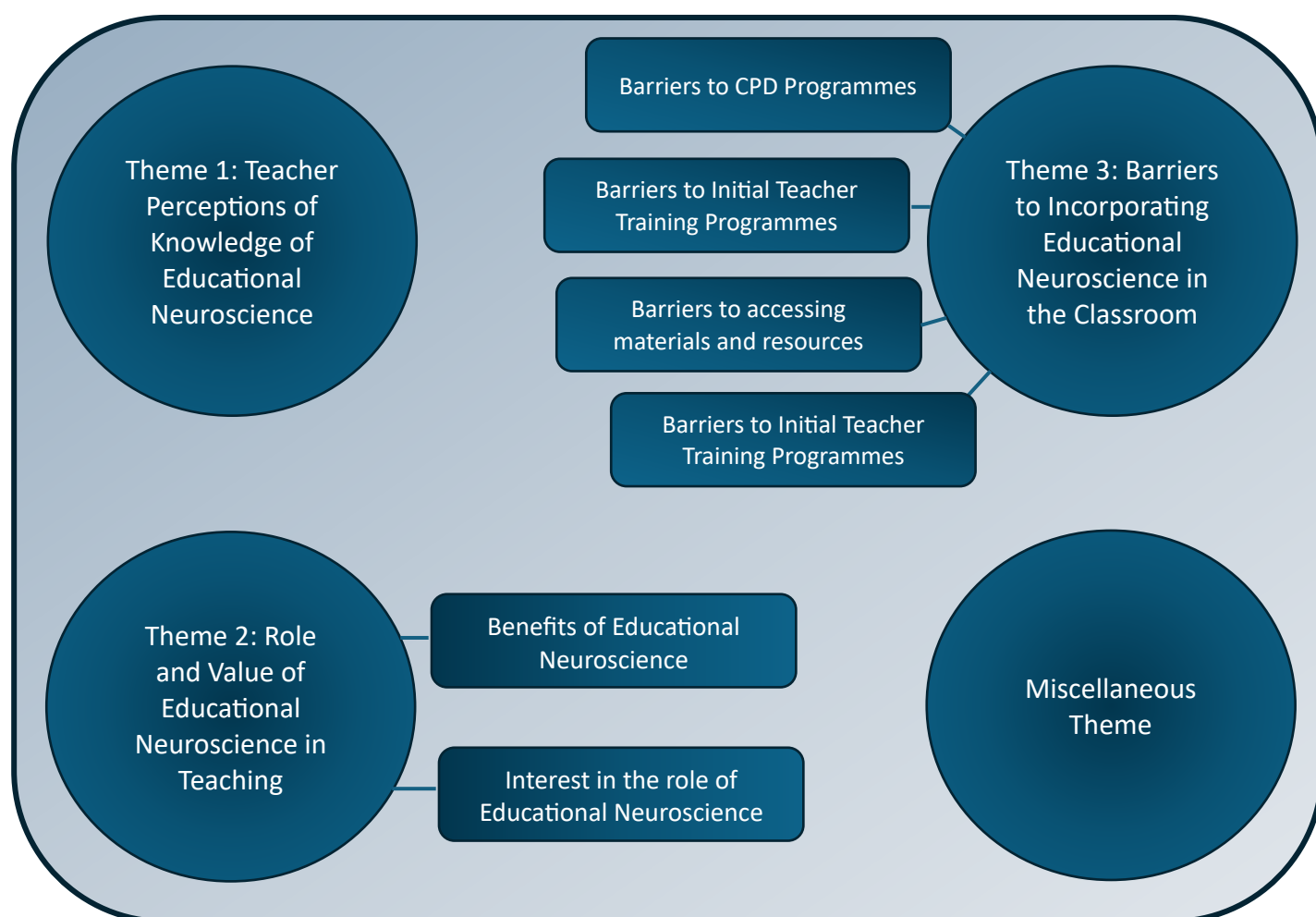
Initially, the results were structured to allow comparisons between participants' educational neuroscience training levels and their teaching roles (primary, secondary, SEN). However, within each training level, participants shared similar teaching roles. For instance, all participants in the CPD group reported teaching at the primary level, whereas those with no exposure to educational neuroscience training were all secondary school teachers. As a

result, rather than direct role-based comparisons across training levels, the analysis focused on identifying commonalities and differences based on participants' level of exposure to educational neuroscience training.

Table 9. *Themes and Sub-Themes*

Theme 1: Teacher Perceptions of Knowledge of Educational Neuroscience
• No sub-themes
Theme 2: Role and Value of Educational Neuroscience in Teaching
• Sub-theme 1: Benefits of Educational Neuroscience • Sub-theme 2: Interest in the role of Educational Neuroscience
Theme 3: Barriers to Incorporating Educational Neuroscience in the Classroom
• Sub-theme 1: Barriers to CPD Programmes • Sub-theme 2: Barriers to Initial Teacher Training Programmes (ITTs) • Sub-theme 3: Barriers to accessing materials and resources • Sub-theme 4: Practical implementation in the classroom
Miscellaneous Theme
• No sub-themes

Figure 2. Thematic Map



Theme 1: Teacher Perceptions of Knowledge of Educational Neuroscience

The data revealed nuanced insights into teachers' understanding and application of neuroscientific concepts in educational contexts. Teachers exhibited varying levels of familiarity with educational neuroscience terminology, with some integrating educational neuroscience principles into their teaching without explicitly recognising them as such. For instance, Grace (No Exposure group) suggested that teachers might know more about educational neuroscience than they consciously realise, despite an initial hesitancy towards the term:

"Teachers know more than they consciously think they do. I think if you use the phrase in a general sort of staff room, you'll get a lot of rolled eyes and people go

'ohh don't know about that,' but I think if you start to pause and think about it, you probably do know a lot more about it as a teacher or you do put it into effect and think about it, but without necessarily using the terminology." (Grace, No Exposure group).

Similarly, Henry (No Exposure group) suggested that awareness of educational neuroscience concepts has been increasing, particularly due to the influence of SEN teachers and support staff who regularly use neuroscience-informed language:

"Teachers are more informed about neuroscience than they might think, but I do think the reason for that is SEN teachers and SEN support staff will be using those ideas and that language sort of fairly frequently in staff rooms. And I think that's helped to make the concepts more familiar than certainly they would have been when I started my teaching." (Henry, No Exposure group).

Despite this growing awareness, some teachers, particularly those trained earlier in their careers, noted that educational neuroscience was not part of their initial training. Beth (CPD group) reflected on this gap, highlighting how educational neuroscience was not even a recognised term when they were training as a teacher:

"It's something that obviously wasn't a phrase at all when I was at a training stage. So, 20 years ago, I'd never heard of it at all and it's not a phrase actually that comes up in education much." (Beth, CPD group).

This sentiment aligns with the broader challenge of embedding neuroscience into teacher training. Beth (CPD group) also highlighted that while she had engaged with professional development on topics like autism and dyslexia, the term *educational neuroscience* was never explicitly used:

"I've had training in things like autism, the autistic spectrum, some training in dyslexia training in certain areas, but it's never been termed educational neuroscience. I think that's something that I've never come across actually in the educational context, only kind of outside it; through discussions or reading things and magazines, things like that stuff on the on the Internet as opposed to within education. I don't think it's ever been termed educational neuroscience within a kind of inset situation." (Beth, CPD group).

However, Alice (Formal group) expressed a clearer understanding of the purpose and impact of educational neuroscience, emphasising the relevance of it to classroom practice:

"It's taking all the research about how your brain learns to influence the way that we teach children." (Alice, Formal group).

This contrast suggests that while educational neuroscience principles may be embedded within broader teacher training topics (e.g., SEN, cognitive development), the explicit terminology remains unfamiliar to many teachers. The historical absence of educational neuroscience in teacher training, as noted by several participants, highlights the need for greater integration of educational neuroscience concepts into ITT and CPD to ensure that future teachers are better equipped with this knowledge from the outset of their careers.

Theme 2: Role and Value of Educational Neuroscience in Teaching

This theme explored how teachers perceive the integration of educational neuroscience principles into pedagogical approaches and the value attributed to understanding the neural mechanisms underpinning learning and behaviour. Teachers across different training levels expressed recognition of the significance of educational

neuroscience in informing teaching strategies, particularly for supporting students with diverse learning needs.

This theme was divided into two sub-themes: (1) Benefits of Educational Neuroscience and (2) Interest in the Role of Educational Neuroscience. These sub-themes explain distinct aspects of how educational neuroscience contributes to teaching practices and how teachers perceive its role in the classroom.

Sub-theme 1: Benefits of Educational Neuroscience.

Teachers from all training levels highlighted the potential benefits of educational neuroscience in shaping classroom practice, particularly in adapting teaching strategies to better suit individual students. However, the way these benefits were conceptualised varied depending on the level of exposure to educational neuroscience training.

Alice (Formal group) demonstrated a structured understanding of how neuroscience can influence pedagogy, often embedding these insights within broader school-wide teaching approaches. She described how educational neuroscience principles shaped their school's culture, moving beyond ability-based language:

"We use neuroscience and evidence from neuroscience to influence the way that we teach in the classroom. [...] We teach the children from when they're four about neural pathways, so they understand that learning is about error, it's about practice. In order to strengthen those neural pathways, they need to stick and be resilient, and we try not to use the word 'ability' with our children." (Alice, Formal group).

This whole-school implementation contrasts with participants from the CPD group, who were more focused on the direct classroom application of educational neuroscience-informed strategies but without the same level of institutional integration. Beth (CPD

group), for example, acknowledged the importance of understanding how children learn to provide tailored educational support:

"Yes, it can be because obviously, anything that helps to know how a child learns or their best way of learning or why they're reacting in the way that they do, or learning in the way that they do. I think anything, in terms of tailoring in education to individual children, is really helpful." (Beth, CPD group).

While the formal group highlighted educational neuroscience-informed school-wide practices, CPD participants spoke about its use in adapting to individual students, particularly those with SEN. Diana (CPD group) noted the growing body of research into sensory processing and its role in improving instructional strategies:

"There's a lot of recent research into different reasons why our children have these sensory processing difficulties or they require sensory integrations. There's so much research that's come about in the last, say 10-15 years that has really benefited us in our ability to teach them more effectively." (Diana, CPD group).

Teachers in the informal group also recognised the importance of neuroscience for adapting teaching, particularly in neurodiverse and trauma-informed contexts. However, unlike the CPD and formal groups, their focus extended beyond cognitive mechanisms to the emotional and social dimensions of learning. Fiona (Informal group) described how understanding neuroscience can help teachers make sense of student behaviours in ways that avoid deficit-based thinking:

"I think in terms of students understanding their own brain and their own actions, and that they're not internalising it. You know, if we think about behaviours, not internalising it as 'I'm a bad person,' but in terms of understanding 'this is how my brain works, and this is why I react like this.'" (Fiona, Informal group).

This perspective on student self-awareness was largely absent from the discussions in the formal and CPD groups, where the focus was on instructional strategies and school-level integration. Similarly, Emma (Informal group) discussed how knowledge of educational neuroscience can challenge traditional deficit models of education:

"It's definitely essential in special educational needs. I think the understanding of how brains are built and how they can be different. [...] The more understanding that people can have of that, it can't be something that can be learned out of somebody; that is the way their brain is. And yes, there's neuroplasticity; we can make changes, but ultimately, you know, that isn't a weakness; it can be a strength." (Emma, Informal group).

Teachers in the No Exposure group still recognised its potential value in explaining student learning challenges. Ivy (No Exposure group) suggested that neuroscience could provide teachers with better explanations for students' struggles, helping them move beyond surface-level assessments of performance:

"It's beneficial because when teachers come across an individual pupil who is not achieving the outcomes, maybe the teacher thinks he or she should, then neuroscience now gives us possible explanations for that." (Ivy, No Exposure group).

Henry (No Exposure group) speculated that with proper training, teachers could improve their instructional effectiveness:

"With the right training, teachers who have that understanding [educational neuroscience] can probably be effective teachers in most subjects, certainly up to GCSE stage." (Henry, No Exposure group).

This statement suggests that while teachers without educational neuroscience training see its potential, they do not yet have the tools to integrate it into their practice.

Their responses tended to be more general and hypothetical, in contrast to the more concrete examples given by those with formal and CPD training.

Across the groups, educational neuroscience was also seen as valuable for addressing trauma and social-emotional learning, but again, the way this was conceptualised varied by training level. In the formal group, this knowledge was framed as improving the early identification of learning difficulties and providing necessary interventions:

"I think teachers are getting much better at identifying what these different conditions look like. [...] When I was first teaching, I don't remember as many children with ASD being in the classroom. Is it because we just didn't identify the specifics about how they learn, how their brain is wired" (Alice, Formal group).

By contrast, CPD and informal participants described educational neuroscience as a means of better understanding student well-being and emotional responses rather than just as a tool for diagnosis or early intervention. Diana (CPD group) reflected on the importance of addressing students' sensory needs and emotional regulation:

"When you're looking at a child, and all day they want to chew on something and want to climb on a table and then jump off, you have to work out what is going on in their brains—what they need to enable them to learn." (Diana, CPD group).

Informal participants expanded on this further, making connections between neuroscience, adverse childhood experiences, and long-term well-being:

"If we understand about the brain and look at adverse childhood experiences, then we can see the behaviours I'm observing and already know that this child has experienced, you know, four-plus adverse childhood experiences in their life.

Absolutely, you'd be able to think 'OK, well, these are the behaviours we may see; let's keep an eye on them'." (Fiona, Informal group).

Overall, the perspectives of teachers across different training levels suggested that while there is broad agreement on the value of neuroscience for education, the way this value is conceptualised depends on the level of exposure. Formal training tended to lead to structured, school-wide implementation, CPD training focused on refining pedagogy and interventions, informal engagement often resulted in a broader, more student-centred interpretation of neuroscience's role in education, and No Exposure participants recognised its potential but lacked the necessary training to apply it in practice.

Sub-theme 2: Interest in the Role of Educational Neuroscience.

Teachers across all training levels acknowledged the importance of educational neuroscience. While some saw it as a professional necessity, others viewed it as a personal curiosity, and in some cases, interest appeared to be contingent on whether educational neuroscience knowledge was framed in a practical and accessible manner.

Alice (Formal group) articulated a strong belief in educational neuroscience as a fundamental aspect of teaching, framing it as an essential component of effective pedagogy rather than an optional interest.

"I'm fascinated by it. I mean, in terms of neuroscience training, I would very much want it. You know, I think we have to do that. I think that's fundamentally a basic that teachers need because if you don't, [...], if you take as learners, if you forget about your brain, then we've missed a trick, haven't we? Because actually, that's it's all down to your brain, which is why you remember things and learn things. So, if we take that out of the equation, we're on a hide, hiding to nothing, really." (Alice, Formal group).

Alice also linked neuroscience knowledge to a broader frustration with educational policies that fail to consider cognitive mechanisms:

"I think it frustrates me that sometimes politicians forget that there is a brain in the middle between the content that the children are trying to learn and the knowledge that they're telling us we need to be teaching and actually how to do it." (Alice, Formal group).

This emphasis on the systemic integration of educational neuroscience knowledge suggests that formal training leads teachers to view educational neuroscience as an indispensable part of pedagogy rather than an isolated area of study.

Participants in the CPD group also expressed interest in educational neuroscience, but their perspectives were often framed in terms of professional development and personal curiosity. Diana (CPD group) indicated that they would seek out educational neuroscience training even if it were not mandatory:

"I would attend the training even if it wasn't compulsory, just as the personal development and curiosity point of view." (Diana, CPD group).

Another CPD participant acknowledged that while educational neuroscience can be intriguing, teachers' interest levels vary, particularly when discussions become more scientifically detailed:

"In terms of maybe the science behind it, when that's presented, I find that interesting. But I know that some people, kind of at that point, through conversations with colleagues, say, 'I'm not interested in that,' or, 'I switch off because they're not from that kind of [scientific] background.' But I always find it very interesting to listen to the research that's gone into it and the reasoning behind some of the ideas for what can happen in the classroom." (Beth, CPD group).

This response highlights a divide among teachers, as some are drawn to the scientific aspects of neuroscience, while others may disengage if the information is not presented in an accessible or practical way. This contrasts with the formal group, where neuroscience was seen as inherently relevant to teaching, regardless of its complexity.

Despite this variation in depth of engagement, CPD participants widely acknowledged the practical value of educational neuroscience in improving classroom instruction. One participant described how teachers are often willing to engage with educational neuroscience-based training if it is framed as beneficial for student learning:

"Teachers are inherently good people and they want to do the right thing, and if they are told that this is the thing that's going to help a child learn more, we invest in it because we aren't neuroscientific people." (Caroline, CPD group).

This suggests that while educational neuroscience is not necessarily a personal passion for all teachers, its potential to improve teaching effectiveness is a key motivating factor.

The informal group also demonstrated high levels of interest, but rather than positioning educational neuroscience as a core professional necessity, their engagement was often described in terms of personal passion and lifelong learning. One participant framed their enthusiasm as part of their identity as an educator:

"I suppose it's an interest for me. It's a passion. So I enjoy it. I feel like a lifelong learner—that's what we are as teachers; that's what we should be modelling. So I suppose for me, I enjoy finding out more, and that's just a natural thing as a human being, rather than maybe as a teacher." (Fiona, Informal group).

This personal rather than professional framing suggests that those in the informal group may engage with educational neuroscience out of intrinsic curiosity rather than as a

structured part of their professional development. Furthermore, unlike the CPD and formal groups, informal participants saw educational neuroscience as something teachers would be willing to explore even without accreditation or formal recognition:

"I do think people would still show willingness to take educational neuroscience courses even though their effort will not be recognised in a formal accreditation way. I think it depends [on] who and what their inclinations and their reasons for teaching are, but I do think that there would be a majority of people that would." (Fiona, Informal group).

Teachers in the No Exposure group also recognised the importance of educational neuroscience and acknowledged that interest in the field existed among teachers. However, their responses were more general and less detailed than those of participants with training. One participant noted:

"It's not that teachers aren't necessarily interested in neuroscience." (Henry, No Exposure group).

Another agreed that teachers understand its significance:

"They want it, and they recognise the importance of that, which I think is the first step." (Grace, No Exposure group).

However, while these statements indicate awareness and acknowledgment of educational neuroscience's relevance, they do not provide the same depth of engagement or examples of its practical application as those from the formal and CPD groups. The brevity of these responses suggests that while teachers without exposure may be open to learning about educational neuroscience, they do not yet have the knowledge or experience to articulate specific ways in which it might enhance their teaching.

In contrast, Alice (Formal group) was more likely to express frustration that educational neuroscience was not given enough emphasis in education policy, CPD-trained

teachers were focused on educational neuroscience as a tool for professional development, and informal group participants framed it as a personal intellectual pursuit. The No Exposure group, while acknowledging its importance, lacked the detail in discussing its application.

Theme 3: Barriers to Incorporating Educational Neuroscience in the Classroom

Theme 3 delved into the barriers hindering the accessibility and integration of educational neuroscience into classroom settings. This theme was divided into four interconnected sub-themes, each highlighting distinct challenges teachers encounter in incorporating educational neuroscience into their pedagogical approaches.

Sub-theme 1: Barriers to CPD Programmes.

Teachers across all educational neuroscience training levels acknowledged multiple barriers to accessing CPD programmes in educational neuroscience. Some participants expressed frustration over the systemic lack of emphasis on educational neuroscience CPD, while others described how structural constraints, such as school budgets and workload, made CPD engagement difficult.

Alice (Formal group) highlighted a lack of available CPD programmes in educational neuroscience, suggesting that, even for those with an interest, opportunities remain limited:

"I don't think there is much out there." (Alice, Formal group).

It was also acknowledged that while CPD programmes could be beneficial, teacher engagement depends on whether they perceive neuroscience as relevant:

"I do think that neuroscience training could be far better for teachers, but I think you have to have people who buy into it." (Alice, Formal group).

These responses suggest that barriers to CPD in educational neuroscience are not only logistical but also attitudinal, with engagement often depending on whether teachers perceive educational neuroscience knowledge as useful in their practice.

Participants in the CPD group also emphasised the difficulty of finding time for CPD participation. One participant described how time constraints often prevent teachers from engaging in training, even when opportunities are available:

"The biggest one is time. I know there have been courses offered before, and I've done things, but I was lucky because I worked for two days at the moment, so I do have time on some of my other days where I can take part in this. I wouldn't have been able to do it if I was working full time because I would have been in the classroom teaching face to face." (Beth, CPD group).

This suggests that teachers who work part-time or have flexible schedules may be better positioned to access educational neuroscience-related CPD, whereas full-time teachers struggle to balance CPD engagement with their existing workload.

In addition to time constraints, CPD participants also noted that school leadership plays a crucial role in determining access to training. If CPD is not seen as a direct benefit to the school, it is often deprioritised:

"Obviously, it's not a teacher's decision as to whether their time is going to be covered. There's a cost to covering teaching time. If it's something that senior management think is going to benefit the school, they're willing to pay for cover and possibly pay for the course. But if it's something that they don't think is going to have an impact, they're less willing to invest in that." (Caroline, CPD group).

This perspective highlights the institutional gatekeeping of CPD opportunities, as school leaders ultimately determine which training is valued. As a result, neuroscience-focused CPD is often overlooked unless there is a clear, immediate benefit to the school.

Participants in the informal group shared similar concerns about institutional priorities shaping CPD access. One participant reflected on how schools often focus CPD on curriculum-related content rather than topics like educational neuroscience:

"Resources and time because schools want to put you on training that benefits them.

The focus was heavily on curriculum rather than SEN or educational neuroscience 10 years ago." (Emma, Informal group).

Participants noted that educational neuroscience training might not be perceived as a priority within educational institutions, with other areas, such as curriculum development or administrative training, taking precedence.

However, informal group participants also suggested that teachers' career aspirations may influence their willingness to engage in CPD. Some teachers will seek out CPD in educational neuroscience if they believe it will advance their careers:

"So you've got one route of people that are just interested and passionate, who will make time for it, and then you've got another group that maybe are interested in career progression. So if it becomes like an NPQ [National Professional Qualification], absolutely, people will find time for it because they feel that's giving them something to move on in their career and that's going to be recognised by others." (Fiona, Informal group)

This suggests that teachers may be more likely to engage in educational neuroscience-focused CPD if it is linked to career progression, such as inclusion in national professional qualifications (NPQs) or other accreditation schemes.

Teachers in the No Exposure group echoed many of these concerns. Time constraints were widely cited as a barrier, with participants describing CPD as an additional burden on an already demanding workload:

"There's limited time for anything." (Grace, No Exposure group)

"If you're a teacher and you're thinking about what training you might want to do in a particular year, it's going to be constrained by your own time." (Henry, No Exposure group)

Financial constraints also loom large as a significant barrier, as indicated by teachers' references to the costs associated with training programmes. The notion of being *"constrained to a certain extent by the cost involved"* (Ivy, No Exposure group) highlights the financial burdens placed on individual teachers and schools in pursuing educational neuroscience-focused CPD initiatives. This financial pressure often makes it difficult for teachers to prioritise such training, especially when funding must be justified within tight school budgets:

"It's low down the list of priorities for teachers to go to their employer and say, 'I want the school to spend £200 sending me on a training course about neuroscience' because the answer will probably be no." (Henry, No Exposure group).

Henry (No Exposure group) also perceived the absence of mandatory educational neuroscience training requirements as a major systemic barrier, noting the contrast between teachers and other professions that require ongoing professional training:

"I've got good friends who are doctors, and they have to regularly attend refresher training in certain aspects of their profession, but teachers don't. You do your teacher training, get your certificate, and that's it—you could spend 40 years teaching and not really have to attend specific training." (Henry, No Exposure group)

The data also showed that teachers often have to make personal sacrifices to pursue educational neuroscience-focused CPD. References to "*quirky teachers*" (Ivy, No Exposure group; Henry, No Exposure group) who invest their own time and resources into acquiring knowledge of educational neuroscience highlight the individual effort needed to overcome institutional barriers.

Overall, these findings suggest that while time, cost, and institutional support are barriers across all training levels, teachers' perceptions of CPD in educational neuroscience vary based on prior exposure. Alice (Formal group) views the lack of available training as the main issue. CPD-trained teachers recognise the potential value but struggle with time constraints and school leadership approval. Informal participants seek educational neuroscience-related CPD independently and are more likely to engage if it supports career progression. No Exposure participants, however, express greater scepticism, viewing CPD in educational neuroscience as a lower priority and potentially just another passing educational trend.

Sub-theme 2: Barriers to Initial Teacher Training Programmes (ITT).

Substantial barriers to integrating educational neuroscience within ITT programmes were identified across all training groups. These barriers included curriculum constraints, the prioritisation of subject expertise over pedagogical knowledge, and the lack of research-informed content. Participants also highlighted the overwhelming nature of ITT, misconceptions embedded in training, and the challenge of bridging theoretical knowledge with classroom practice.

Participants in the No Exposure group expressed concerns about how ITT prioritises subject expertise over a deeper understanding of cognition and learning:

"There's still a lot of emphasis placed on the idea that teachers are subject experts, and I've always been slightly uncomfortable with that. It's far more important for teachers to be experts about psychology and neuroscience than to be experts about a particular subject. There is a cultural change that probably needs to happen in the sense that the education profession needs to put more emphasis on understanding human psychology and how the human brain works (neuroscience), and perhaps a little bit less emphasis on what a teacher knows about certain subjects." (Henry, No Exposure group).

Many teachers encountered outdated theories during ITT, which contributed to distrust in research-based practices. Ivy (No Exposure group) reflected:

"Some of the things we were taught when I was on teacher training now seem to be in the 'this has been disproved' category. Things like learning styles were a big thing when I was doing my teacher training—I still had to put them on my lesson plans. And then obviously with research, we now know this isn't valid." (Ivy, No Exposure group).

Similarly, Alice (Formal group) described how her training placed undue emphasis on learning styles despite the lack of scientific validity:

"At that time when we did it, it was more about this whole thing about learning styles... the whole course really was about thinking about people having different learning styles and being aware of that in the classroom. But I know it's moved on since then." (Alice, Formal group).

The CPD group also noted how misconceptions, such as Brain Gym, were embedded in their training:

"Especially at the time that I was doing my degree, it was the whole sort of Brain Gym sort of things. Teachers believed that if you rub your ears, you get oxygen into your brain." (Caroline, CPD group).

ITT programmes often lack structured support in evidence-based pedagogy, leaving new teachers to navigate their learning independently:

"When I trained to teach, it was completely just sink or swim and kind of find out as you go along." (Beth, CPD group).

The data further revealed a disconnect between the theoretical foundations of ITT programmes and the practical realities of teaching. Participants reflected on how their training introduced abstract theories that felt disconnected from their classroom experiences. One teacher from the No Exposure group described the challenge of bridging the gap between theoretical knowledge and practice:

"Teachers are digesting some of that material, but they're trying to digest it without the mind and training." (Ivy, No Exposure group).

This highlights the difficulty that teachers face in applying educational theory, including educational neuroscience-informed practices, without the necessary mentorship, real-world application, or ongoing reinforcement. Participants from the CPD group further reflected on this issue, noting how ITT often overwhelms new teachers with information, making it difficult for them to meaningfully engage with educational neuroscience at an early stage:

"Initial teacher training is just so full on. There's so much to try to cover in one academic year." (Grace, No Exposure group),

"Maybe not in massive detail because that year... it's difficult to go into things in a lot of detail. There's a lot that you've got to learn to do, and it's all very daunting just in

terms of the practicalities of being able to teach at that point. It should be touched on in teacher training, but possibly teachers should come back to something like this five years down the line when they've got over the hurdles of learning to teach in general and how to run a classroom." (Beth, CPD group).

This reflects a broader systemic issue, where ITT programmes tend to prioritise curriculum content over deeper pedagogical principles, including educational neuroscience, child development, and social-emotional learning. Participants expressed concern that this imbalance results in a fragmented approach to teacher preparation, with fundamental aspects of how children learn being overshadowed by immediate curricular demands.

Consequently, many teachers only engage with educational neuroscience later in their careers, often through self-directed learning or CPD rather than structured training.

Another systemic barrier is the discouragement of experimentation and risk-taking. While trainee teachers initially demonstrate enthusiasm for new strategies, this is often diminished by school expectations:

"We've had quite a few PGCE students coming into the department in the last few years, and they will take risks; they're quite happy to try something completely bonkers in a lesson and give it a go because they are just learning. But once you get stuck in the role of day-to-day teaching, that enthusiasm gets sucked out." (Henry, No Exposure group).

Teachers face additional pressure due to conflicting messages about experimentation:

"It's important that you've got support during the trial-and-error phase. But schools say they want you to take risks, and yet they expect perfection at the same time."

That stress, the pressure... that's why people don't feel like they want to try new things." (Grace, No Exposure group),

"One of the challenges of trial and error is that while it's trial and error for you, that kid—it's their one chance in your classroom." (Henry, No Exposure group).

Moreover, some teachers felt unprepared to critically evaluate neuroscience-related research, further hindering its integration into their practice.

"I don't have the time and critical awareness of the field to be able to look into the depth of all those papers." (Ivy, No Exposure group).

This highlights how ITT programmes may fail to equip teachers with the necessary analytical skills to interpret and apply educational neuroscience research. Without sufficient training in critically assessing research, teachers are left to independently determine which concepts are relevant and valid. This lack of guidance further exacerbates the difficulty of integrating research-informed strategies into everyday teaching practice.

Despite these barriers, participants across all groups expressed a strong desire for improved educational neuroscience training opportunities. They advocated for comprehensive programmes that promote both theoretical understanding and practical application. A participant from the Informal group suggested that educational neuroscience training should be integrated at multiple stages of a teacher's career:

"Increased knowledge or topics in educational neuroscience should be embedded in initial teacher training programmes for pre-service teachers, but also in-service teachers." (Fiona, Informal group).

This aligns with broader calls from participants for accessible and engaging training formats that cater to diverse learning preferences and professional backgrounds. Some

suggested that evidence-based educational neuroscience training should be a requirement for all teachers, rather than an optional area of professional development:

"It has to start with teacher training so that the teachers coming into the profession have that mindset that educational neuroscience is integral to what my job as a teacher is going to be like." (Grace, No Exposure group).

The data indicates that ITT programmes are not currently equipping teachers with the foundational knowledge they need to integrate educational neuroscience into their practice. Participants across groups criticised the lack of emphasis on educational neuroscience, the disconnect between theory and classroom application, and the rigid structures that discourage risk-taking and innovation.

There was broad agreement that educational neuroscience should be a core part of ITT curricula, rather than an optional area of professional development later in a teacher's career. However, participants also acknowledged that ITT alone is not sufficient and structured, ongoing CPD is needed to reinforce and expand on educational neuroscience knowledge as teachers progress in their careers.

Sub-theme 3: Barriers to Accessing Materials and Resources.

This sub-theme highlights the challenges teachers face in accessing educational neuroscience materials and resources.

A major barrier across all groups is the difficulty in identifying trustworthy and reliable sources amidst the vast amount of available information. This challenge was particularly pronounced among those with no prior exposure to educational neuroscience, who frequently expressed uncertainty about where to begin their search. One participant remarked, questioning the credibility of online sources:

"I wouldn't know where to start really. I suspect they are out there, but I'd need someone to sort of point me in the direction of where to begin. There are so many people set themselves up as experts in education, particularly whether that's because they're selling CPD courses or they're selling books or they're trying to sell resources." (Grace, No Exposure group).

Similar concerns were raised by participants in the informal training group, who found it difficult to locate quality resources unless they stumbled upon them by chance:

"It's quite hard to find sometimes like quality resources or accurate. So I would go to their website to look for stuff, but I don't think everybody really knows about these places. It's quite hard, you know, you kind of come across it by accident rather than, you know, being like, oh, this is a really useful list of places that you can go to access this information." (Fiona, Informal group).

Another significant barrier is time constraints. Teachers with no prior exposure noted that even if resources were available, the process of finding those relevant to their specific teaching contexts was cumbersome:

"There will be lots of information out there, journal articles you know there will be lectures, there'll be videos, probably be podcasts, but it's about sort of sifting through those and finding something that's sort of really relevant for the school I'm working at, for the type of people I'm teaching. I guess that's probably something else that may put teachers off is how quickly can you find stuff that's relevant for your context as a teacher." (Henry, No Exposure group).

Similarly, Alice (Formal group) expressed frustration over the challenge of engaging with dense research papers, citing time constraints as a major barrier:

"If you go into all the other science papers research papers, they're quite dense and they're quite hard to access and I haven't got time to read a research paper." (Alice, Formal group).

This highlights a broader issue faced by teachers, as the complex language and academic jargon in educational neuroscience resources make them inaccessible and impractical within their demanding schedules.

In contrast, some in the informal group indicated a preference for physical books, as they found them easier to revisit and highlight for practical use:

"I do find them very useful and I find that if it's a physical book, I can return to them, I can highlight them, I can pull pieces." (Fiona, Informal group).

A further challenge is financial constraints. Budgetary limitations were raised as a concern across different training levels, with one participant from the informal group stating: *"Budgetary constraints."* (Emma, Informal group). In the no exposure group, there was a mention of restricted access to academic journals due to paywalls:

"The problem with accessing some of the journals is often these are closed and locked behind various things." (Ivy, No Exposure group).

Ivy (No Exposure group) also noted that while guest accounts exist, they are not always practical during a busy school day:

"You can register for a guest account but that isn't always that practical when you're in the middle of a working day." (Ivy, No Exposure group).

Interestingly, Ivy (No Exposure group) also acknowledged that educational neuroscience resources were becoming slightly more accessible, but still remained difficult to navigate effectively: *"It is beginning to get more accessible."* (Ivy, No Exposure group). It

was also recognised that a quick search could yield easier-to-understand information but still struggled with trust and credibility:

"It would be easy to search just for blogs or you know online, but how would I trust them?" (Grace, No Exposure group).

As the CPD group participants dominantly talked about the challenges related to ITT and CPD programmes, very limited discussions were dedicated to this specific topic. Consequently, no data was available from participants at the CPD level, which could be attributed to the primary focus of their discussions on broader systemic issues rather than this particular aspect.

Sub-theme 4: Practicality (Link to Classroom).

The fourth sub-theme, which focuses on the practicality of incorporating educational neuroscience principles into the classroom, highlighted the importance of ensuring that knowledge of educational neuroscience translates into strategies that teachers can implement to support student learning. Teachers across different training levels expressed a strong desire for educational neuroscience to provide practical solutions applicable to their teaching contexts. One participant articulated this sentiment by stating:

"I'd want it to have the practicalities of things I can do. Otherwise, it just becomes intellectual curiosity for the sake of it." (Ivy, No Exposure group).

Furthermore, teachers stressed the importance of understanding how educational neuroscience can directly impact classroom practices and student outcomes. One participant asked,

"How is this going to make a practical difference to how I help my pupils learn?"
(Henry, No Exposure group).

However, concerns regarding the accessibility and quality control of educational neuroscience resources were raised:

"There's a lot of stuff out there and again just being able to quality control it." (Ivy, No Exposure group).

The current theme also highlighted the need for practical implementation toolkits. A participant from the Informal group highlighted the importance of actionable resources:

"It's a toolkit that's needed, not just like the research... Something quick to read on the research and then like the toolkit of how that can be implemented with examples." (Emma, Informal group).

However, concerns about the potential misuse of such toolkits in schools were also raised:

"I do like the idea of the toolkit, but I worry about how schools then turn that into a never-ending checklist and audit. We've all filled in those audits that become 'Are you doing this?' and it always becomes 'Yeah', just kind of performative rather than actually thought about." (Ivy, No Exposure group).

Overall, while the findings in this sub-theme reinforce those of earlier themes, they provide further insight into how the accessibility of educational neuroscience materials and structured support influences teachers' ability to implement research-informed strategies in the classroom. Teachers with no exposure struggle with accessibility and identifying credible sources, whereas those with informal or formal training have developed strategies to locate and use relevant information.

Miscellaneous Theme

The miscellaneous theme covers seven codes that were found to be not directly relevant to the research questions but still noteworthy. These included general systemic

issues such as resistance to change in teaching practices and variability in the application of educational neuroscience across different educational contexts. For example, codes such as "teachers' reluctance to adopt new methods" and "changes in teachers' pay across urban and rural schools" were deemed relevant but were not directly tied to the primary themes.

Discussion

This study aimed to explore teachers' perceptions of educational neuroscience, including their knowledge of educational neuroscience, its role and value in teaching, and the barriers to incorporating it in the classroom. The findings provide insights into the complexities of how teachers engage with educational neuroscience principles in educational settings. This section examines how these findings align with existing literature, discusses their implications, and proposes recommendations for addressing the identified challenges. Additionally, it suggests strategies for enhancing the integration of educational neuroscience in teaching.

The analysis identified three main themes: (1) Teacher Perceptions of Knowledge of Educational Neuroscience Knowledge, (2) the Role and Value of Educational Neuroscience in Teaching, and (3) Barriers to Incorporating Educational Neuroscience in the Classroom. These themes also included several sub-themes that further explained the details within each main category.

Teachers exhibited varied levels of familiarity with educational neuroscience terminology and concepts, with some integrating neuroscientific principles into their teaching practices without explicitly recognising them as such. The participant with formal training demonstrated a clear and structured understanding of educational neuroscience, explicitly linking it to classroom teaching. In contrast, those who had engaged with CPD in related areas, such as neurodiversity, often applied educational neuroscience-informed

strategies without identifying them as part of educational neuroscience. Similarly, teachers with no exposure acknowledged the implicit presence of these concepts in their practice, particularly in understanding student behaviour and well-being. Moreover, SEN professionals were recognised as playing a key role in making educational neuroscience-informed strategies more accessible within schools, highlighting the informal diffusion of such knowledge.

This aligns with findings from prior research that many UK teachers are familiar with educational neuroscience concepts, often applying them unconsciously in their pedagogical approaches (Thomas et al., 2024; Thomas & Arslan, 2024). The data indicate that, while awareness of educational neuroscience principles is growing, explicit terminology remains unfamiliar to many teachers, particularly those trained earlier in their careers. The influence of specialised education professionals, particularly those involved in SEN, was noted in promoting awareness of educational neuroscience concepts within school settings. This finding echoes the literature, which highlights the role of SEN professionals in disseminating neuroscientific knowledge (Rogers & Thomas, 2022).

These findings highlight a broader issue: educational neuroscience concepts are often embedded within other areas of teacher training (e.g., SEN, cognitive development) but are rarely framed explicitly. The historical absence of educational neuroscience in ITT programmes, as noted by participants across different training levels, highlights the need for greater integration of these concepts into teacher education. While some teachers, such as those in the formal and CPD groups, actively sought educational neuroscience-related training, others expressed hesitation due to a lack of structured guidance and terminology. This suggests that increased awareness and explicit incorporation of educational neuroscience into ITT and CPD could help ensure that all teachers, regardless of their

training background, develop a foundational understanding of how educational neuroscience informs pedagogy.

The perceived value of educational neuroscience in enhancing teaching practices and addressing diverse learning needs was a consistent finding. Teachers acknowledged that educational neuroscience offers a valuable framework for understanding neurocognitive mechanisms, which extends beyond theoretical knowledge to practical implications for classroom strategies, student support, and inclusive education, advocating for tailored approaches that accommodate individual differences. This acknowledgement of neurodiversity highlights the need for inclusive pedagogical approaches informed by educational neuroscience insights to support all learners effectively.

A key finding was the variation in how educational neuroscience was perceived across different training levels. While Formal and CPD participants focused on pedagogical strategies and school-wide implementation, Informal participants emphasised the role of educational neuroscience in supporting student well-being and neurodiversity. No Exposure participants, meanwhile, recognised the field's potential but lacked the necessary knowledge to apply it effectively. This divergence suggests that tailored professional development approaches may be needed to support different teacher groups, ensuring that neuroscience training is framed in ways that align with teachers' existing knowledge and professional contexts. This highlights the importance of structuring educational neuroscience training to meet the needs of teachers at different stages of their professional journey, reinforcing the necessity of both foundational ITT and ongoing CPD opportunities.

The review by Dubinsky et al. (2019) further emphasises the value of neuroscience knowledge in enhancing teacher practice, mainly through active learning strategies and understanding cognition and brain function. This can significantly enrich teaching

methodologies beyond what is typically offered in ITT by enabling teachers to create more dynamic and interactive learning environments tailored to their students' cognitive needs (Dubinsky, 2010). However, the practical application of knowledge of educational neuroscience was emphasised, with teachers expressing a need for actionable strategies that can be readily implemented in the classroom. Notably, this aligns with the findings regarding training exposure, as teachers with formal or CPD experience were better positioned to translate educational neuroscience into practice. In contrast, those with informal or no prior exposure highlighted the need for clearer guidance and structured support. This gap highlights the need for enhanced incorporation of educational neuroscience principles into teacher training programmes, offering practical guidance and resources to support teachers in effectively applying educational neuroscience concepts in their classrooms. Doing so would enable teachers to understand better and use neuroscientific insights, addressing the dynamic nature of knowledge of educational neuroscience applications and the need for individualised pedagogical strategies.

This aligns with the literature that supports practical educational neuroscience applications (Thomas et al., 2024), both in teaching to optimise student learning outcomes (Dubinsky et al., 2019) and in informing evidence-based instructional strategies to support students with SEN (S. Blakemore & Frith, 2005). Furthermore, the study revealed a strong interest among teachers in furthering their understanding of educational neuroscience, highlighting the importance of ongoing professional development in this area. This interest aligns with findings from a recent survey, which indicated that a majority of UK teachers believe educational neuroscience is relevant to their professional development and are keen on incorporating its insights into their practice. However, similar to the current study

findings, many teachers expressed a need for practical guidance and additional knowledge to effectively apply educational neuroscience strategies (Thomas et al., 2024).

Despite the growing recognition of educational neuroscience's potential, several barriers to its effective integration into teacher training and professional development were identified. A major challenge across all groups was the limited availability and accessibility of educational neuroscience-focused CPD. Teachers interested in such training often struggled to find relevant opportunities, and time constraints further limited engagement, particularly for full-time teachers. Institutional support also played a crucial role, with school leadership often deprioritising neuroscience-related CPD favouring curriculum-focused training. Financial constraints and the lack of mandatory requirements further hindered participation, particularly for those not previously engaged with such training.

For ITT, the main obstacles included curriculum constraints, the prioritisation of subject expertise over cognitive science, and the persistence of outdated theories within teacher training. Participants noted that ITT programmes already cover vast content, making it difficult to allocate space for neuroscience. Some suggested that while an introduction to neuroscience should be included in ITT, deeper engagement might be more beneficial later in teachers' careers when they have gained more classroom experience.

These barriers are often rooted in a combination of factors. Firstly, educational institutions typically focus on meeting immediate curriculum and assessment demands, which leaves limited time and resources for incorporating transdisciplinary fields like educational neuroscience. Secondly, a lack of awareness and understanding among policymakers and educational leaders about the tangible benefits of educational neuroscience may result in it being deprioritised compared to traditional teacher training areas such as curriculum content and classroom management. Additionally, the

fragmentation between research and practice, where research findings are not translated into actionable, teacher-friendly formats, limits teachers' ability to see the relevance of educational neuroscience to their everyday practice. Financial constraints and competing priorities for professional development budgets also exacerbate the issue, as schools must prioritise training that meets statutory or regulatory requirements, often leaving educational neuroscience-focused training on the periphery. Reliance on personal time and resources poses significant challenges, particularly in environments where teachers may already be stretched thin. Addressing these systemic barriers requires a concerted effort to raise awareness of educational neuroscience's practical applications, integrate it into teacher training as a foundational element, and establish stronger collaborations between researchers, educators, and policymakers. The study highlights the need for structural reforms in teacher training programmes to address the dearth of educational neuroscience content (McMahon et al., 2019) and the development of targeted training programmes to support teachers in navigating the complexities of neuroscientific literature (Ansari et al., 2011; Tan & Amiel, 2022).

Teachers also reported difficulties in accessing reliable educational neuroscience materials and resources, citing the overwhelming amount of information and the lack of guidance on where to find credible sources. Teachers expressed apprehension about the credibility of online resources, such as blogs and websites, questioning their expertise and reliability. Budgetary constraints also pose challenges, as teachers may not have the financial means to access premium resources or subscriptions, and restricted access to journals due to paywalls further impedes their ability to stay up to date with the latest research findings. However, a critical issue is the lack of educational neuroscience training as part of ITT. If educational neuroscience is fully embedded into ITT programmes, teachers

would have better ability to discriminate between high and poor-quality educational neuroscience materials and interpret research findings before entering the profession. This ability can then be further developed through CPD initiatives. This resonates with previous research highlighting the gap between teachers' theoretical knowledge and practical application of educational neuroscience principles (Goswami, 2008).

In conclusion, the study identified several key findings. Teachers exhibited a varied understanding of educational neuroscience, with some integrating neuroscientific principles into their teaching practices without explicitly recognising them as such. The value of educational neuroscience in enhancing teaching and addressing diverse learning needs was acknowledged, and there is a strong interest among teachers in further understanding of educational neuroscience. However, significant barriers were identified, including gaps in formal training during ITT programmes, limited availability of educational neuroscience-focused professional development, and difficulties in accessing reliable educational neuroscience resources. Practical constraints, such as time, accessibility, and cost, further hindered engagement with educational neuroscience training and materials. These findings highlight the need for more accessible and flexible opportunities for teachers to engage with educational neuroscience, which Study 3 aimed to explore.

Addressing these barriers is crucial for maximising educational neuroscience's potential to enhance educational practices. By bridging the gap between theory and practice, these efforts can empower teachers to effectively leverage neuroscientific insights, ultimately benefiting both teachers and students in diverse educational contexts. The next section provides actionable implications of the findings that might be realised, which include integrating educational neuroscience content into ITT curricula, promoting collaborative

efforts between researchers, educators, and policymakers, and improving access to high-quality educational neuroscience resources.

Implications and Recommendations

The findings of this study have several implications for enhancing the integration of educational neuroscience in teaching practices. First, there is a clear need to prioritise the inclusion of educational neuroscience content in ITT curricula to ensure that teachers are equipped with a robust understanding of neuroscientific principles before entering the profession. This can be achieved by incorporating fundamental neuroscientific principles (e.g., ‘Concepts of Educational Neuroscience Teacher Literacy’, Tokuhamma-Espinosa & Nouri, 2023) into teacher training syllabi (Kelly, 2017) and developing tailored training programmes that address the diverse needs of teachers across different educational contexts (Amiel & Tan, 2019). Efforts are also needed to enhance teachers’ access to comprehensive educational neuroscience training (Fragkaki et al., 2022), equipping them with the knowledge and skills required to leverage neuroscientific insights effectively in their teaching practices. While embedding educational neuroscience into ITT programmes is a crucial step, training opportunities should extend beyond ITT to reach teachers throughout their careers.

The recently updated ‘Initial Teacher Training and Early Career Framework’ (‘ITTECF’, Department for Education, 2024a) provides an essential foundation for incorporating educational neuroscience principles. By combining and refining the prior ITT Core Content Framework and Early Career Framework, the ITTECF includes updates on supporting pupils with SEN, high-quality oral language (oracy), and early cognitive development. These inclusions reflect a step in the right direction for embedding educational neuroscience concepts into teacher training.

The ITTECF also addresses evidence literacy and essential topics such as memory and attention, equipping teachers with foundational knowledge about cognitive processes relevant to classroom practice. However, as noted in the literature review, the crowded ITT curriculum often limits the depth of coverage for these concepts. Furthermore, much of this knowledge is introduced during the early career induction period rather than as foundational content in initial training. Future efforts should explore ways to enhance the depth and breadth of educational neuroscience training within ITTECF to ensure teachers are well-prepared to apply these principles in practice.

Expanding CPD opportunities beyond the ITT stage is essential to provide teachers with ongoing access to educational neuroscience insights. Building on the ITTECF's structured approach during early career induction offers a valuable starting point, but continuous professional development is necessary to reinforce and build upon this foundational knowledge. To achieve this, transdisciplinary collaborations between researchers, educators, and policymakers are essential. Such partnerships can develop tailored training programmes that address teachers' diverse needs across various educational contexts (Amiel & Tan, 2019), ensuring that educational neuroscience principles remain relevant and actionable.

A critical component of this effort is promoting a culture of continuous learning and promoting professional communities dedicated to translating research findings into classroom practices. This requires educational neuroscience resources that go beyond theoretical insights, offering teachers practical and actionable strategies they can implement in their teaching (Roehrig et al., 2012). Developing a robust translation framework is key to bridging the gap between theory and practice (Walker et al., 2019). Collaborative efforts can focus on creating user-friendly materials, accessible training

programmes, and real-world examples that align with teachers' day-to-day challenges. By enhancing both access to resources and opportunities for professional growth, these initiatives can ensure that educational neuroscience findings are effectively integrated into educational practices, ultimately improving student learning outcomes.

Efforts to enhance the accessibility and reliability of educational neuroscience materials and resources are essential (Gordon et al., 2024; Willis, 2008). Creating curated resource lists, developing user-friendly platforms for accessing educational neuroscience literature (e.g., accessible summaries of research findings), and subsidising access to premium educational resources can mitigate the challenges teachers face in finding credible information. Online electronic information resources, such as the websites of the Centre for Educational Neuroscience (educationalneuroscience.org.uk), Learnus (learnus.co.uk) and Learning Scientists (learningscientists.org), are particularly important and should be further developed in collaboration with researchers, practitioners and information specialists. Establishing a 'trusted provider' status for these resources is crucial. This could be achieved by ensuring that resources are produced and delivered by credible, research-based institutions, such as universities and recognised research centres. Structured content grounded in research evidence and practical tools like scenarios and interactive assessments can enhance trust and usability for educators. By facilitating teachers' access to accessible, high-quality educational neuroscience content, educators can better equip themselves with the knowledge and resources needed to incorporate neuroscientific principles into their teaching practices effectively.

Limitations and future research

A notable limitation of this study was the high attrition rate among participants, which resulted in fewer individuals joining the study than initially anticipated. The

discrepancy between the number of those who initially agreed to be contacted, those who responded to the invitation, and those who finally participated highlights the difficulties in maintaining participant engagement over time.

Despite this challenge, valuable insights were gleaned from each of the four educational neuroscience training levels involved in the study. The findings highlight the importance of formal educational neuroscience training in enhancing teachers' knowledge of educational neuroscience and suggest that future studies should explore how to make such training more accessible and appealing to teachers. This accessibility could be enhanced by integrating educational neuroscience concepts into ITT programmes to ensure a foundational understanding, which can then be further developed through CPD. However, it is important to acknowledge the uneven representation across the levels. Specifically, only one participant was included in the formal training level, which limits the insights derived from this level. This underrepresentation is particularly important given the distinct nature of formal training and its potential impact on teachers' perceptions and practices. Future research should aim to recruit a larger and more balanced sample across all educational neuroscience training levels to ensure more robust comparisons and a fuller understanding of the differences in teacher perspectives.

The study also identified a confound between training level and teaching sector. All participants with formal and CPD training were from the primary sector, while all participants with no educational neuroscience exposure were from the secondary sector. This overlap complicates the interpretation of whether differences in responses are attributable to training level, teaching sector, or a combination of both. Addressing this confound in future studies would require ensuring balanced representation of participants

across both training levels and sectors. This approach would allow for a more nuanced understanding of how these variables interact and influence teacher perceptions.

Although focus group sessions were conducted for groups with three or more participants, participant availability precluded organising focus groups for every group. Consequently, dyadic interviews were conducted for groups with two participants, and individual interviews were employed for groups with only one participant. While these methods allowed for qualitative data collection and provided valuable insights, each had its own set of limitations, including potential biases and restrictions in the level of interaction and depth of exploration. The variation in data collection approaches may influence the research outcomes (Farnsworth & Boon, 2010).

The decision, rather than conducting three individual interviews instead of a dyadic and an individual interview for the CPD group, resulted in a mix of discussion formats, one allowing interaction between two participants and another providing an independent perspective. While the dyadic interview facilitated dialogue, enabling participants to build on each other's responses, the individual interview allowed for more personal reflection. This combination may have influenced the nature of the data collected, as interactive discussions can sometimes generate richer ideas, while individual interviews may encourage deeper introspection. A focus group might have yielded broader exchanges of ideas, while three individual interviews could have provided a more uniform set of independent reflections. Future research should consider the potential implications of these methodological choices, as different interview structures may shape the way participants articulate their views and respond to peer input.

Exploring alternative methods for data collection that accommodate group dynamics while ensuring inclusivity can enhance the comprehensiveness of future studies. For

instance, using mixed methods approaches that combine quantitative surveys with qualitative focus groups or interviews can provide a more holistic understanding of the research questions (Creswell & Plano Clark, 2011). Additionally, methods such as participatory action research (PAR) can engage participants more actively in the research process, ensuring that their voices are heard and their experiences are accurately represented (MacDonald, 2012). Such approaches can capture a wider range of perspectives and ensure that smaller groups are not overlooked, thereby enriching the data and making the findings more robust and inclusive (Bryman, 2016). Furthermore, observational studies or experimental interventions, could provide additional insights. Future research could consider incorporating these approaches, which could complement the perspectives gathered in this study, as partially examined in Study 3 (Chapter 4).

Conclusion

This study provided insights into teacher perceptions regarding knowledge of educational neuroscience, its role in teaching, and the barriers hindering its integration into the classroom. The findings highlight the varying levels of familiarity and engagement with educational neuroscience concepts among teachers and a desire for comprehensive training in educational neuroscience. Despite recognising the transformative potential of educational neuroscience in informing teaching practices and promoting inclusive education, teachers face multiple barriers, including the lack of educational neuroscience content in ITT programmes, limited access to educational neuroscience-focused professional development that are delivered by credible sources, and challenges in accessing reliable educational neuroscience materials.

Several recommendations have been proposed to overcome these barriers and maximise educational neuroscience's potential in enhancing teaching practices. These

include prioritising the integration of educational neuroscience content into teacher training curricula, fostering collaborative efforts between academic researchers, educators, and policymakers, and enhancing the accessibility and reliability of educational neuroscience materials and resources from trusted sources which address practical implementation. By addressing teachers' expressed needs and preferences, this study can exert a tangible influence on the development of educational practices, providing valuable insights into the challenges and opportunities surrounding teachers' engagement with neuroscientific principles in educational settings.

Through collaborative efforts and a commitment to continuous learning, the gap between theory and practice in educational neuroscience can be bridged. This will ultimately benefit teachers, students, and researchers alike. This study's findings contribute to the growing body of research on educational neuroscience and provide actionable recommendations for future initiatives aimed at improving teacher training and professional development in this field, thereby enhancing teaching effectiveness and pupil learning experiences.

Chapter 4

Training in Educational Neuroscience (Study 3)

Training in Educational Neuroscience (Study 3)

Rationale and Research Questions

Study 1 of this research (Arslan et al., 2022) examined teachers' existing knowledge of educational neuroscience and investigated the sources from which this understanding was derived. It demonstrated that informal exposure to educational neuroscience does not necessarily translate into a robust understanding. Teachers who primarily relied on informal learning resources were found to be more susceptible to neuromyths—misconceptions about the brain and learning that lack scientific validity—and were less equipped to differentiate these misconceptions from accurate, research-supported findings (neuro-facts). Among the identified means of educational neuroscience training, only formal and structured educational neuroscience training significantly correlated with higher knowledge of educational neuroscience and a better ability to discriminate between neuromyths and neuro-facts. This finding highlighted a critical need for structured educational neuroscience training.

Study 2 then investigated teachers' perceptions of the value of educational neuroscience and the barriers to accessing related training. While teachers expressed considerable interest in applying educational neuroscience insights, they reported significant challenges. These included limited access to continuous professional development (CPD), insufficient educational neuroscience content within Initial Teacher Training (ITT) programmes, and practical barriers such as time constraints, financial limitations, and complex academic language. Teachers emphasised the need for comprehensive educational neuroscience training that deepens their understanding of the field and offers practical insights for evaluating different classroom interventions. Additionally, they highlighted the need for accessible, flexible learning formats, such as

asynchronous modules, that could accommodate their diverse learning preferences, professional backgrounds, and workload demands.

These findings align with broader research, such as a recent national survey of over 1,000 teachers in the UK, which found strong support for incorporating educational neuroscience into teaching practices (Thomas et al., 2024). Of the teachers familiar with educational neuroscience, 76% recognised its benefits, particularly in understanding brain development and addressing individual learning needs. Additionally, 71% agreed that educational neuroscience is relevant to their professional development, and 55% believed they could apply these insights in the classroom if practical guidance were provided. Many teachers have already encountered neuroscience concepts through informal means, such as online resources, blogs, and videos. Yet, they still perceived the need for structured training to implement these ideas effectively in their teaching. As evidenced by Study 1, this informal exposure has often been insufficient for building accurate understanding, leaving teachers susceptible to neuromyths and lacking the structured training required to implement these insights effectively in their teaching. This growing interest in incorporating educational neuroscience into education aligns with a broader shift towards evidence-based teaching practices and integrating interdisciplinary research into classroom applications (Im et al., 2018; Pickering & Howard-Jones, 2007; Wilcox et al., 2021).

Together, these findings indicate a growing interest in educational neuroscience and highlight the need for formal, structured approaches to integrating educational neuroscience into ITT programmes. However, despite this enthusiasm, there remains a significant gap in formal training opportunities that provide practical applications of neuroscience theories (Privitera, 2021; Tokuhamma-Espinosa & Nouri, 2020, 2023).

Addressing this gap in ITT programmes could offer structured, research-informed training

that helps teachers critically evaluate neuroscience concepts, reducing reliance on informal, unregulated resources and enhancing educational outcomes. Teachers equipped with structured knowledge of educational neuroscience could be better prepared to apply insights from the field in their classrooms.

However, the inclusion of additional content in ITT programmes presents practical challenges, as these curricula are already densely packed with foundational areas of teacher training. Standalone modules could offer an alternative by addressing gaps in training through flexible, accessible formats that complement, rather than replace, existing ITT content.

Building on the previous two studies' findings and the literature mentioned above, this study evaluates the effectiveness of structured educational neuroscience training, such as the standalone, asynchronous course designed in this research, providing insights into its potential role in bridging gaps identified in teachers' educational neuroscience training. It focuses on the fourth research question: "What is the impact of a structured educational neuroscience training programme on teachers' knowledge and perceptions of educational neuroscience?"

The aims of this study were to a) develop and implement a structured educational neuroscience training programme that is time-efficient, cost-effective, and offers easily accessible resources and practical tools that teachers can readily use in their classrooms, and b) test the findings from Study 1, where it was hypothesised that exposure to structured educational neuroscience training would result in a higher level of knowledge of educational neuroscience than other forms of educational neuroscience training. By doing so, the study aimed to demonstrate that accessible and credible evidence from educational neuroscience exists for teachers to use.

Hypotheses

In this study, teachers completed a short, structured course in educational neuroscience. Their knowledge of educational neuroscience was tested before and after the course, and these scores were compared with those of a control group who did not receive the course.

The hypotheses tested in this study were as follows:

1. The mean difference in knowledge of educational neuroscience scores of the treatment group would be higher after completion of the educational neuroscience course compared with their scores before completing the course.
2. The mean difference in knowledge scores of the treatment group would be higher after completion of the educational neuroscience course compared with the scores from the control group.

Methods

Design

This study used a true experimental pre-post-test design with control and treatment groups to evaluate the impact of an educational neuroscience course on teachers' knowledge. By assessing participants' knowledge before and after the course, the design offered a clear framework for measuring changes resulting from the intervention. The course was delivered via an online learning platform, chosen to provide flexibility and accessibility for participants managing diverse schedules and workloads.

Participants

Full ethical approval for the project was granted by the UCL Institute of Education Ethics Committee in advance of the study (Appendix A).

The participants for this study were drawn from a pool of 32 individuals from Study 2 who had agreed to participate in future research. An *a priori* power analysis was conducted before data collection using G*Power 3.1 (Faul et al., 2009) to determine the required sample size for detecting a large effect size (Cohen's $d = 0.8$) with an $\alpha = 0.05$ and power ($1 - \beta$) = 0.80 for a one-tailed dependent samples *t*-test. The analysis indicated that a total sample of 24 participants (12 per group) was required to achieve adequate power. A large effect size was selected for the analysis to focus on changes that have practical significance in educational settings. Given the considerable demands on teachers' time and resources, only interventions demonstrating meaningful improvements in targeted domains are likely to justify their implementation on a wider scale. Thus, the current study prioritised detecting large effects to align with its aim of identifying impactful and scalable interventions.

The pool of potential participants had varying levels of educational neuroscience training: four with formal training, ten with CPD-level training, eleven with informal exposure, and seven with no prior exposure. To ensure balanced representation across training levels, a stratified randomisation approach was used. Participants were first categorised into strata based on their prior training level (formal, CPD, informal, no exposure). Participants were randomly assigned to the treatment or control group within each stratum.

Due to the unequal distribution of participants across training levels, exact splits between groups were not always possible. For example, in the "no exposure" category ($n = 7$), random assignment resulted in four participants in the treatment group and three in the control group. Similarly, in the "informal exposure" category ($n = 11$), random assignment resulted in six participants in the treatment group and five in the control group. Participants

in the Formal and CPD training levels were randomly assigned evenly between the two groups.

This stratified randomisation process ensured balanced representation across the groups and resulted in seventeen potential participants for the treatment group and fifteen for the control group.

Email invitations were sent to 32 potential participants, clearly outlining the study's purpose, structure, and time commitment. This communication included information about the study's objectives, ethical considerations, inclusion and exclusion criteria, and an explanation of the voluntary nature of participation (see the *Procedure* section for details on the information provided). Of the 32 invited participants, 11 from the treatment group and 7 from the control group agreed to participate. Measures such as email reminders and gift card provision were implemented to minimise participant attrition. Despite these efforts, 2 participants from the control group dropped out, leaving 5 who completed the study. Similarly, 3 participants from the treatment group dropped out before completing the course, resulting in a final sample of 8 participants who fully engaged with and completed the course. This resulted in an overall participation rate of approximately 41% from the initial pool.

Similar to Studies 1 and 2, the age data was categorical, and individual ages were unavailable. To estimate the mean age, midpoints were assigned to each age category (e.g., 21.5 for 18-25, 28 for 26-30, etc.). These midpoints were weighted by the frequency of participants within each category, and a weighted average was calculated. This approach yielded a mean age of 45.75 years ($SD = 8.57$) for the treatment group and 47.5 years ($SD = 4.0$) for the control group. All participants were active teachers in schools across the UK, and

detailed demographic data, including teaching experience and educational qualifications, are provided in the *Descriptive Statistics* section.

Materials

The study materials included course sessions, a pre-post-test measure, and a feedback form. Each component is described in detail below, along with the rationale for the chosen course format and any adjustments made during the study design.

Course Design and Delivery Rationale

The original plan for the course involved a flipped classroom instructional strategy, with participants completing preparatory materials asynchronously, followed by synchronous sessions (Hamdan & Mcknight, 2013; Jensen et al., 2022). These synchronous sessions were initially scheduled to occur fortnightly over two months, with five sessions lasting two hours each (10 hours total). However, findings from Study 2 and feedback from initial course invitations revealed significant challenges with this format. Study 2 findings highlighted that teachers' limited time availability created a barrier to participation. Feedback from initial invitations to the current course further revealed that teachers were reluctant to commit to a time-intensive format, especially without a formal qualification attached to it. One participant even withdrew due to scheduling conflicts with live sessions.

To address these concerns, the course structure was revised to focus exclusively on asynchronous content, including short pre-recorded videos and interactive tools like quizzes and classroom-based scenarios. This adjustment aimed to enhance accessibility and flexibility, accommodating participants' varied schedules and workloads while maintaining engagement with practical and interactive content. The revised design ensured the course was both manageable and aligned with teachers' needs for flexible professional development.

An asynchronous online learning platform, *UCL Extend*, was selected for course delivery due to its accessibility, flexibility, and cost-effectiveness. Designed specifically for short courses, professional education, and public access to educational resources (UCL, 2018), UCL Extend offers tracking features that enable participants and tutors to monitor engagement and progress through the modules. This online format allows participants to access modules and tests at their convenience and from any location, making accommodating the demands of busy teaching schedules (Howard & Scott, 2017; Soffer et al., 2019) easier. Additionally, the platform integrates diverse multimedia resources, such as videos and interactive quizzes, which have been shown to enhance learner engagement and improve knowledge retention (Abdulrahman et al., 2020). By combining these elements, UCL Extend maximises accessibility and supports the learning needs of teachers, particularly those facing time constraints, ensuring the course is both practical and impactful.

Course Content

The course content was refined to focus on key cognitive mechanisms of learning while maintaining an accessible level of detail to ensure it remained manageable for teachers. Five core topics were covered: the nature of evidence, memory, attention, executive functions, and neuroplasticity. These topics were selected based on relevant literature on key educational neuroscience concepts in teacher knowledge (Tokuhamas-Espinosa, 2018; Tokuhamas-Espinosa & Nouri, 2020, 2023) and valid educational neuroscience resources (e.g., Centre for Educational Neuroscience, 2018; Howard-Jones et al., 2016; Mareschal et al., 2013; Thomas et al., 2020). The course aimed to maintain a focus on broader, fundamental concepts that could be delivered within the time constraints.

Based on feedback from Study 2 that highlighted the applicability of such content, practical classroom-based scenarios (vignettes) and related multiple-choice questions

(MCQs) were integrated into the sessions. This also helped make the course more engaging for teachers. Each scenario presented a realistic teaching situation, followed by an MCQ to assess participants' understanding of relevant educational neuroscience concepts.

Participants were prompted to select their answers and, upon submission, were provided with a brief explanation of the correct answer. This immediate feedback reinforced key concepts and allowed participants to reflect on the rationale behind the answers.

An example scenario from the memory session and related MCQ are as follows:

Scenario: "Mr. Patel, a dedicated primary school teacher, structured his lesson to introduce a new topic on "Planets and their Moons". He began by explaining the concept of moons, then transitioned to the factual details about specific planets and their moons.

After introducing the topic, Mr. Patel handed out activity sheets. Instead of simply asking students to memorise the names of planets and their moons, he encouraged them to link Mars with the "Royal Mail Postbox". The iconic postbox, always painted in a vibrant shade of red, serves as a symbol of communication and connection. By associating Mars, the Red Planet, with the enduring image of the red postbox, students could easily recall not only the colour of Mars but also the idea that, like the postbox, the planet has been a constant presence in the cosmic landscape".

After this description, participants were asked the following question:

"Which type of memory is Mr. Patel introducing to aid students in remembering the names of the planets?

- A) Semantic memory
- B) Procedural memory
- C) Episodic memory
- D) Working memory"

An answer explanation was then provided after the response submission: "Mr. Patel's teaching approach is a good example of elaboration. This teaching strategy, which involves associating names of planets with memorable references, primarily taps into Episodic Long-Term Memory (C). Episodic memory is a type of long-term memory associated with the ability to recall specific events or experiences from personal episodes, often linked to particular times and places. In this scenario, Mr. Patel is helping students create a personal narrative around the concept of Mars by associating it with the red postbox, making the information more relatable and easier to remember over time."

In addition to the scenarios and MCQs, practical short tips were presented throughout the sessions. For example, after discussing short-term memory, participants were offered this practical tip: "Short-term memory is limited but can be supported by breaking information into smaller chunks." The practical tips and immediate feedback provided during quizzes aimed to reinforce learning and consolidate knowledge, as timely feedback is crucial for effective learning (Butler & Roediger, 2008; Roediger & Butler, 2011).

The course was piloted with two primary school teachers and two PhD students in education and special education. The purpose of piloting was to ensure smooth delivery and ease of access to the course content. Specifically, piloting participants were asked to test whether the instructions for each module were clear and easy to follow, as clear guidance is essential to allow participants to navigate the materials confidently without needing additional support. They also assessed the functionality of interactive elements, such as quizzes and scenario-based questions, to confirm that these tools worked as intended and offered an engaging experience. Additionally, participants reviewed accessibility aspects, including compatibility across devices and readability of text and visuals, to ensure the materials were accessible on various screens, such as mobile phones and desktops, and that

font sizes, contrast, and layout were comfortable for extended viewing. This piloting phase helped identify and address potential issues, ensuring participants would encounter a seamless, user-friendly experience that maximised their focus on the learning content. Details of each session are outlined in the following sections.

Session 1: Introduction and ‘The Nature of the Evidence’.

The course started with an introductory session on the nature of evidence to help teachers better understand what constitutes research evidence and how to engage with it. This topic was included because research indicates that teachers need to develop skills in research methods to engage with educational research effectively, understand how to evaluate evidence, assess the validity of teaching methods, and make informed classroom decisions (Georgiou et al., 2020; Munthe & Rogne, 2015; Tack et al., 2018; Vanderlinde & van Braak, 2010).

The session introduced teachers to the foundational concepts of research evidence, the peer-review process, and the importance of critically interpreting research to avoid misconceptions, such as neuromyths. The session highlighted the importance of using peer-reviewed sources in educational neuroscience research to guide teaching practices. To support teachers in locating reliable and accessible information, several reputable, user-friendly websites were introduced as resources. These platforms, such as the Centre for Educational Neuroscience (educationalneuroscience.org.uk), Learnus (learnus.co.uk), the Learning Scientists (learningscientists.org), and Tooled Up Education (tooledupeducation.com), provide evidence-based educational content in formats accessible to educators. These resources help teachers locate research-backed insights without navigating dense academic journals, making it easier to integrate scientifically supported strategies into their classrooms.

In the session, a scenario involving "Jack," a teacher who initially implemented the learning styles approach based on a blog recommendation, illustrated the importance of evidence-based evaluation. Jack's approach was challenged as he learned that there was no empirical support for learning styles improving educational outcomes. Teachers were then prompted to reflect on which steps Jack should consider before adopting new methods. The correct response involved seeking evidence that validates any new strategy and encouraging educators to prioritise empirically supported practices.

For a more detailed explanation of the content covered in this session, please refer to Appendix H.

Session 2: Memory

This session focused on memory as a foundational cognitive process that underpins learning and academic success. Memory, as discussed, is essential for information retention, knowledge acquisition, and skill development, all of which are critical within educational settings. The inclusion of memory in this course was informed by established evidence, demonstrating its impact on academic outcomes, particularly for students with SEN (Squire, 2004; Ullman, 2016).

The session began with a brief definition of memory in the context of learning, followed by a detailed exploration of its various systems and processes. Emphasis was placed on the complex and interconnected nature of memory, with a thorough description of the different processes that constitute memory and how they relate to learning (Roxin & Fusi, 2013; Sridhar et al., 2023). These processes were presented under two main sub-headings: long-term memory and short-term memory. Declarative memory—which encompasses episodic and semantic memory—and procedural memory were examined in long-term memory. These distinctions are critical for teachers to understand how different

types of memory function and how they influence student learning, enabling them to develop targeted strategies to address memory-related challenges in the classroom (Morgan-Short & Ullman, 2023; Ullman, 2016).

For example, research highlights that children with poor short-term memory are more likely to face academic challenges (Kemény et al., 2024; Murrihy et al., 2017).

Evidence-based strategies, such as segmenting information into smaller, more manageable chunks, are discussed to address this. Teachers are also introduced to practical approaches like repetition and retrieval practice, which educational neuroscience research identifies as powerful tools for supporting long-term memory retention (Cepeda et al., 2006; Roediger & Butler, 2011). In particular, retrieval practice and spaced repetition were emphasised as effective methods to strengthen memory over time and improve the durability of learning.

Furthermore, understanding the types of memory enables teachers to tailor their approaches to different learning activities. Teachers were guided on how to apply these insights to enhance both procedural and declarative memory. For example, procedural memory can be supported through repeated practice of tasks such as solving mathematical problems or rehearsing language patterns, while declarative memory can be enriched through techniques like storytelling or providing contextual cues that deepen students' understanding of content. These approaches aim to make learning more engaging and accessible, particularly for diverse learners.

For a more detailed explanation of the content covered in this session, please refer to Appendix I.

Session 3: Attention

This session began with an introduction to the concept of attention, which is fundamental in educational settings as it directly influences students' engagement and

information-processing capabilities (Posner & Rothbart, 2007; Stevens & Bavelier, 2011).

Attention was defined as a state of consciousness allowing an individual to selectively focus on specific stimuli, a process essential for students' ability to remain on task and engage with learning materials effectively.

Attention was included in the course due to its critical impact on academic performance. Effective learning requires sustained focus, but various classroom dynamics—such as background noise, task difficulty, or personal motivation—can either enhance or detract from a student's capacity to focus (Posner & Rothbart, 2007; Stevens & Bavelier, 2011). This makes it imperative for educators to understand attention mechanisms and apply strategies to support sustained focus, such as structuring lessons to minimise distractions or providing intermittent breaks.

The session explored two primary types of attention: bottom-up and top-down attention. Bottom-up attention, which is automatic and involuntary, responds immediately to external stimuli (Katsuki & Constantinidis, 2014). An example is a student's automatic reaction to a loud noise, drawing attention away from their task without conscious control. Top-down attention, in contrast, involves deliberate focus guided by internal motivations such as personal interest or task requirements (Gibson et al., 2023; Katsuki & Constantinidis, 2014). An example provided involved a student consciously re-focusing on a reading task after a momentary distraction, demonstrating active cognitive engagement.

The session also introduced the concept of "switch cost," a cognitive slowdown or increased likelihood of errors when shifting attention between tasks or focusing modes (e.g., from reading to listening) (J. T. Bowling et al., 2019; Sawaki & Luck, 2013). This concept is particularly relevant in classrooms where students are frequently required to alternate

between activities, highlighting the importance of reducing unnecessary task-switching to prevent cognitive overload.

Teachers were encouraged to consider the limited capacity of top-down attention, particularly in younger students, and to design lesson plans that mitigate attention fatigue. Incorporating structured breaks and using varied, interactive instructional approaches can help re-engage students and sustain their focus for extended periods. For example, when introducing complex material, breaking the lesson into manageable, engaging segments can ensure that students remain attentive and fully engaged with the content.

By understanding these attention mechanisms, educators can support students in sustaining focus throughout lessons, enabling them to engage effectively with learning tasks, process information efficiently, and manage distractions or multitasking demands. This understanding is integral for academic success (Fan et al., 2002; Fortenbaugh et al., 2017; Hampton Wray et al., 2017).

For a more detailed explanation of the content covered in this session, please refer to Appendix J.

Session 4: Executive Function, Self-Regulation and Metacognition

This session focused on three crucial components in learning: executive function, self-regulation, and metacognition.

These are higher-order cognitive processes that are important in understanding new concepts, self-directed learning and coping in social contexts, making them especially relevant in educational settings where students frequently engage in tasks requiring concentration, planning, and adaptability (Efklides, 2006; Frazier et al., 2021; Panadero, 2017; Schunk & Greene, 2017). Understanding these processes allows teachers to support students' cognitive and emotional development, which can be beneficial for all students but

is particularly impactful for those with SEN, who may experience challenges in these areas (Diamond, 2013; Rogers & Thomas, 2022).

Executive Function

Executive function refers to a set of higher-order cognitive processes essential for goal-directed behaviour and managing complex tasks (Diamond, 2013; Diamond & Ling, 2019). This session introduced three core components—inhibitory control, task switching, and working memory. These skills enable students to plan, follow instructions, focus, adapt to new information, and handle cognitive demands, all of which are vital for success in the classroom (Miyake & Friedman, 2012). By understanding these cognitive abilities, teachers can better support student learning, especially for those who may struggle with these skills, such as students with Special Educational Needs (SEN).

Inhibitory control is the ability to filter out irrelevant information to maintain focus on important tasks. This ability is vital for controlling behaviours that may not be optimal or appropriate for the task at hand (Diamond, 2013; Diamond & Ling, 2019; Nigg, 2017). This skill is crucial for students in classrooms where distractions, like background noise, are constant, as it helps them sustain attention on essential tasks such as listening to instructions. For teachers, understanding inhibitory control can guide strategies to create an environment where students can concentrate more effectively, such as by minimising potential distractions or encouraging focus in specific ways. For instance, when working on a reading assignment, students with strong inhibitory control can filter out background chatter from classmates and maintain their focus on the text. Teachers can support this skill by providing goal-oriented instructions, such as setting a specific reading target for each time segment.

This approach helps students focus on immediate goals and reduces the likelihood of distraction, reinforcing their ability to stay engaged.

Task switching, also known as set-shifting, is the ability to adapt to changing conditions and switch between tasks or rules as needed. This aspect of executive function involves applying different rules to process information or respond to stimuli (Diamond, 2013; Kray & Dörrenbächer, 2019). In classroom settings, this skill enables students to transition smoothly between subjects, activities, or instructions, which is essential in a learning environment where students frequently move from one type of task to another. Understanding task-switching can help teachers facilitate these transitions and support students in managing the cognitive demands of adapting to new information. In practice, students often need to switch from one cognitive mode to another—such as moving from a math problem to a reading assignment. Teachers can encourage smoother transitions by using clear verbal cues or routines, such as announcing, “Now we’re moving to our reading work,” which signals the need for a shift in focus. This simple adjustment helps students mentally prepare for new tasks, maintaining engagement and cognitive flexibility.

Finally, working memory is the ability to carry out a thinking task while temporarily holding information in mind at the same time. This skill is essential for students to follow multi-step instructions, engage in problem-solving, and retain information over short periods in the classroom (Cowan, 2008, 2017; Diamond, 2013; Diamond & Ling, 2019; Klingberg et al., 2005; Titz & Karbach, 2014). Teachers who understand working memory can adjust their instructional strategies to prevent cognitive overload, such as breaking down tasks into manageable steps or providing visual aids. For example, during a mental math exercise, students use their working

memory to keep numbers in mind while calculating. Teachers can support this process by delivering instructions step-by-step and checking for understanding before moving to the next step. This approach allows students to effectively utilise their working memory, reducing cognitive strain and enhancing their ability to process and retain information.

Self-Regulation

Self-regulation refers to the ability to manage and regulate one's emotions, motivations, and behaviours in different situations to meet specific goals (Panadero, 2017; Zimmerman & Schunk, 2011). This skill helps students navigate academic and social challenges in school, allowing them to adjust their behaviour in response to feedback and regulate emotional responses to challenges. Self-regulation skills can be especially challenging for students with SEN, highlighting the need for explicit instruction and support in this area (Holmes et al., 2016; Robson et al., 2020).

Understanding self-regulation enables teachers to support students in developing these skills, particularly benefiting students who may struggle with impulse control, including those with SEN. For example, teaching students to pause and use deep breathing exercises before assessments or challenging tasks helps them manage anxiety and maintain focus. This technique helps students practice emotional regulation, preparing them to approach tasks with a calm, productive mindset, which is essential for learning and retention. By integrating self-regulation strategies into classroom routines, teachers equip students with practical tools to manage their behaviour and emotions, which promotes a learning environment where students feel empowered to tackle academic challenges.

Metacognition

Metacognition, or "thinking about one's own thinking," provides students with an awareness of how their cognitive processes function during learning and allows them to, monitor and assess their learning processes, leading to better learning outcomes (Flavell, 1979; Roebbers, 2017). This ability is central to independent learning, as it enables students to identify gaps in their knowledge and actively seek ways to improve their understanding. Studies suggest that metacognitive skills correlate with higher academic performance, as students who engage in metacognitive practices are better at setting goals, monitoring progress, and employing effective learning strategies (Dunlosky & Rawson, 2015; McCardle et al., 2017; Zepeda et al., 2015).

For teachers, understanding metacognition means they can better support students in becoming reflective, self-directed learners. For example, teachers can encourage students to engage in self-assessment after introducing a new concept. Providing prompts like, "What did I understand well?" and "What questions do I still have?" allows students to evaluate their comprehension actively. This self-assessment practice encourages students to recognise areas they need to revisit, thereby promoting a habit of reflection that supports lifelong learning. By incorporating metacognitive strategies into the classroom, teachers help students develop the awareness and adaptability needed for complex tasks, setting them up for sustained academic success.

For a more detailed explanation of the content covered in this session, please refer to Appendix K.

Session 5: Neuroplasticity

Learning is a good example of the brain's adaptive capacity, which allows it to develop and modify its structure as a result of experiences. This session explored the brain's capacity to adapt and reorganise itself in response to learning and environmental changes.

Defined as the brain's ability to form, reorganise, and strengthen neural connections based on experiences and practice, neuroplasticity is central to understanding how learning shapes cognitive functions over time (Erickson et al., 2013; Forget et al., 2024; Marzola et al., 2023). This session highlighted the importance of neuroplasticity as an educational foundation, allowing teachers to appreciate that learning can physically alter brain pathways and highlighting that abilities and skills can improve with practice and effort.

By exploring neuroplasticity, teachers were encouraged to recognise that students, regardless of age or initial ability, can continuously learn and improve. The concept reinforces that persistence and resilience are vital, allowing educators to view challenges as opportunities for growth. When teachers communicate this perspective, they empower students to believe in their potential, highlighting that effort is a crucial path to mastery.

To illustrate the relevance of neuroplasticity in education, the session explained that each time a student learns a new skill, connections between neurons are formed and strengthened through repetition (Draganski et al., 2004; Dubinsky & Hamid, 2024; Kleim & Jones, 2008). Each time a new skill is practised, these neural connections are strengthened, making it easier for the brain to use these pathways for recalling and applying the learned information. Teachers were encouraged to cultivate classroom environments that value growth, persistence, and learning from mistakes, emphasising the brain's ongoing potential to adapt and learn.

This approach emphasises effort over inherent ability, supports academic growth and builds students' confidence and resilience in the learning process. To help visualise and reinforce these concepts, the session included a 2-minute video from Sentis (2012), which highlights the key ideas covered. After the video, the session addressed some common misconceptions about brain development. For example, it was previously believed that the

brain was ‘fixed’ after childhood. However, recent advances in neuroimaging technology have shown that the brain continues to adapt and change throughout life, regardless of age (Erickson et al., 2013, 2019; Fuchs & Flügge, 2014; Marzola et al., 2023). This understanding of neuroplasticity was presented as particularly important for teachers, as it challenges the idea that students' abilities, intelligence, or talents are static. Instead, the session suggested that these capacities can be developed with dedication, effort, and resilience (Dubinsky & Hamid, 2024).

For a more detailed explanation of the content covered in this session, please refer to Appendix L.

Course Media and Presentation Preparation

PowerPoint slides were created for each session to support effective visual learning and engagement, incorporating visual aids such as infographics, videos, images, and charts. These slides were intentionally designed to be simple and uncluttered, with minimal text to ensure clarity and focus on key concepts. Each slide used a combination of images and concise points to reinforce the spoken explanations visually, and slide layouts were chosen to maintain consistency across sessions, enhancing participant familiarity with the format.

Once the slides were created, they were exported into video format. The process involved recording a presenter delivering explanations for each slide using screen-recording software. The presenter's image appeared in a video bubble overlaying the slides, enabling participants to see and hear the presenter as they navigated through the material. This provided a more personal and interactive feel to the asynchronous learning experience. After recording, the videos were edited to ensure smooth transitions and clear audio-visual synchronisation before being uploaded to UCL Extend. To ensure a seamless user experience, the course recordings were tested for compatibility across multiple devices,

including smartphones, tablets, Macs, and PCs. This systematic approach to preparing course materials ensured visually accessible content for each session. The video format further enabled flexible learning, accommodating teachers' demanding schedules while supporting consistent engagement.

Pre-Test and Post-Test Measures

The Educational Neuroscience Knowledge Test (ENKT) developed in Study 1 was used to assess participants' knowledge of educational neuroscience in both the pre-test and post-test phases of this study. The ENKT evaluates teachers' ability to differentiate between neuromyths from correct scientific information (neuro-facts)—a critical skill that relies on applying knowledge to distinguish scientific information from misconceptions. The consistency in using the same measure for both the pre-test and post-test allowed for a clear evaluation of the course's effectiveness in enhancing participants' knowledge of educational neuroscience. Below is a brief explanation of the ENKT, but a detailed explanation of the measure's development, structure, and scoring, including the sources of the neuromyths and neuro-facts, can be found in Chapter 2, specifically under the *Materials: Questionnaire* section.

Description of the ENKT. The ENKT consists of 36 statements, divided into eighteen neuromyths and eighteen neuro-facts. Each statement was related to either General Cognitive Function (GCF; $10+10 = 20$ statements) or SEN ($8+8 = 16$ statements). For all statements, participants were asked to what extent they agreed or disagreed with the statements on a 5-point Likert scale from 1 (strongly agree) to 5 (strongly disagree). Participants' overall knowledge of educational neuroscience was quantified using differentiation scores, calculated by subtracting neuro-fact scores from neuromyth scores, resulting in an index that ranges from -72 to +72 for 18 neuromyths and 18 neuro-facts.

Additionally, two related sub-indexes were created. The first calculated mean knowledge using the differentiation approach across the GCF-related neuromyths and neuro-facts (*GCF knowledge*), and the second calculated mean knowledge across the SEN-related neuromyths and neuro-facts (*SEN knowledge*).

Alignment of Course Content with Assessment Objectives. The course in the current study covered key educational neuroscience concepts, including memory, attention, executive functions, and neuroplasticity. These topics aligned with the assessment tool's focus, as they represent fundamental areas of educational neuroscience relevant to teaching and learning (Gordon et al., 2024; Thomas et al., 2020; Tokuhamma-Espinosa, 2008; Tokuhamma-Espinosa & Nouri, 2023). By targeting these core concepts, the course aimed to enhance teachers' knowledge and ability to critically evaluate educational neuroscience statements. The ENKT provided a practical and meaningful way to assess whether the increased knowledge gained through the course translated into improved differentiation skills. The alignment of the course content with the assessment tool ensured a direct connection between what was taught and measured.

Measures to Minimise Practice Effects. Several measures were taken to administer the post-test to reduce practice effects due to familiarity with the task. Firstly, an approximately eight-month interval was maintained between the pre-test (completed in June 2023) and the post-test (concluded in February 2024). This extended gap helped minimise the likelihood of participants recalling their previous responses.

Additionally, the order of pre-test and post-test statements was randomised, ensuring that participants received the same pre-test questions as a post-test but in a different order. This randomisation ensured that answers to a given question could not cue retrieval of the answer to the next, further reducing potential practice effects. By

introducing this randomisation and an extended time interval, the study sought to balance any potential practice effects and increase the reliability of the pre-post-test comparisons (Duff et al., 2010; McCaffrey & Westervelt, 1995).

Feedback Form

The feedback form aimed to assess participants' perceptions of the course's effectiveness, relevance, and practicality for teaching. The form included nine statements rated on a 5-point Likert scale, ranging from 'strongly agree' to 'strongly disagree,' covering areas such as how useful participants found the course for improving their teaching strategies, the accessibility of the evidence provided, and the applicability of classroom-based scenarios and practical tips. Participants could also provide open-ended feedback to share additional insights on the course experience. Responses to these statements were subsequently scored, with Likert-scale answers used to gauge general satisfaction, while open-ended responses provided qualitative insights into areas for improvement. Table 10 shows the feedback form questions.

Table 10. Feedback Form Questions

Question
1. This course has demonstrated that there is accessible evidence in educational neuroscience for practitioners.
2. I found this course useful for teaching practice.
3. Session materials were easy to engage with*
4. Flexible course completion allowed me to finish the course at my own pace*
5. I had enough time to complete the course materials*
6. Classroom-based scenarios and related questions will help me consolidate the knowledge gained.
7. Practical tips will help me implement what I have learned in this course in my practice.
8. Now I know what information is available, it will help me generate more effective teaching activities for my students.
9. Now I know what information is available, it will help me develop more effective teaching strategies for children with SEN.
Additional comments or feedback about the course**

Notes. SEN = Special Educational Needs (abbreviation was not used in the original feedback form).

*Not included in the analysis (details given in the data analysis section).

**Provides an open-ended space for participants to share any additional insights, suggestions, or feedback on their course experience.

Procedure

Participants for the treatment and control groups were recruited from Study 2, selecting those who had expressed interest in further research. Pre-test scores were collected during the Study 2 recruitment phase to facilitate logistical planning for the current study. This early collection ensured a longer interval between the pre-test and post-test phases, as the pre-test was completed well before the educational neuroscience course. When participants received invitation emails for the current study, they had already completed the pre-test, which remained open for a month and concluded in June 2023 for both groups.

Both the treatment and control groups received invitation emails in December 2023 for the current study. These invitations briefly outlined the study's purpose and what they were asked to take part in the research. The email reminded them they had completed part of the current study materials (pre-test) in their previous engagement with the research, but the content of the invitation email differed slightly between the potential participants of the treatment and control groups.

For the treatment group, the email included a research information sheet (Appendix M), a consent form (Appendix N), and a link to enrol and complete the educational neuroscience course on the online platform (UCL Extend). The research information sheet clearly detailed the study procedures and the inclusion and exclusion criteria. It addressed ethical considerations, explaining the voluntary nature of participation and assuring participants of confidentiality and data security. Participants were instructed to read the research information sheet and were informed that enrolling in the course implied consent.

The control group received a slightly different research information sheet (Appendix O) and a link to the post-test instead of the course enrolment. This version of the

information sheet excluded details about the course enrolment. Instead, participants were informed that their only task was to complete a brief questionnaire (post-test). They were also told that their responses would contribute to evaluating the effectiveness of an online course. The email for the control group excluded the consent page, as participants provided consent (Appendix N) on the first page of the post-test after clicking the link. Both groups were notified that they would receive a £15 Amazon gift card as a token of appreciation upon task completion.

The treatment group received the invitation email in December 2023. Upon completing all modules, participants were prompted to complete the post-test and the feedback form to evaluate their knowledge and experience. The course closed in February 2024 upon completion of the last treatment group participant.

As soon as the first five treatment group participants completed the course in mid-January 2024, control group participants received invitation emails to complete the post-test measure. This helped keep the post-test data collection time as consistent as possible between treatment and control groups and to avoid attrition in the control group. All control group participants completed the post-test by early February 2024. Both the treatment and control groups received a £15 Amazon gift card upon completion of the tasks.

Data Analysis

The data analysis was conducted in two main steps: Inferential Analysis and Feedback Analysis. The first step examined differences in knowledge of educational neuroscience before and after the educational neuroscience course, both within and between groups. The second step analysed participants' feedback to gain insights into their perceptions of the course. While the primary aim of this study was to evaluate the impact of

an educational neuroscience course, the feedback analysis was included as an exploratory addition to refine future implementations.

T-tests were used to compare performance between the treatment and control groups before and after the course. Given the small sample size, independent and paired-sample *t*-tests were used to compare knowledge scores within and between groups. While multiple *t*-tests increase the likelihood of Type I error, these were independent comparisons, which mitigates some concerns about inflated false positives. Additionally, a factorial ANOVA was not performed due to concerns about statistical power and the complexity of interaction effects in a small dataset.

First, pre-test scores were compared between the treatment and control groups to ensure they were comparable in terms of their knowledge of educational neuroscience.

Due to the limited number of participants in the current study sample, the analysis incorporated data from Study 1 of this PhD project, which included 366 participants who completed the ENKT that assesses teachers' knowledge of educational neuroscience. This larger dataset provided a broader baseline for comparison. It allowed the study to determine whether the pre-test scores of the control and treatment groups were consistent with a broader population. By validating the reliability of the pre-test data in this way, the analysis ensured that any observed changes in knowledge could be attributed to the course rather than initial differences between the groups. This baseline comparison also helped contextualise subsequent inferential tests, addressing the study's primary hypotheses.

After these preliminary analyses, further *t*-tests were conducted to assess knowledge changes within and between control and treatment groups after the course. Comparisons of pre-test and post-test scores in the treatment group evaluated knowledge improvement, while testing in the control group helped account for the possible practice

effects over the same period. A final comparison of post-test scores between groups provided insight into the course's effectiveness. Effect sizes were calculated to measure the impact, with larger values in the treatment group indicating a substantial knowledge gain from the course, supporting the course's effectiveness.

After these steps, the Mann-Whitney U test and the Wilcoxon signed-rank test, which are the non-parametric alternatives to independent-sample *t*-tests and paired-sample *t*-tests, were conducted. This was a precaution due to the small sample size. Same results would provide support for the parametric tests.

For the second step, feedback data from the educational neuroscience course were analysed to evaluate participants' perceptions of the course's value, accessibility, and practicality. Quantitative responses from the feedback form's Likert-scale questions were summarised to assess the course's effectiveness in addressing barriers identified in Study 2 and supporting teaching practices. Open-ended responses were reviewed and grouped into key areas of feedback, such as the course's positive impact, suggestions for improvement, and challenges with implementation, to provide additional insights into participants' experiences.

Results

This study examined whether structured educational neuroscience courses would improve teachers' knowledge of educational neuroscience as assessed by the ENKT developed in Study 1. The results are organised into three parts: (1) Descriptive Statistics, summarising participant demographics and baseline characteristics; (2) Inferential Analysis, which includes a structured sequence of comparisons to evaluate the course's impact on participants' knowledge; and (3) Feedback Analysis, which explores participants'

perceptions of the course, using both quantitative Likert-scale responses and qualitative open-ended feedback.

Descriptive Statistics

The study included 13 participants, with 8 in the treatment group and 5 in the control group. Both groups reported substantial teaching experience, with each participant having more than six years of overall teaching experience. Study 1, which served as a baseline reference, included a larger sample of 366 participants, most of whom had similarly extensive teaching experience: 79.2% reported six or more years of teaching experience, 12% had between 3 and 5 years, and 8.7% had two years or less. This larger dataset provides a broader population context against which to compare the pre-test scores of the treatment and control groups. Table 11 shows a summary of age, gender, and experience across groups.

Table 11. *Summary of Age, Gender, and Years of Teaching Experience Across Groups*

Group	Mean Age (SD)	N (F)	Mean Years of Teaching Experience
Treatment	45.75 (8.57)	8 (7)	6 or more
Control	47.5 (4)	5 (4)	6 or more
Study 1	42.39 (10.7)	366 (288)	Mixed, *predominantly 6 or more

Notes. *SD* = Standard Deviation; *F* = Females

*79.2% had six or more years of teaching experience

The educational neuroscience training backgrounds varied across groups. These were categorised into four distinct groups, as established in Study 1:

1. Formal: Structured undergraduate, postgraduate, or doctoral-level educational neuroscience training.
2. CPD: Continuing professional development level, but no formal educational neuroscience training.

3. Informal Exposure: Engagement with professional or educational materials related to educational neuroscience, but neither formal nor CPD-level educational neuroscience training.
4. No exposure to any identified educational neuroscience training.

The intervention and control groups differed slightly in whether any had formal educational neuroscience training. In the treatment group, 2 participants had formal educational neuroscience training, compared to none in the control group. While both groups included participants with CPD-level training (2 in the treatment group and 2 in the control group) and participants with no prior training (3 in the treatment group and 3 in the control group). Study 1 data provided a broader reference for these training backgrounds, with 29 participants reporting formal educational neuroscience training, 80 having CPD training, 118 with informal exposure, and 139 with no prior educational neuroscience training.

Most participants in the current study held additional roles beyond their primary teaching responsibilities. All participants in the treatment group reported holding additional roles, including Headteacher/Head of School/Acting Head (3 participants), Subject Lead (3 participants), Deputy or Assistant Head (1 participant), and Head of Sixth Form (1 participant). In contrast, in the control group, 3 out of 5 participants held additional roles, such as Headteacher/Head of School/Acting Head (1 participant), Head of Year/Phase (1 participant), and Executive Leader/MAT CEO (1 participant), while the remaining 2 participants reported no additional roles beyond their primary teaching duties. This demonstrates a higher level of engagement in additional roles within the treatment group compared to the control group.

Qualifications also varied across the groups. Five out of eight participants in the treatment group held a master's degree, while the remaining three held bachelor's degrees or a PGCE/PGDE qualification. In the control group, three participants held master's degrees, and two held bachelor's degrees. Information on roles and qualifications was not available in the Study 1 data.

For SEN teaching experience, twelve participants reported more than six years of teaching experience with SEN students, while one participant had between 3 and 5 years of experience.

In Study 1, the distribution of SEN experience was similarly robust: 71% had six or more years, 12% had 3–5 years, and 13.4% had two years or less, with only 3.6% reporting no SEN teaching experience. The substantial SEN experience observed in both Study 1 and the current study's sample serves as a relevant baseline reference for evaluating the impact of the educational neuroscience course on teachers' knowledge.

Assessed by the ENKT developed in Study 1, Table 12 summarises the mean pre-test and post-test knowledge of educational neuroscience differentiation scores for the treatment and control groups across three indexes: Overall knowledge, GCF knowledge, and SEN knowledge. Study 1 baseline scores are included for comparison with a broader sample, representing data collected at a single time point before the pre-test.

Table 12. *ENKT Scores for Treatment and Control Groups, with Study 1 Baseline*

Index	Group	Pre-Test	Post-Test	*Study 1
		Mean (<i>SD</i>)	Mean (<i>SD</i>)	Mean (<i>SD</i>)
Overall (GCF + SEN)	Treatment	21.00 (5.55)	31.63 (7.82)	19.55 (9.57)
	Control	21.80 (9.81)	22.00 (11.00)	
GCF Knowledge	Treatment	10.50 (4.38)	17.13 (4.64)	8.88 (4.78)
	Control	13.40 (7.70)	12.40 (7.50)	
SEN Knowledge	Treatment	10.50 (2.98)	14.50 (3.66)	10.67 (6.67)
	Control	8.40 (3.44)	9.60 (4.28)	

Notes. ENKT = Educational Neuroscience Knowledge Test; *SD* = Standard Deviation; Overall = Knowledge of educational neuroscience using 18 neuromyths and 18 neuro-facts; SEN Knowledge = SEN-related knowledge of educational neuroscience using 8 SEN-related neuromyths and 8 neuro-facts; GCF Knowledge= General Cognitive Function (GCF)-related knowledge of educational neuroscience using 10 GCF-related neuromyths and 10 neuro-facts.

*Study 1 data represent baseline scores collected at a single time point before the pre-test.

Inferential Analysis

Inferential analyses were conducted to test the two main hypotheses related to changes in knowledge of educational neuroscience to evaluate the effectiveness of the educational neuroscience course. Five key analyses were conducted sequentially, examining pre-test and post-test scores across the treatment and control groups. Each step involved comparing knowledge of educational neuroscience across three indexes—overall knowledge (36 statements), GCF knowledge (20 statements), and SEN knowledge (16 statements). The hypotheses were tested primarily using the overall index, with the GCF and SEN indexes validating the findings further. Each step initially included parametric tests, then were followed by non-parametric alternatives as a precaution due to the small sample size.

Step 1: Pre-Test Comparisons Between Treatment and Control Groups

The first analysis involved two-tailed independent-sample t -tests on pre-test scores between treatment and control groups to ensure initial comparability in knowledge levels across three indexes. This step was crucial for determining if any post-test differences could be attributed to the course rather than initial knowledge discrepancies.

Overall Knowledge. No significant difference was found between the treatment group ($M = 21.00$, $SD = 5.55$) and the control group ($M = 21.80$, $SD = 9.81$), $t(11) = -0.19$, $p = .85$. A non-parametric Mann-Whitney U test result was consistent with this, showing no significant difference between the groups ($U = 19.00$, $Z = -0.15$, $p = .88$).

GCF Knowledge. GCF knowledge also showed no significant difference between the treatment group ($M = 10.50$, $SD = 4.38$) and control group ($M = 13.40$, $SD = 7.70$), $t(11) = -0.88$, $p = .47$. A non-parametric Mann-Whitney U test result was consistent with this, showing no significant difference between the groups ($U = 17.00$, $Z = -0.44$, $p = .72$).

SEN Knowledge. SEN knowledge scores were also comparable, with no significant difference between treatment ($M = 10.50$, $SD = 2.98$) and control ($M = 8.40$, $SD = 3.44$), $t(11) = 1.17$, $p = .29$. A non-parametric Mann-Whitney U test result was consistent with this, showing no significant difference between the groups ($U = 13.50$, $Z = -0.96$, $p = .35$).

These results confirm that the treatment and control groups were comparable across all three indexes before the educational neuroscience course.

Step 2: Pre-Test Comparisons with Study 1 Data

Two-tailed independent-sample t -tests were also conducted to compare the pre-test scores of both treatment and control groups against Study 1 baseline data to establish relevance to a broader population.

While the sample size for the current study is limited, these comparisons with Study 1, which involved a much larger sample, help to validate the findings by establishing that the treatment and control groups' pre-test knowledge aligns closely with the knowledge levels of a broader, more representative population. This comparability adds robustness to the conclusions drawn from the course's effects on knowledge of educational neuroscience.

Overall Knowledge. The treatment group's pre-test scores ($M = 21.00$, $SD = 5.55$) were not significantly different from Study 1 ($M = 19.55$, $SD = 9.57$), $t(372) = 0.43$, $p = .67$. A non-parametric Mann-Whitney U test supported this finding, indicating no significant difference ($U = 1289.00$, $Z = -0.58$, $p = .56$). Likewise, the control group's scores ($M = 21.80$, $SD = 9.81$) were comparable to Study 1, $t(369) = 0.52$, $p = .6$. The non-parametric Mann-Whitney U test yielded consistent results ($U = 800.50$, $Z = -0.48$, $p = .63$).

GCF Knowledge. For GCF knowledge, the treatment group ($M = 10.50$, $SD = 4.38$) and the control group ($M = 13.40$, $SD = 7.70$) showed no significant differences from Study 1 ($M = 10.67$, $SD = 6.67$), $t(372) = -0.07$, $p = .94$ for the treatment group and $t(369) = 0.91$, $p = .37$ for the control group. A non-parametric Mann-Whitney U test supported this finding, showing no significant difference between the treatment and Study 1 ($U = 1454.50$, $Z = -0.03$, $p = .98$) and between control and Study 1 ($U = 738.50$, $Z = -0.74$, $p = .46$).

SEN Knowledge. Similarly, SEN scores showed no significant difference between the treatment ($M = 10.50$, $SD = 2.98$) or control groups ($M = 8.40$, $SD = 3.44$) and Study 1 baseline ($M = 8.48$, $SD = 4.78$), $t(372) = 0.95$, $p = .34$ for the treatment group and $t(369) = -0.23$, $p = .82$ for the control group. A non-parametric Mann-Whitney U test supported this finding, showing no significant difference between the treatment and Study 1 ($U = 1108.00$, $Z = -1.18$, $p = .24$) and between control and Study 1 ($U = 880.00$, $Z = -0.15$, $p = .89$).

These findings confirm that both groups are representative of a broader population in knowledge of educational neuroscience before the course. This also set the scene for subsequent inferential tests addressing Hypothesis 1 and Hypothesis 2.

Step 3: Pre-Post Comparisons Within the Treatment Group

The first hypothesis proposed that the mean difference in knowledge of educational neuroscience scores of the treatment group would be higher after completing the educational neuroscience course compared with their scores before taking the course. Two-tailed paired-sample t -tests were conducted on the treatment group's pre-test and post-test scores to test this hypothesis.

Overall Knowledge. The treatment group's post-test scores ($M = 31.63$, $SD = 7.82$) were significantly higher than their pre-test scores ($M = 21.00$, $SD = 5.55$), $t(7) = 4.72$, $p = .002$, with a large effect size (Cohen's $d = 1.67$). The Wilcoxon Signed-Rank Test confirmed this result, indicating a significant increase in scores, $Z = -2.53$, $p = .01$, with all participants showing positive ranks.

GCF Knowledge. GCF knowledge also showed a significant increase from the pre-test ($M = 10.50$, $SD = 4.38$) to the post-test ($M = 17.13$, $SD = 4.64$), $t(7) = 4.19$, $p = .004$, with a large effect size (Cohen's $d = 1.48$). The Wilcoxon Signed-Rank Test supported

this finding, showing a significant improvement, $Z = -2.53$, $p = .01$, with all participants displaying positive ranks.

SEN Knowledge. SEN knowledge scores increased significantly from the pre-test ($M = 10.50$, $SD = 2.98$) to the post-test ($M = 14.50$, $SD = 3.66$), $t(7) = 2.65$, $p < .03$, with a large effect size (Cohen's $d = 0.94$). The Wilcoxon Signed-Rank Test showed a consistent pattern, revealing a significant increase in scores, $Z = -1.99$, $p < .05$, with all participants displaying positive ranks.

These results support Hypothesis 1, demonstrating that the treatment group showed a significant improvement in knowledge of educational neuroscience following the educational neuroscience course, even with a smaller-than-planned sample size. The observed large effect sizes across all knowledge domains (Overall, GCF, and SEN) highlight the practical relevance of these findings, aligning with the study's focus on identifying meaningful and impactful changes, as reflected in the a priori power analysis.

Step 4: Pre-Post Comparisons Within the Control Group

To control for potential practice effects, two-tailed paired-sample t -tests were conducted on the control group's pre-test and post-test scores over the course period. This step was essential for confirming that any observed improvement in the treatment group's knowledge was due to the course and not merely a result of repeated testing.

Overall Knowledge. The control group's pre-test ($M = 21.80$, $SD = 9.81$) and post-test scores ($M = 22.00$, $SD = 11.00$) were not significantly different, $t(4) = 0.34$, $p = .75$, with a small effect size (Cohen's $d = 0.15$). Consistently, the Wilcoxon Signed-Rank Test also indicated no significant change, $Z = -0.38$, $p = .71$, with a nearly equal distribution of positive and negative ranks.

GCF Knowledge. GCF scores showed no significant change from the pre-test ($M = 13.40$, $SD = 7.70$) to the post-test ($M = 12.40$, $SD = 7.50$), $t(4) = 1.05$, $p = .35$, with a medium effect size (Cohen's $d = 0.47$). The Wilcoxon Signed-Rank Test supported this finding, showing no significant change, $Z = -1.11$, $p = .27$, with slightly more negative ranks than positive ranks.

SEN Knowledge. SEN knowledge scores also showed no significant change from the pre-test ($M = 8.40$, $SD = 3.44$) to the post-test ($M = 9.60$, $SD = 4.28$), $t(4) = 1.04$, $p = .36$, with a small effect size (Cohen's $d = 0.46$). The Wilcoxon Signed-Rank Test was in line with this result, showing no significant difference, $Z = -1.08$, $p = .28$, with a small difference in positive and negative ranks.

These findings suggest that, without the course, knowledge of educational neuroscience in the control group remained stable across all indexes, ruling out the possibility of practice effects.

Step 5: Post-Test Comparisons Between Treatment and Control Groups

Finally, the second hypothesis posited that the mean difference in knowledge scores of the treatment group would be higher after completing the educational neuroscience course compared with the scores from the control group.

To evaluate this hypothesis, two-tailed independent-sample t -tests were conducted to compare the post-test scores between the treatment and control groups.

Overall Knowledge. Although post-test comparisons showed higher mean scores in the treatment group ($M = 31.63$, $SD = 7.82$) compared to the control group ($M = 22.00$, $SD = 11$), this difference was not statistically significant in a two-tailed test, $t(11) = 1.85$, $p = .09$. Similarly, the Mann-Whitney U test showed consistent results with no significant difference ($U = 8.50$, $Z = -1.69$, $p = .09$). However, given the

directional hypothesis that the course would improve knowledge, a one-tailed t -test yielded a significant result, $p < .05$. This result, coupled with a large effect size (Cohen's $d = 1.06$), suggests that the course may have had a meaningful impact on the treatment group's knowledge.

GCF Knowledge. GCF knowledge showed no significant post-test difference between the treatment group ($M = 17.13$, $SD = 4.64$) and control group ($M = 12.40$, $SD = 7.50$), $t(11) = 1.42$, $p = .25$, although the effect size was moderately large (Cohen's $d = 0.81$). Similarly, the Mann-Whitney U test showed consistent results with no significant difference ($U = 10.00$, $Z = -1.48$, $p = .17$).

SEN Knowledge. For SEN knowledge, the treatment group ($M = 14.50$, $SD = 3.66$) outperformed the control group ($M = 9.60$, $SD = 4.28$), $t(11) = 2.21$, $p < .05$, with a large effect size (Cohen's $d = 1.257$), indicating a substantial course effect on SEN knowledge. Similarly, the Mann-Whitney U test showed consistent results with significant difference ($U = 7.00$, $Z = -1.91$, $p < .05$).

These findings partially support Hypothesis 2. While the difference in SEN knowledge was significant between the treatment and control groups, the differences in overall and GCF knowledge were not statistically significant. It is important to note that the overall score is a combination of SEN knowledge and GCF knowledge. As such, the significant improvement in SEN knowledge was effectively diluted by the more variable and inconsistent progress in GCF knowledge, resulting in a non-significant overall score. This highlights that the progress in SEN was more consistent across participants, while GCF knowledge gains were less uniform. However, the large effect sizes suggest that the treatment may have also had a practical impact on these areas.

The smaller standard deviation for SEN knowledge scores suggests that participants experienced more consistent gains in this area, potentially reflecting better alignment between the course content and SEN-related items in the ENKT. In contrast, the larger standard deviation in GCF knowledge scores indicates that progress in this domain was more variable or haphazard, which could reflect a less direct correspondence between the course material and the GCF-related items.

Feedback Analysis

Understanding teachers' perceptions of the course's value, accessibility, and practicality is crucial, especially given the findings from Study 2. In that study, teachers indicated a strong interest in educational neuroscience but identified significant barriers to accessing educational neuroscience courses, including time constraints, lack of flexible learning options, and academic language that felt too complex or removed from practical application. These challenges highlighted the need to design educational neuroscience training that is accessible, relevant, and engaging for teachers. Thus, gathering feedback on the course in Study 3 provides insights into whether this course effectively addressed the issues raised in Study 2 and met teachers' learning needs and preferences.

Feedback was collected through a feedback form at the course's conclusion. As outlined in section *Feedback Form* section, the form included nine statements rated on a 5-point Likert scale on topics such as the perceived value of educational neuroscience evidence, the course's usefulness for teaching, and the applicability of practical strategies and classroom scenarios.

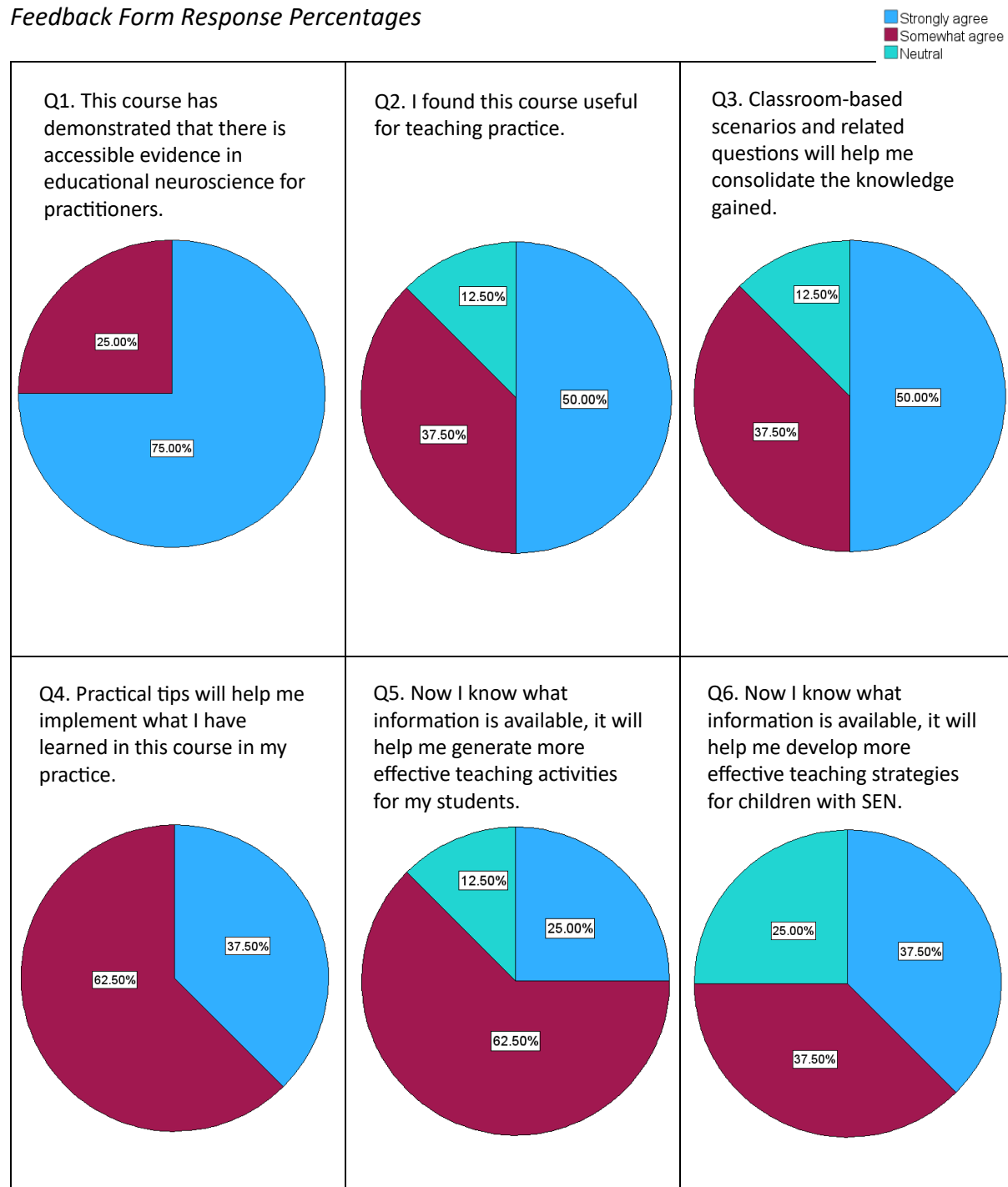
Three statements which were not directly relevant to the study's primary research questions were excluded from the primary analysis. These statements focused on logistical aspects of the course experience: a) "Session materials were easy to engage with," b)

“Flexible course completion allowed me to finish the course at my own pace,” and c) “I had enough time to complete the course materials.” As these items still provided insights into the course's accessibility and usability, responses to these items were summarised to inform the broader discussion on the practical implications of the course design, particularly in addressing accessibility and time-related barriers identified in Study 2.

Responses to these three statements were overwhelmingly positive. All participants (100%) agreed or strongly agreed that the session materials were easy to engage with and that the course allowed for flexible completion at their own pace. Additionally, 87.5% of participants agreed or strongly agreed that they had enough time to complete the course materials, with 12.5% remaining neutral. These findings reinforce the course's accessibility and practicality, supporting its alignment with the barriers to professional development identified in Study 2, such as limited time and workload constraints.

The feedback to the main questions was also overwhelmingly positive, with a high proportion of participants agreeing or strongly agreeing that the course provided accessible evidence and practical knowledge that would support their teaching practices. Specifically, all participants agreed that the course demonstrated that accessible educational neuroscience evidence exists for educators. Most participants also rated the course highly for its practical applicability, noting that the classroom-based scenarios and practical tips would help them consolidate and apply the knowledge gained. Responses to each of the survey's Likert-scale items are displayed in Figure 1, which visually represents the distribution of responses across the various feedback areas.

Figure 1
Feedback Form Response Percentages



The quantitative feedback was further supported by participants' comments in the open-ended section, which provided additional insight into their course experience. Positive comments reflected a strong appreciation for the engaging design and well-organised nature of the content, with one participant noting, "Amazing course and delivery. I will

consider this as I plan my own CPD session to be delivered next month.” Another participant highlighted the course’s practical relevance, commenting, “This was a very interesting course. It was well presented and brought user-friendly information to the teaching profession.”

Constructive feedback offered suggestions for potential improvements. For example, one participant suggested a more extended timeline: *“A video released once per week would be useful—it would allow more time for things to sink in.”* Another recommended incorporating additional interactive elements to help consolidate learning: *“More interactive questions (like in the first session) would help to consolidate each section.”*

Several participants also noted the challenge of fitting the course into their schedules, especially during busy periods. One participant remarked, *“Two weeks felt a little pressured to complete the course, but having a time limit was probably helpful in ensuring it didn’t get pushed onto the non-urgent list too often. Perhaps a half-term would be more manageable?”*

In addition, there was interest in linking educational neuroscience concepts more closely to existing teaching strategies. One participant expressed this as follows: *“It would be good to have basic neuroscience linked to current teaching strategies and popular approaches already seen across schools.”* This feedback aligns with the challenges highlighted in Study 2, where teachers expressed a desire for practical applications of educational neuroscience that could seamlessly integrate into familiar teaching strategies. In Study 2, participants cited barriers such as complex academic language and the limited applicability of educational neuroscience concepts to classroom practice. By providing scenario-based examples and practical classroom tips, the course in Study 3 addressed these concerns, making neuroscience content more accessible and directly relevant to

existing teaching methods. This indicates that a structured course can effectively bridge the gap between theoretical concepts and practical teaching strategies, offering insights that align with teachers' needs and expectations.

In summary, the feedback collected from the educational neuroscience course participants indicates a strong endorsement of the course's structure, content, and accessibility. The positive responses, especially regarding the value of accessible educational neuroscience evidence and the usefulness of practical strategies, suggest that this course format could successfully address some of the key barriers identified in Study 2. However, the constructive feedback on pacing and interactivity highlights opportunities for further refinement.

Discussion

Overview of the Study

This study evaluated the effectiveness of a structured educational neuroscience course on teachers' knowledge of educational neuroscience. Using a true experimental design, participants completed an online educational neuroscience course, and their knowledge of educational neuroscience was assessed before and after the course. Additionally, teachers' feedback on the course was assessed to examine whether the course effectively addressed the barriers identified in Study 2, including challenges related to time, accessibility, and practicality.

The results demonstrated that the course significantly improved participants' knowledge of educational neuroscience compared to the control group, particularly in SEN knowledge. However, between-group comparisons showed that the observed changes were not consistently reliable across all domains of the ENKT. For example, while statistically significant improvements were seen within the treatment group for overall knowledge, GCF

knowledge, and SEN knowledge, comparisons between the treatment and control groups showed mixed results. Specifically, the treatment group showed statistically significant gains in SEN knowledge but not in overall knowledge or GCF knowledge, though large effect sizes suggested meaningful differences. These inconsistencies could be attributed, at least in part, to the study's small sample size, which limits statistical power and the ability to detect smaller, yet meaningful, differences.

Despite these limitations, the large effect sizes observed for most comparisons, even with a smaller sample size than originally planned, indicate that the course had a substantial impact on participants' knowledge and suggest that similar results could be achieved with larger samples.

It is also worth noting that the ENKT provided a rigorous framework for assessing participants' knowledge. Unlike traditional assessment methods that merely test neuromyth or neuro-fact beliefs, ENKT used a differentiation score to measure teachers' ability to discern scientifically supported information from misconceptions. This approach offers a more nuanced perspective on how educational neuroscience training impacts teachers' critical thinking skills, enabling them to make more informed decisions and effectively challenge and reduce neuromyths. This differentiation score uniquely contributes to the literature, showcasing a potential method for assessing teachers' capacity to critically apply their knowledge of educational neuroscience.

Teachers' Feedback and Practical Implications

The design of the current study differed from earlier work by integrating focus group discussions from Study 2, directly shaping the content and structure of the educational neuroscience training to meet teachers' preferences. Teachers emphasised the need for practical, flexible, and accessible training, particularly for teachers with high workloads. In

response, the course was adapted to include asynchronous modules with classroom-based scenarios and practical tips, allowing teachers to engage with the material at their convenience and apply relevant insights to their teaching. These adjustments address critical challenges that previous studies have not systematically tackled, such as creating a format that respects teachers' limited time while providing practical applications for the classroom.

The findings also highlight the importance of closely aligning course content with assessment measures. The significant and consistent improvement in SEN knowledge suggests that the course was well-targeted in this domain. In contrast, the more variable progress in GCF knowledge highlights the need to evaluate and strengthen the alignment of course content with GCF-related test items in future iterations. Ensuring comprehensive coverage of both domains may help reduce variability in outcomes and support balanced knowledge gains.

Teachers' feedback to the course of the current study further indicated that this structured, accessible course was valuable in addressing the barriers identified in Study 2. Specifically, participants found the course's practical, flexible design relevant and manageable within their schedules. Positive feedback, especially regarding practical scenarios and flexibility, reinforced the course's success in meeting teachers' needs, suggesting that structured educational neuroscience training has the potential to close the gap in knowledge of educational neuroscience identified in prior studies.

Moreover, participants emphasised that realistic, classroom-based examples were particularly valuable for translating theoretical concepts into day-to-day teaching practice. This highlights the importance of designing flexible, relatable, and practical training formats to support sustained engagement without imposing excessive demands on teachers' time.

The flexible, asynchronous online format was also noted as a positive aspect. This format is increasingly recognised as a critical component of modern professional development, especially given the significant workload pressures that teachers face. Compared to traditional in-person training, online formats promote greater participation and sustained engagement, particularly for teachers with limited time (Russell et al., 2019). This approach is particularly advantageous as it is less intrusive for teachers; it does not require them to be in a specific place at a designated time, allowing them to engage with content at their own pace and convenience. This flexibility aligns well with the demands of their professional schedules and could be a practical solution for integrating educational neuroscience into teacher training without adding substantial time commitments. These findings suggest that short, accessible educational neuroscience training could significantly impact teacher knowledge without being overly burdensome, which may increase teachers' willingness to participate and engage fully with professional development opportunities in educational neuroscience.

Together, these responses suggest that structured, accessible educational neuroscience training, as provided in this study, offers a valuable alternative to integrating additional content into already crowded ITT programmes. By providing standalone or supplementary modules, this training can effectively address teachers' needs for flexible, research-informed professional development that applies educational neuroscience insights to classroom practice, whether as part of their CPD or as optional enrichment alongside ITT.

Previous Research and Addressing Neuromyths

Study 1 (Arslan et al., 2022) demonstrated that teachers' knowledge of educational neuroscience varies based on their prior training experiences in educational neuroscience, with formal training proving to be the most effective in improving knowledge compared to

informal or CPD-level training. Research increasingly supports the value of structured educational neuroscience training in enhancing teachers' understanding of educational neuroscience concepts and addressing persistent neuromyths (Brick et al., 2021; Cui & Zhang, 2021; Dubinsky et al., 2022; Ferreira & Rodríguez, 2022; Gordon et al., 2024; Tokuhamma-Espinosa & Nouri, 2023).

The current training builds on these findings by showing that a structured educational neuroscience course, particularly in an online format, can lead to measurable improvements in teachers' understanding of educational neuroscience. These results align with previous studies, including those by McMahon et al. (2019) and Ruiz-Martin et al. (2022), which highlighted the value of formal educational neuroscience training in enhancing teachers' understanding of cognitive processes and their application in education.

Furthermore, the findings from this study extend the work of Ferreira and Rodríguez (2022), who found that targeted neuroscience education improved neuroscience literacy and reduced neuromyth beliefs among teachers. While Ferreira and Rodríguez (2022) found that dispelling neuromyths often requires prolonged interventions, our approach achieved similar outcomes over a concise, four-week period by delivering structured training through short video modules with integrated testing, demonstrating the potential for reducing neuromyths through efficient, accessible formats.

Implications for Teacher Training

While this study primarily focused on evaluating the impact and relevance of educational neuroscience training for teachers, the findings indicate that such training holds significant value both within ITT programmes and as part of CPD for in-service teachers. At present, ITT lacks formalised and structured educational neuroscience training, leaving

teachers and schools to navigate this domain independently (e.g., ‘work it out themselves’). Although the recently introduced ITTECF (Department for Education, 2024a) makes some efforts to incorporate relevant principles, its coverage of educational neuroscience remains limited. As demonstrated in Study 1 and the current study, the inclusion of formalised and structured educational neuroscience training should be a substantial part of ITT moving forward.

ITT programmes are foundational for building teacher knowledge, especially when educational neuroscience content is included (Arslan et al., 2022; Tokuhamma-Espinosa & Nouri, 2020, 2023). However, CPD is essential for keeping teachers updated with the latest research and teaching strategies, which are crucial for addressing evolving classroom challenges (Hachem et al., 2022; Rato et al., 2022; Thomas et al., 2024), and our 4-week educational neuroscience course showed that even short but structured training can improve knowledge. These findings highlight the importance of providing both initial and ongoing professional development to ensure sustained improvements in educational practice.

Strengths and Limitations

Strengths

One of the main strengths of this study is its robust design, which included a true experimental pre-post-test structure that enabled comparison between a treatment group and a control group. This design allowed for a more precise assessment of the impact of educational neuroscience training on teachers' knowledge. It helped attribute changes in knowledge of educational neuroscience specifically to the course itself, reducing the likelihood of confounding variables affecting the results.

The significant strength is the decision to separate GCF and SEN content within the course and assessment measures. By distinguishing between these two domains, the study demonstrated how specific areas of knowledge of educational neuroscience—both GCF and SEN knowledge—can be targeted and improved independently through structured training. This separation provided valuable insights into how different facets of knowledge of educational neuroscience are assimilated by teachers, suggesting that tailored training can effectively enhance teachers' understanding of both general and SEN-specific concepts in educational neuroscience, which is particularly relevant for supporting diverse learner needs.

Another strength of the study was its use of an asynchronous online learning platform. This format allowed teachers from various locations and school contexts to participate in the course, which, while limited in sample size, suggests the potential for broader application in diverse educational settings. The flexibility of the online format was particularly important for accommodating participants' busy schedules, enabling them to engage with the course material at their own pace. While the small sample size limits the generalisability of the findings, the successful participation of teachers with different professional backgrounds demonstrates the feasibility of using this format to reach a varied audience in future, larger-scale studies.

Limitations

Despite its strengths, the study also had limitations that may impact the interpretation and generalisability of the findings. One primary limitation was the reduced sample size, which may have constrained the statistical power of the analyses and increased the likelihood of Type II errors (failing to detect true effects). Although a power analysis was conducted to determine the necessary number of participants, recruitment challenges

persisted, resulting in a smaller cohort than originally planned. These recruitment difficulties were exacerbated by the lingering effects of the COVID-19 pandemic on educators' workloads, compounded by a crisis around teacher stress that was at its peak during data collection (National Foundation for Educational Research, 2024).

The period following the pandemic saw a surge in teacher stress, with many educators facing increased workloads and greater responsibility for addressing gaps in students' academic, emotional, and social development. Recent reports have found that nearly 90% of teachers cite excessive workload as a major hindrance to engaging in professional training and development (Ofsted, 2024). A similar report from this period, such as the UCL Working Lives of Teachers and Leaders study (Department for Education, 2024e), indicates that full-time teachers in the UK were averaging 52-hour work weeks, leaving little time for additional commitments like professional learning. This stress was further intensified by broader systemic issues affecting the teaching profession, including staff shortages and escalating administrative demands (National Foundation for Educational Research, 2024). The convergence of these pressures contributed to an environment where many teachers could not allocate time to participate in studies or professional development, reflecting the broader challenges in recruiting for educational research during this time.

Although post-test comparisons between the treatment and control groups did not show statistically significant differences for Overall and GCF knowledge, the large effect sizes observed suggest meaningful improvements that may not have been fully detected due to the limited sample size. In contrast, the course's impact on SEN knowledge demonstrated both statistical and practical significance, highlighting the value of structured educational neuroscience course in areas directly applicable to classroom practice. These findings reinforce the potential of such training to benefit teachers, especially in addressing

specific educational needs, and emphasise the need for further validation with larger, more diverse samples.

Despite these limitations, the large effect sizes observed for most comparisons, even with a smaller sample size than originally planned, indicate that the course had a substantial impact on participants' knowledge and suggest that similar results could be achieved with larger samples. While caution is needed when interpreting large effect sizes from small samples, as these can sometimes overestimate the true effect (Button et al., 2013), the literature also acknowledges that such findings may indicate an underlying genuine impact, especially if confirmed by subsequent larger studies. Button et al. (2013) highlighted the potential for inflated effect sizes in underpowered studies but recognised that, in some cases, these findings could reflect real and meaningful effects. Therefore, although small sample sizes can carry risks, the large effect size observed in this study may still reflect a significant and robust outcome. This implies that scaling up educational neuroscience training to larger teacher education programmes could yield similarly impactful results, provided future studies continue to validate these findings with more participants.

In addition, the study did not directly examine the transfer of knowledge of educational neuroscience into observable changes in classroom practice or student outcomes. While the course improved teachers' theoretical understanding of educational neuroscience, further research is necessary to determine whether this translates into practical applications that enhance teaching quality and support student learning. Employing longitudinal designs or mixed-method approaches, including classroom observations and student assessments, could offer insights into the long-term effects of educational neuroscience training on educational outcomes.

Finally, although the asynchronous online format was effective in increasing accessibility and flexibility, participant feedback suggested that a more extended time frame and additional interactive elements could further enhance engagement and knowledge retention. Future iterations of the course could incorporate live sessions or peer discussions to facilitate deeper understanding, as well as flexible pacing that better accommodates teachers' needs for both flexibility and interactivity.

In summary, while this study provides promising evidence of the potential for structured educational neuroscience training to enhance teachers' knowledge, further research is needed to validate these findings with larger samples, evaluate the practical application of knowledge of educational neuroscience in classrooms, and optimise course delivery to align with teachers' professional needs.

Future Research

Future research in educational neuroscience training, similar to the current study, should consider flexible, bite-sized, but structured learning options as a valuable approach for engaging teachers in professional development. The current study's asynchronous, online format allowed teachers to interact with content at their own pace, accommodating the demands of their busy schedules. This flexibility may reduce time commitments, potentially increasing participation and alleviating barriers posed by heavy workloads. Developing similar models for educational neuroscience training could support teachers' continued professional growth without adding excessive strain.

The promising large effect sizes observed in this study suggest that structured educational neuroscience training can significantly improve teachers' knowledge. However, future studies should validate these findings with larger, more diverse samples to confirm the robustness of the effects. With large effect sizes observed in this study, further research

could validate the scalability and consistency of these findings, ensuring broader applicability and reliability across diverse educational settings.

Future courses should refine the balance of content to address SEN and GCF-related concepts equally. Aligning course materials with all test domains can minimise variability in knowledge gains and promote more uniform outcomes, ensuring that teachers benefit equally from training in both GCF and SEN knowledge.

Participant feedback emphasised the value of incorporating more interactive elements, such as live sessions, peer discussions, and additional scenario-based questions, to deepen engagement and knowledge retention. However, future courses should implement these enhancements thoughtfully, balancing interactivity with the flexibility that teachers value. Incorporating concise, targeted interactive components would enable teachers to benefit from engaging in meaningful activities without adding undue strain to their already demanding workloads.

Finally, future research should evaluate whether knowledge gains translate into observable changes in classroom practices and student outcomes. Much of the existing educational neuroscience training for teachers has not specifically examined student outcomes (Privitera, 2021), nor has it focused on long-term effects on teaching practices. To address this, future studies could employ diverse data collection methods, such as classroom observations or longitudinal designs, to better understand the impact of educational neuroscience training on teaching behaviour, classroom dynamics and student achievement. Such methods would offer valuable insights into the long-term benefits of educational neuroscience training (Ferreira & Rodríguez, 2022) and its potential scalability across different educational settings, potentially informing the development of training programmes that yield measurable improvements in educational practice.

Implications

The outcomes of this study have important implications not only for the design of teacher training programmes but also for developing shorter, targeted educational neuroscience courses.

To maximise the efficacy of such training, it is essential that shorter educational neuroscience courses come from credible, research-based institutions such as universities and research centres. Furthermore, the positive feedback from participants demonstrates the value of providing accessible, flexible, and interactive online learning opportunities for teachers. The course's asynchronous format allowed participants to engage with the material at their own pace, making it adaptable to busy teaching schedules while still offering engaging, scenario-based activities. Using classroom-based scenarios and practical tips was particularly well-received and deemed helpful for translating theoretical knowledge into classroom practice, indicating that such training can be engaging and applicable and support knowledge retention.

These findings provide compelling evidence for including structured, accessible educational neuroscience training in teacher education. They highlight its potential as standalone modules to complement ITT curricula by serving as optional enrichment for pre-service teachers or as part of CPD for in-service teachers. This approach would provide a feasible and scalable solution for embedding educational neuroscience training into ITT programmes without overloading ITT curricula. By offering such training as optional modules or extensions, teacher education programmes can maintain the integrity of their core content while providing teachers with access to valuable neuroscience insights.

Integrating educational neuroscience content in ITT can provide new teachers with a foundational knowledge of this field, equipping them from the outset with insights into

learning processes that benefit both typically developing and SEN students. For in-service teachers, ongoing CPD incorporating educational neuroscience content can offer continuous support for adapting to new research insights and addressing evolving classroom challenges.

Together, these approaches highlight a broader potential for structured, research-informed educational neuroscience training to substantially impact educational practice, supporting teachers in critically evaluating and effectively applying educational neuroscience concepts to enhance student learning outcomes.

Conclusion

This study builds upon the findings of Studies 1 and 2, demonstrating the importance of structured educational neuroscience training for teachers. Study 1 highlighted the importance of formal and structured educational neuroscience training, while Study 2 identified significant barriers to accessing educational neuroscience training. By addressing these challenges, this study evaluated the impact of a short, structured educational neuroscience course on teachers' knowledge.

The primary outcome confirms that the pilot programme effectively improved teachers' knowledge of educational neuroscience. The structured approach, combining accessible online content and practical classroom scenarios with integrated testing, successfully enhanced participants' knowledge of educational neuroscience and was well-received. The asynchronous online format effectively addressed barriers identified in Study 2, such as limited time and accessibility. Teachers' positive feedback highlights the importance of offering flexible, accessible training formats that respect their demanding schedules while delivering practical, research-informed content.

While this study demonstrated the feasibility of integrating educational neuroscience training into teacher education, it highlighted areas for refinement. The

study's small sample size reflects broader challenges in recruiting teachers for professional development during periods of high workload and stress. Participant feedback also suggested that future iterations could incorporate more interactive elements. These adjustments, alongside efforts to scale and validate the programme with larger, more diverse samples, will help refine the training's design and impact.

Looking ahead, a focus on bridging theory and practice is crucial. The findings suggest that standalone training can effectively complement existing teacher training and development frameworks, supporting teachers in critically applying educational neuroscience insights. However, additional research is needed to explore how this knowledge translates into classroom practices and student outcomes. Incorporating long-term evaluations and classroom observations will provide a clearer understanding of the training's practical benefits.

In summary, this study highlights the potential of structured, accessible educational neuroscience training delivered by credible sources to enhance teacher knowledge and support evidence-informed practices. Future efforts should aim to scale these findings, refine delivery methods, and assess their long-term impact on teaching and learning. By embedding such training within teacher education, whether through optional enrichment to ITT or standalone CPD modules, teachers can be better equipped to meet the diverse needs of their students and apply the latest research in meaningful ways.

Chapter 5
General Discussion

General Discussion

Introduction

This chapter synthesises the findings from three interconnected studies focused on the potential value of including educational neuroscience in teacher training in the UK. The primary aim of this thesis was to examine the state of knowledge of educational neuroscience among teachers, their perspectives towards educational neuroscience training and materials, and the effects of developing and implementing a structured educational neuroscience training programme for teachers. As discussed in Chapter 1, the inclusion of educational neuroscience in teaching has the potential to greatly enhance educators' knowledge and facilitate evidence-based instructional strategies, particularly in Special Educational Needs (SEN) contexts. This claim is supported by findings from recent studies showing that educational neuroscience professional development can significantly improve teacher-student relationships and overall teaching practices (Cherrier et al., 2023; Hachem et al., 2022; Walsh et al., 2024).

Each study in this thesis focused on a distinct aspect of integrating educational neuroscience into teacher training. Study 1 used a questionnaire to investigate teachers' understanding of evidence-based concepts (neuro-facts), their beliefs in common misconceptions (neuromyths), and their ability to differentiate between the two. A differentiation index was subsequently developed to assess their overall knowledge of educational neuroscience and the factors influencing this knowledge. Study 2 examined teachers' attitudes towards educational neuroscience, highlighting barriers to accessing and engaging with related training and materials. Finally, building on the insights from Studies 1 and 2, Study 3 assessed the impact of a structured educational neuroscience course on

improving teachers' knowledge through a pre-test and post-test design. Participant feedback was also collected to guide future research and development in this area.

The three studies collectively identified significant gaps in teachers' knowledge of educational neuroscience. They emphasised the need for practical, accessible training materials to unlock the full potential of educational neuroscience in teacher education. Notably, despite the increasing recognition of the value of educational neuroscience in teaching, there is currently no structured or formalised educational neuroscience training in ITT. The absence of structured training leaves teachers and schools without consistent means of accessing and applying neuroscience-informed strategies in classrooms. While the recently introduced ITTECF represents some progress in incorporating relevant principles into ITT, this coverage of educational neuroscience remains limited.

Synthesis and Discussion of Key Findings

Study 1 aimed to assess teachers' knowledge of educational neuroscience and identify the factors influencing this knowledge. To achieve this, the Educational Neuroscience Knowledge Test (ENKT) was developed and administered among a diverse group of teachers to evaluate their ability to distinguish neuromyths from neuro-facts. Teachers reported engaging with various means of educational neuroscience training, including formal programmes (undergraduate, postgraduate, or doctoral-level), Continuing Professional Development (CPD-level) training, informal exposure to educational materials, and, for some, no exposure.

The results showed no correlation between years of teaching experience and knowledge of educational neuroscience, indicating that neuromyths persist regardless of teaching experience. Regarding the educational neuroscience training levels, however, teachers who had engaged with formal educational neuroscience training were better able

to distinguish myths from facts and thus exhibited higher knowledge of educational neuroscience compared to CPD-level, informal training and no-exposure levels. This suggests that teachers may continue to rely on outdated or inaccurate information about the brain and learning without formal training.

The persistence of neuromyths among teachers is a significant concern, as it perpetuates the use of ineffective or counterproductive teaching practices (Grospietsch & Lins, 2021; Grospietsch & Mayer, 2020; Tardif et al., 2015). Moreover, widespread beliefs in these misconceptions undermine the adoption of evidence-based practices and divert valuable time and resources toward approaches that lack empirical support (Dekker et al., 2012; Howard-Jones, 2014; Tokuhamma-Espinosa & Nouri, 2023; Torrijos-Muelas et al., 2021).

In the context of Initial Teacher Training (ITT), this highlights the need for structured, formal training that introduces teachers to core educational neuroscience principles early in their careers. Embedding educational neuroscience into ITT programmes would allow trainee teachers to develop a foundation of accurate knowledge, reducing their susceptibility to neuromyths. Tokuhamma-Espinosa and Nouri (2023) emphasise research literacy and evidence-based practice as a core component of educational neuroscience. Including this component as part of the curriculum is an essential aspect for teachers as this approach has been credited with promoting critical thinking and enabling teachers to scrutinise new educational trends more effectively, which could also lead to a reduction in neuromyth beliefs. This aligns with the broader literature on the impact of structured training on knowledge acquisition, particularly in evidence-based practices (Georgiou et al., 2020, 2023; M. J. Kennedy et al., 2017; Slavin, 2020).

Evidence-based practice is crucial as it ensures that teaching strategies are grounded in rigorous research, leading to more effective teaching and improved student outcomes

(Hattie & Zierer, 2019). However, the current lack of formal and structured training means many teachers struggle to identify and apply evidence-based practices (Kretlow & Helf, 2013). Without structured professional development, teachers are often left to motivate themselves (Oliver et al., 2018) or rely on their schools to provide the necessary resources, which can lead to significant inconsistencies in knowledge and application (E.-K. Kennedy & Monsen, 2016). This inconsistency can be problematic as it could result in uneven educational experiences for students and undermine the overall quality of education (M. M. Kennedy, 2016).

The findings of Study 1 that teachers who had engaged with formal educational neuroscience training were better able to differentiate myths from facts underlines the importance of accurate, evidence-based educational neuroscience training within teacher education. However, designing and embedding educational neuroscience into ITT and professional development programmes requires a systemic effort (Butterworth & Tolmie, 2013; Tardif et al., 2015), particularly given the logistical and perceptual barriers that may hinder teachers' engagement with such training. To better understand these challenges and teachers' views on educational neuroscience training, Study 2 was conducted. This study used a qualitative approach, including focus groups and semi-structured interviews, to explore teachers' perspectives on educational neuroscience, its potential value in classroom practice, and the barriers to accessing training and materials. The key findings highlighted several important insights.

Firstly, teachers expressed a strong interest in educational neuroscience, recognising its potential value in improving teaching practices and supporting diverse learning needs, particularly for SEN students. This aligns with growing evidence that teachers are increasingly interested in engaging with educational neuroscience and applying its principles

in the classroom (Dubinsky et al., 2022; Thomas et al., 2024). Teachers are drawn to educational neuroscience because they see its potential to provide a scientific understanding of how students learn, enabling them to address diverse learning needs better and improve classroom strategies through evidence-based approaches. However, significant barriers to accessing educational neuroscience training were identified, including limited time, financial constraints, and a lack of easily accessible, high-quality resources.

Teachers highlighted a significant disconnect between theoretical knowledge of educational neuroscience and its practical application in classrooms. They emphasised the need for practical, actionable strategies and resources to bridge this gap. This aligns with findings from Ching et al. (2020), who reported that teachers often struggle to translate theoretical knowledge into practical applications. Similar barriers have been noted in previous research, which acknowledges the logistical challenges teachers face when attempting to engage with new academic research (Dubinsky et al., 2019, 2022). These issues speak to the gap between research and practice in educational neuroscience, pointing to the need for training and resources that are both scientifically robust and adaptable to diverse classroom contexts.

This disconnect reinforces Privitera's (2021) argument on the importance of making accurate educational neuroscience materials more accessible. It also supports Butterworth and Tolmie's (2013) call for bidirectional collaboration between researchers and practitioners to facilitate the translation of neuroscience research into practical classroom strategies. As teachers are the fundamental practitioners in this process, the production of educational neuroscience materials and training rests on collaboration with them. This would help ensure that the materials and training are not only scientifically robust but also

practically relevant to teachers' needs, considering the challenges they face, as identified in Study 2.

Lastly, there was a clear call for ongoing educational neuroscience training. Teachers emphasised the importance of embedding educational neuroscience not only in ITT but also as a core component of CPD. These challenges reflect broader structural issues within teacher training frameworks, particularly the limited capacity of ITT programmes to incorporate educational neuroscience comprehensively (McMahon et al., 2019; Tokuhamas-Espinosa & Nouri, 2023). This underscores the need for accessible training that is time-efficient, practical, and tailored to teachers' needs while also accounting for the already demanding structure of ITT programmes.

To address these challenges, Study 3 suggested the inclusion of standalone complementary modules. These modules could offer an alternative by addressing gaps in training through flexible and accessible formats that complement, rather than replace, existing ITT content.

Study 3 developed a structured educational neuroscience training course tailored to teachers' schedules. Delivered through an online platform, the study used an experimental pre-test and post-test design to evaluate the course's impact on teachers' knowledge of educational neuroscience and collected participant feedback to identify areas for course improvement.

Topics such as memory, attention, executive functions, and neuroplasticity were covered, providing teachers with a foundational understanding of these critical areas (e.g., Gordon et al., 2024; Tokuhamas-Espinosa & Nouri, 2020, 2023). This targeted approach ensured that teachers could grasp relevant neuroscience principles without becoming overwhelmed by the breadth of the field.

The findings revealed positive improvements in the treatment group's scores from the pre-test to the post-test. In contrast, the control group's post-test scores remained comparable to their pre-test scores, indicating no change in their knowledge of educational neuroscience over the same period.

The key outcome of Study 3 highlights the importance of formalised training delivered by reputable institutions, aligning with Study 1's finding that structured educational neuroscience training is essential for equipping teachers with accurate, evidence-based knowledge. Tokuhamma-Espinosa (2018) supports the view that structured educational neuroscience training promotes a deeper understanding of cognitive mechanisms, which in turn enhances teachers' ability to implement educational neuroscience-informed strategies. Ensuring that teachers receive knowledge from reliable sources is not just a matter of improving their understanding but also a critical step in addressing several broader issues in education.

Firstly, reliable training mitigates the risk of misinformation. Neuromyths often stem from oversimplified or misinterpreted neuroscience findings, which are perpetuated through unvetted resources, popular media, or poorly designed CPD programmes (Dekker et al., 2012; Howard-Jones, 2014; Tokuhamma-Espinosa & Nouri, 2023). When teachers rely on such sources, it can lead to ineffective teaching strategies, wasted resources, and even harm student learning outcomes. For example, the belief in "learning styles" has led many educators to focus on tailoring instruction to perceived visual, auditory, or kinaesthetic preferences despite robust evidence showing this approach has no impact on learning effectiveness (e.g., Cuevas & Dawson, 2018; Dekker & Kim, 2022; Dündar & Gündüz, 2016; Newton & Salvi, 2020; Papadatou-Pastou et al., 2021; Pashler et al., 2008; Rogowsky et al.,

2020, 2020). Formalised training could ensure that teachers can critically evaluate such claims and base their practices on scientifically validated strategies.

Secondly, reliable training promotes consistency in teaching practices. Without research-informed training programmes, teachers are left to navigate fragmented resources of varying quality, resulting in inconsistent application of educational neuroscience concepts. This inconsistency can exacerbate educational inequalities, particularly in diverse SEN contexts, where effective, evidence-based strategies are needed most (Desimone & Garet, 2017; M. M. Kennedy, 2016; Opfer & Pedder, 2011). Structured training provides teachers with a shared foundation of knowledge, helping to ensure all students benefit from effective, research-informed instruction.

Lastly, sourcing knowledge from professional bodies promotes research literacy among teachers. This is essential for debunking neuromyths and enabling teachers to engage critically with new research. By doing so, they can adapt their practices as the field evolves and avoid wasting valuable resources on ineffective practices rooted in neuromyths. Research indicates that teachers need to develop skills in research methods to engage with educational research effectively, understand how to evaluate evidence, assess the validity of teaching methods, and make informed classroom decisions (Georgiou et al., 2020; Munthe & Rogne, 2015; Tack et al., 2018; Vanderlinde & van Braak, 2010). Teachers trained in research literacy can better differentiate between fads and genuinely transformative insights, preventing the proliferation of untested or pseudoscientific methods in education. Furthermore, these skills empower teachers to implement educational neuroscience-informed strategies effectively and innovate within their classrooms. This confidence can reduce reliance on trial-and-error methods, improve classroom management, and enhance

student-teacher relationships, as supported by recent studies (Cherrier et al., 2023; Hachem et al., 2022; Walsh et al., 2024).

After completing the course, teachers provided overwhelmingly positive feedback, highlighting its strengths in offering practical and accessible educational neuroscience training. One of the most appreciated aspects was the inclusion of classroom-based scenarios and related activities that bridged the gap between theoretical knowledge and real-life application. Teachers reported feeling more equipped to implement educational neuroscience-informed strategies in the classroom, particularly in terms of adapting their teaching to support students with SEN.

The course's online delivery format was another widely praised feature. It offered time-efficient and easily accessible materials, making professional development more feasible for time-constrained teachers. This aligns with existing research indicating that technology-enhanced learning can improve engagement through features such as multimedia content, interactive quizzes, and scenario-based learning (Abdulrahman et al., 2020), emphasising the value of interactive learning in improving retention (Herrington et al., 2014). Such design elements likely contributed to the knowledge gains observed in participants, as evidenced by the pre-test to post-test improvements.

The success of the structured course highlights the importance of basing educational neuroscience training on rigorous research while ensuring its design is practically applicable. By focusing on real-world teaching challenges, the course helped teachers feel more confident in integrating educational neuroscience into their classrooms. Importantly, its structured design directly addressed several barriers identified in Study 2, including time constraints, inaccessible academic language, and the practicality of resources. By offering flexible provisions and accessible materials, the course demonstrated how these barriers

can be overcome, enabling teachers to engage with complex topics like educational neuroscience more effectively. This adaptability made the course particularly impactful for teachers navigating the logistical and resource constraints typical in professional development settings (Popova et al., 2022).

In the broader landscape of teacher education, the findings of this thesis highlight the urgent need to rethink how teacher training programmes are designed. Such redesign efforts must ensure that these programmes not only equip teachers with the tools they need at the start of their careers but also provide structured pathways for continued professional growth and adaptation to evolving educational challenges. This echoes concerns raised in the literature about the need for systemic changes to integrate educational neuroscience into teacher education (McMahon et al., 2019; Rogers & Thomas, 2022; Thomas et al., 2024; Tokuhamma-Espinosa & Nouri, 2023).

Recent governmental initiatives in the UK, such as the updated Initial Teacher Training Core Framework ('ITTECF', Department for Education, 2024a), demonstrate promising steps in this direction. For example, the ITTECF highlights the importance of incorporating content related to understanding working memory and the practice of breaking down material into smaller steps within ITT programmes. These additions align with foundational educational neuroscience principles. However, while trainee teachers are required to engage with this framework, its scope and depth remain limited due to the already packed nature of ITT programmes. This limitation highlights the importance of supplementary measures to ensure a robust understanding of educational neuroscience among teachers without overburdening the ITT curricula and teachers' limited time to engage with this training.

Providing such training through standalone modules that complement ITT programmes rather than through replacing their content, can be a valuable approach to achieve this for ITT programmes, as Study 3 demonstrated. With this, teachers could be provided with the foundational skills and understanding of this field from the outset, equipping them to apply these insights effectively in their classrooms. CPD incorporating educational neuroscience can ensure that in-service teachers keep themselves informed about the developments in educational neuroscience and stay updated with current research and teaching strategies, especially those relevant to students with SEN.

However, it is essential to consider that although CPD sessions are a commonly used avenue for professional growth, they are often fragmented, less comprehensive, and may vary significantly in quality (M. M. Kennedy, 2016; Opfer & Pedder, 2011), leading to an inconsistent understanding of educational neuroscience concepts (Mystakidis et al., 2023). These short-term, occasional sessions may lack depth and continuity (Desimone, 2009; M. M. Kennedy, 2016), making it challenging for teachers to engage with complex topics like educational neuroscience or to evaluate neuromyths critically. Online formats, though flexible, may inadvertently contribute to this fragmentation if not carefully structured or supplemented with follow-up support.

This thesis supports that such training should begin during the ITT stage to establish a solid foundation of knowledge early in teachers' careers (Tokuhamma-Espinosa, 2008, 2017; Tokuhamma-Espinosa & Nouri, 2023) and to promote research literacy from the outset, but with complementary standalone modules. Meanwhile, ongoing, well-structured CPD programmes can sustain and expand this knowledge, allowing teachers to adapt to new research findings and evolving educational challenges. Academic institutions should preferably provide these programmes to ensure an optimal structure, as such institutions

are better equipped to deliver evidence-based, rigorously developed training materials that align with current research. This dual structure would maintain the quality of training and ensure that teachers receive comprehensive, consistent, and evidence-informed guidance throughout their professional journeys.

Limitations and Future Directions

This thesis offers valuable insights into the role of educational neuroscience in teacher training; however, several limitations need to be considered, alongside potential future research directions that can address these gaps.

Limitations

One significant limitation of this research is the relatively small sample sizes in Studies 2 and 3, albeit for different reasons. Although efforts were made to recruit a more diverse group of participants, it proved very difficult to reach the sample size that was initially planned. Study 2, which employed a qualitative approach, included a diverse range of contributors in terms of teaching experience and roles. This diversity provided rich, in-depth insights into teachers' perspectives on educational neuroscience training. However, the relatively small sample size still limits the breadth of views captured. For example, larger numbers could have provided a wider range of perspectives, particularly from teachers at different career stages or teaching across diverse socioeconomic contexts. While generalisability is not the primary aim of qualitative studies, a broader sample would have strengthened the study's ability to capture nuanced views and identified trends that might differ across demographic or professional subgroups.

In contrast, Study 3, which used a true experimental design, was more affected by the small sample size, as this limited the statistical power of the study and potentially impacted the robustness of the findings. A smaller sample size increases the likelihood of

random variation influencing the observed outcomes, possibly leading to overestimating or underestimating the true effects of the structured educational neuroscience training designed in the study. Additionally, the inability to conduct more nuanced subgroup analyses (e.g., by subject specialisation or school type) limits the study's capacity to explore how different teacher demographics or contexts might moderate the impact of the training. Recruitment challenges for this study were significantly influenced by the lingering effects of the COVID-19 pandemic, which exacerbated educators' workloads and stress levels. Teachers were managing the dual burden of addressing student learning gaps while maintaining their usual responsibilities (National Foundation for Educational Research, 2024), with many averaging over 50-hour work weeks (Department for Education, 2024e). These circumstances, alongside broader systemic challenges such as staff shortages and increased administrative demands, left many teachers unable to allocate time for professional development or participation in research studies, contributing to the reduced sample size.

Despite this limitation, the findings from Study 3 align with those of Study 1, which demonstrated that teachers with formal educational neuroscience training were better able to distinguish neuromyths from neuro-facts and demonstrated higher levels of knowledge than those without such training. This consistency across both studies reinforces the validity of the observed improvements in Study 3 and suggests that structured educational neuroscience training is essential for equipping teachers with accurate, evidence-based knowledge.

A further consideration is the scope of educational neuroscience topics covered in Study 3. The course focused primarily on core concepts such as memory, attention, and executive functions. The topics chosen were purposefully few in number to accommodate

the limited time teachers could dedicate to volunteering in this study. While this focused approach provided a solid foundation in educational neuroscience, it also means that the effect of the training can only be understood within the context of these selected concepts. The field of educational neuroscience is inherently broad, encompassing critical areas such as emotional regulation, social cognition, and the neuroscience of motivation, which are also highly relevant to teaching practice but could not be included in the training. These additional topics are crucial for understanding how students process emotions, interact socially, and remain engaged in learning, which are vital aspects that directly impact classroom dynamics and student outcomes (S.-J. Blakemore, 2008; Ng, 2023; Tokuhamas-Espinosa, 2008; Tokuhamas-Espinosa & Nouri, 2023; Wang et al., 2023).

Lastly, this research primarily focused on measuring teachers' knowledge of educational neuroscience and their perceived challenges in engaging with educational neuroscience training and materials. While these measures provided valuable insights into teachers' understanding and attitudes, the studies did not include direct observations of how this knowledge was practically applied in classroom settings. This limitation restricts the ability to determine the real-world impact of the training on teaching practices and student outcomes.

Future Research

Building on these limitations, several areas for future research are proposed to further enhance the understanding and application of educational neuroscience in teacher training.

To address the limitation of small sample sizes, future research should aim to recruit larger and more diverse samples for both qualitative and quantitative studies. This would enhance the robustness and reliability of the findings, reducing the potential influence of

random variation and ensuring that observed effects are more reflective of broader teacher populations. Importantly, for qualitative studies like Study 2, expanding the sample size would enable a broader exploration of viewpoints while retaining the depth of analysis that is the hallmark of this methodology. For quantitative studies like Study 3, larger samples would improve the precision of findings and facilitate more detailed subgroup analyses, such as examining differences by subject area, school type, or demographic factors. These efforts would provide richer insights into how educational neuroscience training impacts teachers in varied contexts, ultimately strengthening the evidence base for its implementation.

Future research should also expand the scope of educational neuroscience training topics to cover broader areas, such as emotional regulation, social cognition, and the neuroscience of motivation. This could be achieved through extended training programmes or elective modules, enabling teachers to delve deeper into specific areas of interest. Tailored content focusing on SEN-related topics, such as the cognitive challenges faced by students with ADHD, dyslexia, or autism, could provide teachers with specialised strategies for supporting diverse learners while maintaining the flexibility that teachers need.

To gain a deeper understanding of the practical application of knowledge of educational neuroscience, future research should build on this study by observing and collecting data directly from schools. For instance, observing the interventions teachers implement, the language they use when discussing neuroscience concepts, and their decision-making processes could offer practical evidence of how knowledge of educational neuroscience translates into classroom practice. This approach would not only support the findings of this thesis but also provide a richer understanding of how educational

neuroscience is integrated into everyday teaching practices, highlighting areas of success or potential challenges that may still need to be addressed.

Future studies should include longitudinal designs to track teachers over time, exploring how they integrate educational neuroscience strategies into their teaching and how these strategies influence educational outcomes. For example, such studies could investigate whether improvements in teacher knowledge lead to enhanced classroom practices and whether these practices have a measurable impact on student learning, motivation, or socio-emotional development. This long-term follow-up would provide a more holistic evaluation of the impact of educational neuroscience training, offering valuable insights into its sustainability and effectiveness in real-world settings.

Ultimately, the goal of educational neuroscience training is to improve educational practices in ways that positively impact student outcomes. Future research should prioritise evaluating the effects of educational neuroscience-informed teaching on student outcomes, such as academic performance, motivation, and socio-emotional development. Further experimental designs in which teachers are randomly assigned to receive educational neuroscience training could provide robust evidence of its impact. By comparing the outcomes of students taught by educational neuroscience-trained teachers with those of students in non-educational neuroscience classrooms, future studies could demonstrate the practical benefits of integrating educational neuroscience into teacher training programmes.

CPD also represents a critical avenue for future research, particularly in addressing neuromyths and promoting evidence-based practices among in-service teachers (Tokuhamas-Espinosa, 2018; Tokuhamas-Espinosa & Nouri, 2020, 2023). CPD programmes designed to correct misconceptions about neuroscience should prioritise accessibility and practicality, ensuring that teachers can engage with the material despite professional

commitments. Integrating flexible online formats could help overcome logistical barriers highlighted in Study 2, such as time constraints and limited access to resources. For example, interactive multimedia resources or myth-busting workshops delivered via online platforms could enable teachers to engage with content at their convenience while providing actionable strategies for classroom application.

Finally, given the UK-centric focus of this research, the findings provide valuable insights into the UK context. However, educational neuroscience is a globally relevant field, and the results may need to fully capture how educational neuroscience training operates in other cultural and educational contexts. Future studies should explore cross-cultural comparisons of educational neuroscience training, examining how different systemic, cultural, and educational factors shape teachers' engagement with educational neuroscience and their willingness to adopt evidence-based practices. Conducting studies in other countries would allow researchers to gain insights into best practices worldwide, offering valuable recommendations for how educational neuroscience training can be adapted and improved across various educational contexts.

General Conclusion

The studies in this thesis collectively highlight the importance of structured educational neuroscience opportunities. Teachers expressed significant value for educational neuroscience, recognising its potential to improve teaching practices and support diverse learning needs, particularly in SEN contexts. However, barriers such as time constraints, financial limitations, and the accessibility of high-quality resources hinder the widespread adoption of reliable educational neuroscience training. Despite these challenges, when delivered by a reliable source, even a short, structured educational neuroscience course positively influenced teachers' understanding of educational neuroscience concepts, providing evidence for the potential impact of structured training on teacher knowledge and practice.

The findings suggest a substantial need for accessible, structured, and practical training providing actionable classroom use strategies. Introducing educational neuroscience through standalone, complementary modules during ITT can provide teachers with a foundational understanding of neurocognitive processes early in their careers without overburdening the already packed ITT curricula. This early exposure can help teachers develop evidence-informed instructional strategies they can apply throughout their teaching journey. For already trained teachers, CPD offers a critical avenue for deepening and updating their knowledge of educational neuroscience. However, CPD programmes must be rigorously designed and delivered directly by reputable academic or professional organisations to ensure the content is research-informed and free from misinterpretations often found in secondary or informal sources. This direct sourcing can mitigate the risk of misinformation and ensure that teachers receive reliable and applicable knowledge.

Overall, future efforts should focus on integrating educational neuroscience as part of ITT and CPD programmes that deliver high-quality training tailored to the needs of in-service teachers. These programmes should prioritise practical application and sustainability. In addition, they must balance flexibility with depth, offering online formats or modular approaches to accommodate teachers' professional commitments without compromising the quality of training. Such efforts are vital for promoting a research-literate teaching workforce capable of critically evaluating educational practices and embracing evidence-informed approaches. Through continued exploration and innovation, educational neuroscience can become integral to teacher training, supporting teachers in their professional development and enhancing student outcomes.

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Appendices

Appendix A Ethical Approval for the Project

Institute of Education



Doctoral Student Ethics Application Form

Anyone conducting research under the auspices of the Institute of Education (staff, students or visitors) where the research involves human participants or the use of data collected from human participants, is required to gain ethical approval before starting. This includes preliminary and pilot studies. Please answer all relevant questions in simple terms that can be understood by a lay person and note that your form may be returned if incomplete.

Registering your study with the UCL Data Protection Officer as part of the UCL Research Ethics Review Process

If you are proposing to collect personal data i.e. data from which a living individual can be identified **you must be registered with the UCL Data Protection Office before you submit your ethics application for review**. To do this, email the complete ethics form to the [UCL Data Protection Office](#). Once your registration number is received, add it to the form* and submit it to your supervisor for approval. If the Data Protection Office advises you to make changes to the way in which you propose to collect and store the data this should be reflected in your ethics application form.

Please note that the completion of the [UCL GDPR online training](#) is mandatory for all PhD students.

Section 1 – Project details

- a. Project title: 'Examining the link between education and neuroscience: How neuroscientific understanding of learning can influence SEN teachers' decisions'
- b. Student name and ID number: YASIN ARSLAN/ [REDACTED]
- c. *UCL Data Protection Registration Number: Z6364106/2021/07/137
 - a. Date Issued: 28/07/2021
- d. Supervisor/Personal Tutor: Prof Andrew Tolmie
- e. Department: Psychology and Human Development
- f. Course category (Tick one):

PhD	☒
EdD	☐
DEdPsy	☐
- g. If applicable, state who the funder is and if funding has been confirmed. Confirmed by the Ministry of National Education, Republic of Turkey
- h. Intended research start date: 15.07.2021
- i. Intended research end date: 15.07.2022
- j. Country fieldwork will be conducted in: UK
- k. If research to be conducted abroad please check the [Foreign and Commonwealth](#)

[Office \(FCO\)](#) and submit a completed travel risk assessment form (see guidelines). If the FCO advice is against travel this will be required before ethical approval can be granted: [UCL travel advice webpage](#)

- I. Has this project been considered by another (external) Research Ethics Committee?

Yes ☐

External Committee Name:

Date of Approval:

No ☒ **go to Section 2**

If yes:

- Submit a copy of the approval letter with this application.
- Proceed to Section 10 Attachments.

Note: Ensure that you check the guidelines carefully as research with some participants will require ethical approval from a different ethics committee such as the [National Research Ethics Service](#) (NRES) or [Social Care Research Ethics Committee](#) (SCREC). In addition, if your research is based in another institution then you may be required to apply to their research ethics committee.

Section 2 - Research methods summary (tick all that apply)

- ☒ Interviews
- ☒ Focus Groups
- ☒ Questionnaires
- ☐ Action Research
- ☐ Observation
- ☐ Literature Review
- ☒ Controlled trial/other intervention study
- ☐ Use of personal records
- ☐ Systematic review – **if only method used go to Section 5**
- ☐ Secondary data analysis – **if secondary analysis used go to Section 6**
- ☐ Advisory/consultation/collaborative groups
- ☐ Other, give details:

Please provide an overview of the project, focusing on your methodology. This should include some or all of the following: purpose of the research, aims, main research questions, research design, participants, sampling, data collection (including justifications for methods chosen and description of topics/questions to be asked), reporting and dissemination. Please focus on your methodology; the theory, policy, or literary background of your work can be provided in an attached document (i.e. a full research proposal or case for support document). *Minimum 150 words required.*

Purpose of the research

The United States National Academy of Sciences (Bransford et al., 2000) published a report, emphasizing the importance of neuroscientific knowledge in classroom settings, noting that (p. 341),

"Neuroscience has advanced to the point where it is time to think critically about the form in which research information is made available to educators so that it is interpreted appropriately for practice—identifying which research findings are ready for implementation and which are not."

There was a growing focus in the field of cognitive neuroscience in the 1990s US, where so called brain-based educational programmes were used (Dekker, Lee, Howard-Jones & Jolles, 2012; Geake, 2008). These appealing programmes were very popular among education professionals, but research findings and impact of many of these programmes were inconclusive. Moreover, neuroscience is a complex field and applying neuroscientific data into classroom is difficult (Ansari, Coch & De Smedt, 2011). Such programmes may have given birth to false beliefs about neuroscience and learning science, in other words 'neuromyths', which then became prevalent in teachers' beliefs.

Teachers with a lack of general understanding of neuroscience and the brain can be more inclined to believe in neuromyths, and to use unscientific teaching methods in a classroom. Believing in neuromyths and using such incorrect information in classroom settings may have impacts on a student's learning. For example, "[...] if an educator believes the myth that dyslexia is caused by letter reversals, students who have dyslexia but do not demonstrate letter reversals might not be identified or provided appropriate services." (Macdonald et al., 2017, p. 3)

All these lead us to question if and how teachers apply neuroscientific knowledge into classrooms appropriately and make decisions according to it.

Aims and main research questions

In this research, I am aiming to examine the level of teachers' neuroscience and learning science background, with a particular focus on Special Educational Needs teachers. To facilitate this aim, I will conduct an online questionnaire. This will be followed by semi-structured interviews with a subset of questionnaire participants to gather in-depth responses. According to results of the questionnaire and interviews, prevalent neuromyths

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that participants believe will be identified, and a targeted workshop will be designed. The participants for the workshop will be drawn from the same sample. After the workshop, participants' level of neuroscience and learning science, and beliefs in educational neuromyths will be assessed using a post-test that will consist of the preliminary questionnaire and follow up interviews.

Accordingly, the proposed research will address the following research questions:

- What is the knowledge level of Special Educational Needs (SEN) teachers related to educational neuroscience and learning science?
- To what extent do participants' level of education and teaching experience affect the level of beliefs in educational neuromyths?
- What is the impact of the workshop on knowledge levels prior to workshop, as assessed by pre and post-test scores?

Participants, Measures and Process

The aim is to recruit 200 secondary school teachers in the UK for the first phase of the study, which is an online questionnaire. The questionnaire will cover the following subjects:

- Demographic information,
- Qualifications and background,
- Information on current position,
- Past roles/experiences,
- Special Educational Needs (SEN) experience,
- Field-based background questions, and,
- Knowledge of neuroscience/learning science.

At the end of the survey, participants will be asked if they are willing to participate in a follow-up interview. This semi-structured interview will be designed according to results of the questionnaire, but it will mainly be based on further examination of prevalent false beliefs about neuroscience and learning science. It will cover the same questions as the questionnaire, but in more depth, as part of one-to-one video sessions. Because of the current Covid restrictions, interviews will be conducted online.

The questionnaire and interviews will be followed by a series of professional development sessions (workshop) that will be designed according to cumulative results from the questionnaire and interviews of the pre-test. The workshop will be delivered fortnightly for a 2-month period (5x2h=10 hours in total). The sessions will be synchronous (online), but all will be recorded so the participants will be able to review later. Prior to each session, online materials, such as articles and videos, for preparation and for group discussions will be sent to participants. At the end of each workshop session, participants will be asked to fill in a short feedback form, so the researcher can make arrangements for remaining sessions.

The post-test will use the preliminary questionnaire and follow-up interviews.

Sampling

Participants will be reached via:

- School emails,
- A Master's module of the Birkbeck and UCL IoE's joint programme, 'Educational Neuroscience MA/MSc',
- Social media, and,

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- Snowball sampling.

Research information sheet will clearly outline the study and inclusion/exclusion criteria.

Section 3 – research Participants (tick all that apply)

- ☐ Early years/pre-school
- ☐ Ages 5-11
- ☐ Ages 12-16
- ☐ Young people aged 17-18
- ☒ Adults please specify below
- ☐ Unknown – specify below
- ☐ No participants

Secondary school teachers in the UK

Note: Ensure that you check the guidelines carefully as research with some participants will require ethical approval from a different ethics committee such as the [National Research Ethics Service](#) (NRES) or [Social Care Research Ethics Committee](#) (SCREC).

Section 4 - Security-sensitive material (only complete if applicable)

Security sensitive research includes: commissioned by the military; commissioned under an EU security call; involves the acquisition of security clearances; concerns terrorist or extreme groups.

- a. Will your project consider or encounter security-sensitive material?
Yes* ☐ No ☐
- b. Will you be visiting websites associated with extreme or terrorist organisations?
Yes* ☐ No ☐
- c. Will you be storing or transmitting any materials that could be interpreted as promoting or endorsing terrorist acts?
Yes* ☐ No ☐

** Give further details in **Section 8 Ethical Issues***

Section 5 – Systematic reviews of research (only complete if applicable)

- a. Will you be collecting any new data from participants?
Yes* ☐ No ☐
- b. Will you be analysing any secondary data?
Yes* ☐ No ☐

** Give further details in **Section 8 Ethical Issues***

*If your methods do not involve engagement with participants (e.g. systematic review, literature review) **and** if you have answered **No** to both questions, please go to **Section 8 Attachments**.*

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Section 6 - Secondary data analysis (only complete if applicable)

- a. Name of dataset/s:
- b. Owner of dataset/s:
- c. Are the data in the public domain?
Yes ☐ No ☐
If no, do you have the owner's permission/license?
Yes ☐ No* ☐
- d. Are the data special category personal data (i.e. personal data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person's sex life or sexual orientation)?
Yes* ☐ No ☐
- e. Will you be conducting analysis within the remit it was originally collected for?
Yes ☐ No* ☐
- f. **If no**, was consent gained from participants for subsequent/future analysis?
Yes ☐ No* ☐
- g. **If no**, was data collected prior to ethics approval process?
Yes ☐ No* ☐

** Give further details in Section 8 Ethical Issues*

*If secondary analysis is only method used **and** no answers with asterisks are ticked, go to Section 9 Attachments.*

Section 7 – Data Storage and Security

Please ensure that you include all hard and electronic data when completing this section.

- a. Data subjects - Who will the data be collected from?
The data will be collected from secondary school teachers in the UK
 - b. What data will be collected? Please provide details of the type of personal data to be collected
 - *Gender*
 - *Age*
 - *Formal education and teaching background*
 - *Geographical area in which participants work,*
 - *Information on current position (e.g., teacher, headteacher)*
 - *Emails if they are willing to participate follow-up interviews and workshop.*
- Is the data anonymised?** Yes ☒ No* ☐
- Do you plan to anonymise the data? Yes* ☒ No ☐
- Do you plan to use individual level data? Yes* ☐ No ☒
- Do you plan to pseudonymise the data? Yes* ☒ No ☐

** Give further details in Section 8 Ethical Issues*

c. **Disclosure** – Who will the results of your project be disclosed to?

The results of the research will be used in the thesis and viva and will be published in academic journals. No identifying information will be included in the thesis and publications. Participants will be asked to send an e-mail directly to the researcher and to declare if they would like to be informed about study findings.

Disclosure – Will personal data be disclosed as part of your project?

No. All information will be anonymised and pseudonymised, and no personal data will be disclosed in the project. Only the PhD student will have access to the individually identifiable data.

d. **Data storage** – Please provide details on how and where the data will be stored i.e. UCL network, encrypted USB stick**, encrypted laptop** etc. Questionnaire data will be collected using Qualtrics software, and only the PhD researcher will access the participants' responses via UCL credentials. The raw data, including participants' personally identifiable data (email addresses, if given) will be kept in Qualtrics. Participants' email addresses will be used to ask them to participate in the follow-up study only. The participants' personally identifiable data will be accessible only by the PhD student and will not be kept any longer than 12 months after the successful completion of the PhD.

The processed data will be stored on the PhD student's password-protected laptop in an encrypted excel and SPSS (sav) files and also on the UCL N drive. The data will be coded and fully anonymised. That means the identifiable personal data such as e-mail addresses will be deleted, and the unique reference numbers will be replaced by new ID numbers (e.g., participant 100; participant 101) and stored as such. Once the data is anonymised, it will not be possible to identify (directly or indirectly) individuals from the data or publications because all identifying information will be separated from the research data, and no identifying data will be shared. Thus, no other data collected by the standard questionnaires and from the data defined as special category by UCL Data Protection Policy can be matched with or tracked by the identifying data or unique reference numbers.

Interviews will be conducted online on Microsoft Teams. They will be recorded using MS Teams recorder via the PhD student's UCL credentials. Once the transcripts are ready, all data will be anonymised for data analysis and for future publications, the participants will not be identifiable from transcribed interview data. The raw interview data will not be kept any longer than 12 months after the successful completion of the PhD.

Workshops will be recorded using MS Teams recorder via the PhD student's UCL credentials. Key points will be identified from the recorded sessions, but the participants will not be identifiable from the key points emerged. At the end of each workshop session, participants will be asked to fill in a short feedback form, but no personal data will be collected as the feedback form will be anonymous.

All processed data will be retained for a minimum of ten years after the successful completion of the doctoral project. No personally identifiable data will be held on UCL N drive.

*** Advanced Encryption Standard 256 bit encryption which has been made a security standard within the NHS*

- e. **Data Safe Haven (Identifiable Data Handling Solution)** – Will the personal identifiable data collected and processed as part of this research be stored in the UCL Data Safe Haven (mainly used by SLMS divisions, institutes and departments)?
Yes ☐ No ☒
- f. How long will the data and records be kept for and in what format?
The raw questionnaire data, including personally identifiable data, will be kept in Qualtrics; interview and workshop recordings will be kept on MS Teams using UCL storage, and they will be destroyed no later than 12 months after the successful completion of the PhD.
The pseudonymised data, -that does not include identifying data but includes the unique reference numbers- will be stored on the PhD student's password-protected laptop in an encrypted excel and SPSS (sav) file. For a backup, the pseudonymised data will be transferred to the supervisor via password-protected documents only via UCL e-mail. The original unique reference numbers will be kept no longer than 12 months after the successful completion of the PhD.
The fully anonymised data will all be securely stored and backed up daily on the UCL N drive (100GB of centrally managed storage). No identifying data will be held on the UCL N drive. The anonymised data will also be backed up on the PhD student's password-protected laptop in an encrypted excel and SPSS (sav) file. After the successful completion of the PhD, the anonymised data will be stored on UCL's Research Data Repository and be retained for a minimum of ten years after the successful completion of the doctoral project.

Will personal data be processed or be sent outside the European Economic Area? (If yes, please confirm that there are adequate levels of protections in compliance with GDPR and state what these arrangements are)
No

Will data be archived for use by other researchers? (If yes, please provide details.)
No

- g. If personal data is used as part of your project, describe what measures you have in place to ensure that the data is only used for the research purpose e.g. pseudonymisation and short retention period of data'.
To ensure this,
1) the raw data, including personally identifiable data, will be kept in Qualtrics and be kept for as long as is required, but no longer than 12 months after the successful completion of the PhD. The software provides data recovery in case of any accidental

data loss. The data that includes personally identifiable data will not be kept in somewhere else to decrease the risk of any personal data breach.

2) only the PhD researcher will be able to access the non-anonymised identifying data, and only the PhD student will be in contact with participants.

3) UCL passwords required to log in will be updated in every 3 months.

4) The fully anonymised data will be stored on the UCL N drive and be backed up on the PhD student's password-protected laptop in an encrypted excel and SPSS (sav) file; participants will not be identifiable from this data.

5) On anonymisation, unique reference numbers will be replaced by new ID numbers (e.g., participant 100; participant 101) and stored as such. Therefore, the personally identifiable data cannot be tracked by the unique reference numbers or to the given data.

6) In case of any personal data breach (the accidental or unlawful destruction, loss, alteration, unauthorised disclosure of, or access to, personal data), it will be reported using Personal Data Breach Reporting Form and sent to ISG: isg@ucl.ac.uk

** Give further details in **Section 8 Ethical Issues***

Section 8 – Ethical Issues

Please state clearly the ethical issues which may arise in the course of this research and how will they be addressed.

All issues that may apply should be addressed. Some examples are given below, further information can be found in the guidelines. *Minimum 150 words required.*

- Methods
- Sampling
- Recruitment
- Gatekeepers
- Informed consent
- Potentially vulnerable participants
- Safeguarding/child protection
- Sensitive topics
- International research
- Risks to participants and/or researchers
- Confidentiality/Anonymity
- Disclosures/limits to confidentiality
- Data storage and security both during and after the research (including transfer, sharing, encryption, protection)
- Reporting
- Dissemination and use of findings

Methods, Sampling, Recruitment

Participation will be entirely voluntary. If participants decide to participate by clicking on study link, they will be given an information sheet, and they will be asked to provide their consent for participation. At the end of the questionnaire, they will be kindly asked if they are willing to participate a follow-up interview.

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Informed consent

An electronic information sheet will be made available to participants before consent is gained, and the questionnaire is launched. Online consent will be gained as part of the online questionnaire; the questionnaire will not continue to the next page unless this has been completed. The information sheet covers the following subjects:

- Who is carrying out the research? (Researcher and supervisor contact details)
- Why are we doing this research?
- Why am I being invited to take part?
- Inclusion/exclusion criteria
- What will I be asked to do?
- Do I have to take part? (information about the right to withdraw: participants will clearly be informed that they will be able to withdraw from the study at anytime they wish)
- Anonymity and confidentiality information (in line with the GDPR)
- Risks of taking part (we don't anticipate any negative feelings to arise from this study)
- Data processing information
- Data protection privacy notice
- Debriefing information will be provided to participants at the end of the questionnaire.

Disclosures/limits to confidentiality

Confidentiality will be respected subject to legal constraints and professional guidelines. During the study, participants will be able to skip questions that they do not want to answer. Participants will be informed that assurances on confidentiality will be strictly adhered to unless evidence of wrongdoing or potential harm to themselves is uncovered.

Benefits of the research for the Participants

Participants will be eligible to participate a series of professional development sessions (workshop) related to their misbeliefs about neuroscience and learning science.

Risks to participants and/or researchers

The risks involved in participating are minimal. There is no foreseen physical or mental risk. However, participants may feel discomfort if detailed teaching information is asked during interviews. Therefore, before taking part in the study, all participants will be informed about the content of the research and their right to withdraw at any time without giving a reason. They will also be able to skip questions if they wish. There is no foreseen risk for the researchers.

Data storage

As mentioned above, all data will be kept strictly confidential.

To ensure this,

1) the raw questionnaire data, including personally identifiable data, will be kept in Qualtrics and be kept for as long as is required, but no longer than 12 months after the successful completion of the PhD. The software provides data recovery in case of any accidental data

loss. The data that includes personally identifiable data will not be kept in somewhere else to decrease the risk of any personal data breach.

2) only the PhD researcher will be able to access the non-anonymised identifying data by UCL e-mail address, and password and only the PhD student will be in contact with participants.

3) UCL passwords required to log in will be updated in every 3 months.

4) The fully anonymised data will be stored on the UCL N drive and be backed up on the PhD student's password-protected laptop in an encrypted excel and SPSS (sav) file; participants will not be identifiable from this data.

5) On anonymisation, unique reference numbers will be replaced by new ID numbers (e.g., participant 100; participant 101) and stored as such. Therefore, the personally identifiable data cannot be tracked by the unique reference numbers or to the given data.

6) In the case of any personal data breach (the accidental or unlawful destruction, loss, alteration, unauthorised disclosure of, or access to, personal data) will be reported using Personal Data Breach Reporting Form and sent to ISG: isg@ucl.ac.uk

Dissemination and use of findings

The study will be reported in the PhD thesis to be submitted to UCL Institute of Education. Thus, the results of the research will be used principally in the thesis and viva. The findings will also be considered to be published in academic journals.

Participants will be asked to send an e-mail directly to the researcher and to declare if they would like to be informed about the results of the research.

Please confirm that the processing of the data is not likely to cause substantial damage or distress to an individual

Yes ☒

Section 9 – Attachments.

Please attach your information sheets and consent forms to your ethics application before requesting a Data Protection number from the UCL Data Protection office. Note that they will be unable to issue you the Data Protection number until all such documentation is received

- a. Information sheets, consent forms and other materials to be used to inform potential participants about the research (List attachments below)

Yes ☒ No ☐

- b. Approval letter from external Research Ethics Committee Yes ☐
c. The proposal ('case for support') for the project Yes ☒
d. Full risk assessment Yes ☒

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Section 10 – Declaration

I confirm that to the best of my knowledge the information in this form is correct and that this is a full description of the ethical issues that may arise in the course of this project.

I have discussed the ethical issues relating to my research with my supervisor.

Yes ☒ No ☐

I have attended the appropriate ethics training provided by my course.

Yes ☒ No ☐

I confirm that to the best of my knowledge:

The above information is correct and that this is a full description of the ethics issues that may arise in the course of this project.

Name [Yasin Arslan](#)

Date [28/07/2021](#)

Please submit your completed ethics forms to your supervisor for review.

Notes and references

Professional code of ethics

You should read and understand relevant ethics guidelines, for example:

[British Psychological Society](#) (2018) *Code of Ethics and Conduct*

Or

[British Educational Research Association](#) (2018) *Ethical Guidelines*

Or

[British Sociological Association](#) (2017) *Statement of Ethical Practice*

Please see the respective websites for these or later versions; direct links to the latest versions are available on the [Institute of Education Research Ethics website](#).

Disclosure and Barring Service checks

If you are planning to carry out research in regulated Education environments such as Schools, or if your research will bring you into contact with children and young people (under the age of 18), you will need to have a Disclosure and Barring Service (DBS) CHECK, before you start. The DBS was previously known as the Criminal Records Bureau (CRB). If you do not already hold a current DBS check, and have not registered with the DBS update service, you will need to obtain one through at IOE.

Ensure that you apply for the DBS check in plenty of time as will take around 4 weeks, though can take longer depending on the circumstances.

Further references

Robson, Colin (2011). *Real world research: a resource for social scientists and practitioner researchers* (3rd edition). Oxford: Blackwell.

This text has a helpful section on ethical considerations.

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Alderson, P. and Morrow, V. (2011) *The Ethics of Research with Children and Young People: A Practical Handbook*. London: Sage.

This text has useful suggestions if you are conducting research with children and young people.

Wiles, R. (2013) *What are Qualitative Research Ethics?* Bloomsbury.

A useful and short text covering areas including informed consent, approaches to research ethics including examples of ethical dilemmas.

Departmental Use

If a project raises particularly challenging ethics issues, or a more detailed review would be appropriate, the supervisor must refer the application to the Research Development Administrator via email so that it can be submitted to the IOE Research Ethics Committee for consideration. A departmental research ethics coordinator or representative can advise you, either to support your review process, or help decide whether an application should be referred to the REC. If unsure please refer to the guidelines explaining when to refer the ethics application to the IOE Research Ethics Committee, posted on the committee's website.

Student name: Yasin Arslan

Student department: Psychology and Human Development

Course: PhD



Reviewer 1

Supervisor/first reviewer name: Professor Andrew Tolmie

Do you foresee any ethical difficulties with this research?

No, the research is not ethically challenging, and mitigations for any potential source of discomfort are clearly delineated.

Institute of Education



‘Examining the link between education and neuroscience: How neuroscientific understanding of learning can influence SEN teachers’ decisions’

Research Information Sheet

My name is Yasin Arslan and I am inviting you to take part in my research project, ‘Examining the link between education and neuroscience: How neuroscientific understanding of learning can influence SEN teachers’ decisions’. I am a PhD student at UCL Institute of Education, a world-leading centre for research and teaching in education and social science, and it has been rated as the world number one for Education for the eighth year in a row by the QS World University Rankings by Subject.

I am carrying out this research as part of my doctoral studies and I am examining the common beliefs that teachers may hold about the brain and learning science. I very much hope that you would like to take part. Before you decide whether you want to take part, it is important for you to read the following information carefully. This information sheet will try and answer any questions you might have about the project, but please don’t hesitate to contact me if there is anything else you would like to know.

Who is carrying out the research?

Researcher:

Yasin Arslan, Dept of Psychology and Human Development,
UCL Institute of Education, University College London, UK.
Email: y.arslan@ucl.ac.uk

Supervisors:

Prof Andy Tolmie, Chair of Psychology and Human Development,
UCL Institute of Education, University College London, UK.
Email: andrew.tolmie@ucl.ac.uk

Dr Rebecca Gordon, Associate Professor, Dept of Psychology and Human Development,
UCL Institute of Education, University College London, UK.
Email: rebecca.gordon@ucl.ac.uk

Why are we doing this research?

This research aims to investigate common beliefs that teachers may hold about the brain and learning science. A better understanding of true and false beliefs that teachers may hold will allow us to develop and disseminate evidence-based resources in the future.

Why am I being invited to take part?

You are being invited because you are a teacher in the UK education system. We are interested in what you know about these topics.

What will happen if I choose to take part?

If you agree to take part in the study, you will be asked to fill in an online questionnaire with some of your demographic information (such as educational qualifications and background). You will then be presented with a series of statements which we will ask you to rate in terms of the degree to which you agree or disagree with them.

The questionnaire will take approximately 15 minutes to complete; you will be able to see how much of the questionnaire you have completed as you go through the questions.

What are the benefits of taking part?

You will be eligible to participate in a series of professional development sessions (workshop) in neuroscience and learning science.

Will anyone know I have been involved?

All responses are anonymous and confidential. Only the research team will have access to the responses collected.

What are the risks if I take part?

We do not anticipate any risks related to taking part in this study. However, you are entitled to withdraw from the study at any point. You do not need to give a reason and there are no consequences if you withdraw.

What will happen to the results of the research?

Once data collection is completed, results will be used in a PhD thesis and may be published in a journal article or presented. The anonymity of the participants will be assured. If the research is published, you will not be identifiable in any way. The data will not be made available to any commercial organisations.

Do I have to take part?

It is entirely up to you whether you choose to take part. We hope that if you do choose to be involved that you will find it a valuable experience.

If any of the questions make you uncomfortable or you do not wish to proceed with the study, you have the right to stop at any time.

Please consider taking part if you are either:

- a teacher who is legally qualified to teach in the UK, or,
- a teacher who is completing the induction period for Newly Qualified Teachers (NQTs)/Early Career Teachers (ECTs).

We are sorry, but we cannot include you at this time if you are:

- not legally qualified to teach in the UK (please consider taking part if you are completing the NQT/ECT induction).

Data Protection Privacy Notice

The controller for this project will be University College London (UCL). The UCL Data Protection Office provides oversight of UCL activities involving the processing of personal data, and can be contacted at data-protection@ucl.ac.uk. This 'local' privacy notice sets out the information that applies to this study. Further information on how UCL uses participant information from research studies can be found in our 'general' privacy notice for participants in research studies [here](#). The information that is required to be provided to participants under data protection legislation (GDPR and DPA 2018) is provided across both the 'local' and 'general' privacy notices. The lawful basis that will be used to process any personal data is: 'Public task' for personal data. We will be collecting, with your consent, personal data such as email addresses. Your personal data will be processed so long as it is required for the research project. The data you provide will be anonymised and pseudonymised, and will endeavour to minimise the processing of personal data wherever possible. If you are concerned about how your personal data is being processed, or if you would like to contact us about your rights, please contact UCL in the first instance at dataprotection@ucl.ac.uk.

Contact for further information

If you have any further questions before you decide whether to take part, you can reach me at y.arslan@ucl.ac.uk (Yasin Arslan); or my supervisors, andrew.tolmie@ucl.ac.uk (Andy Tolmie); rebecca.gordon@ucl.ac.uk (Rebecca Gordon).

If you would like to be involved, please complete the following consent form which can be accessed by clicking [here](#) (hyperlink will be provided).

This project has been reviewed and approved by the UCL Institute of Education Research Ethics Committee. Data Protection Registration Number:
Z6364106/2021/07/137

Thank you very much for reading this information sheet.

IOE – FACULTY OF EDUCATION AND SOCIETY



Are you a UK-based teacher?

We are investigating common beliefs that teachers may hold about the brain and learning science.

You are invited to take part in a 15-min online questionnaire. You can use your smartphone, tablet or computer.

Interested? Here is the link & QR:
<https://bit.ly/3umPPve>



**QUESTIONS?
CONTACT US:**

Yasin Arslan (y.arslan@ucl.ac.uk)
Prof Andy Tolmie (andrew.tolmie@ucl.ac.uk)
Dr Rebecca Gordon (rebecca.gordon@ucl.ac.uk)

This project has been reviewed and approved by the
UCL Institute of Education Research Ethics Committee.

Phase 1: Examining the link between education and neuroscience

Start of Block: Research information sheet

Research info 1/2 **Research Information Sheet** My name is Yasin Arslan and I am examining the common beliefs that teachers may hold about the brain and learning science. I am a researcher at UCL Institute of Education, a world-leading centre for research and teaching in education and social science, and it has been rated as the world number one for Education for the eighth year in a row by the QS World University Rankings by Subject. I am inviting you to take part in this research. Before you decide whether you want to take part, it is important for you to read the following information carefully. This information sheet will try and answer any questions you might have about the project, but please don't hesitate to contact me if there is anything else you would like to know. Please consider taking part if you are either: a teacher who is legally qualified to teach in the UK, or, a teacher who is completing the induction period for Newly Qualified Teachers (NQTs)/Early Career Teachers (ECTs). We are sorry, but we cannot include you at this time if you are: not legally qualified to teach in the UK (please consider taking part if you are completing the NQT/ECT induction).

Page Break

Research info 2/2 **Who is carrying out the research?** **Researcher:** Yasin Arslan, Dept of Psychology and Human Development, UCL Institute of Education, University College London, UK. Email: y.arslan@ucl.ac.uk **Supervisors:** Prof Andy Tolmie, Chair of Psychology and Human Development, UCL Institute of Education, University College London, UK. Email: andrew.tolmie@ucl.ac.uk Dr Rebecca Gordon, Associate Professor, Dept of Psychology and Human Development, UCL Institute of Education, University College London, UK. Email: rebecca.gordon@ucl.ac.uk

Why are we doing this research? This research aims to investigate common beliefs that teachers may hold about the brain and learning science. A better understanding of true and false beliefs that teachers may hold will allow us to develop and disseminate evidence-based resources in the future.

Why am I being invited to take part? You are being invited because you are a teacher in the UK education system. We are interested in what you know about these topics.

What will happen if I choose to take part? If you agree to take part in the study, you will be asked to fill in an online questionnaire with some of your demographic information (such as educational qualifications and background). You will then be presented with a series of statements which we will ask you to rate in terms of the degree to which you agree or disagree with them. The questionnaire will take approximately 15 minutes to complete; the bar below will show you how much of the questionnaire you have completed as you go through the questions.

What are the benefits of taking part? You will be eligible to participate in a workshop in neuroscience and learning science. **Will anyone know I have been involved?** All responses are anonymous and confidential. Only the research team will have access to the responses collected. **What are the risks if I take part?** We do not anticipate any risks related to taking part in this study. However, you are entitled to withdraw from the study at any point. You do not need to give a reason and there are no consequences if you withdraw. **What will happen to the results of the research?** Once data collection is completed, results will be used in a PhD thesis and may be published in a journal article or presented. The anonymity of the participants will be assured. If the research is published, you will not be identifiable in any way. The data will not be made available to any commercial organisations. **Do I have to take part?** It is entirely up to you whether you choose to take part. We hope that if you do choose to be involved, you will find it a valuable experience.

If any of the questions make you uncomfortable or you do not wish to proceed with the study, you have the right to stop at any time. **Data Protection Privacy Notice** The controller for this project will be University College London (UCL). The UCL Data Protection Office provides oversight of UCL activities involving the processing of personal data, and can be contacted at data-protection@ucl.ac.uk. This 'local' privacy notice sets out the information that applies to this study. Further information on how UCL uses participant information from research studies can be found in our 'general' privacy notice for participants in research studies here. The information that is required to be provided to participants under data protection legislation (GDPR and DPA 2018) is provided across both the 'local' and 'general' privacy notices. The lawful basis that will be used to process any personal data is: 'Public task' for personal data. We will be collecting, with your consent, personal data such as email addresses. Your personal data will be processed so long as it is required for the research project. If you are concerned about how your personal data is being processed, or if you would like to contact us about your rights, please contact UCL in the first instance at

dataprotection@ucl.ac.uk. Name and contact details of the UCL Data Protection Officer: Alex Potts, a.potts@ucl.ac.uk

Contact for further information If you have any further questions before you decide whether to take part, you can reach me at y.arslan@ucl.ac.uk (Yasin Arslan); or my supervisors, andrew.tolmie@ucl.ac.uk (Andy Tolmie); rebecca.gordon@ucl.ac.uk (Rebecca Gordon). This project has been reviewed and approved by the UCL Institute of Education Research Ethics Committee. Thank you for reading this information sheet. If you would like to be involved, please complete the consent form on the next page.

Page Break

Consent form Thank you for considering taking part in this research. If you have any questions arising from the Information Sheet or explanation already given to you, please ask the researcher before you decide whether to join in.

	I confirm (tick box)
I confirm that I have read and understood the Information Sheet of this study. I have had an opportunity to consider the information and what will be expected of me. I have also had the opportunity to ask questions which have been answered to my satisfaction and would like to take part in this online questionnaire.	☐
I understand that all personal information will remain confidential and that all efforts will be made to ensure I cannot be identified.	☐
I understand that the data gathered in this study will be stored anonymously and securely. It will not be possible to identify me in any publications.	☐
I understand that my participation is voluntary and that I am free to withdraw at any time without giving a reason. I understand that if I decide to withdraw, any personal data I have provided up to that point will be deleted unless I agree otherwise.	☐
I understand that the risk of participating is minimal, but the support will be available to me should I become distressed during the course of the research.	☐
I understand that the data will not be made available to any commercial organizations but is solely the responsibility of the researcher undertaking this study.	☐
I understand that I will not benefit financially from this study or from any possible outcome it may result in in the future.	☐
I understand that my anonymised research data may be used by other authenticated researchers for future research. [No one will be able to identify you when this data is shared.]	☐
I understand the inclusion and exclusion criteria as detailed in the Information Sheet and that the criteria can be further explained to me by the researcher if I ask.	☐
I confirm that I do not fall under the exclusion criteria.	☐
I am aware of who I should contact if I wish to lodge a complaint.	☐
I confirm that I voluntarily agree to take part in this study.	☐

End of Block: Consent form

Start of Block: I. Demographic Information

Q1 What is your gender?

- ☐ Female
 - ☐ Male
 - ☐ Non-binary / third gender
 - ☐ Prefer not to say
-

Q2 2. Which of the following age groups includes your age?

- ☐ 18-25
- ☐ 26-30
- ☐ 31-35
- ☐ 36-40
- ☐ 41-45
- ☐ 46-50
- ☐ 51-55
- ☐ 56-60
- ☐ 61-65
- ☐ 66+

End of Block: I. Demographic Information

Start of Block: II. Qualifications and Background

Q3 Which of the following qualifications have you earned? Please select all that apply.

- ☐ Postgraduate certificate or diploma
 - ☐ Bachelor of Arts (BA)
 - ☐ Bachelor of Science (BSc)
 - ☐ Master of Arts (MA)
 - ☐ Master of Science (MSc)
 - ☐ Doctor of Education (EdD)
 - ☐ Doctor of Philosophy (PhD)
 - ☐ Other (Please specify)
-

Q4 Which of the following areas, if any, relates to your highest qualification?

- ☐ Educational Psychology/Psychology of Education
 - ☐ Psychology
 - ☐ Educational Neuroscience
 - ☐ Child Development
 - ☐ Special and Inclusive Education
 - ☐ None of the above
-

Q5 Which of the following levels are you certified to teach? Please select all that apply.

- ☐ Early Years Education (age 3-5)
 - ☐ Primary Education (age 5-11)
 - ☐ Secondary Education (11-16)
 - ☐ Further Education (16-18)
 - ☐ Other (please specify)
-

Q6 Which of the following subjects or areas are you certified to teach? Please select all that apply.

- ☐ STEM
 - ☐ Arts and Humanities
 - ☐ Health and Physical Education
 - ☒ None of the above
-

Q7 Have you obtained Qualified Teacher Status (QTS)? If yes, please indicate the year in which you obtained QTS.

- ☐ No
 - ☐ Yes (please indicate the year)
-

Q8 Are you a newly qualified teacher (NQT/Early Career Teacher (ECT))?

- ☐ No
- ☐ Yes
-

Q9 Have you completed the statutory induction for NQT/ECTs? If yes, please indicate the year in which you completed the induction.

- ☐ I am currently completing the induction
- ☐ No
- ☐ Yes (please indicate the year)
-

End of Block: II. Qualifications and Background

Start of Block: III. Past roles/experiences

Q10 How many years of classroom teaching experience do you have? Please also include your induction period for NQT/ECT in your answer.

- ☐ 0 (no classroom teaching experience)
- ☐ Less than a year
- ☐ 1-2
- ☐ 3-5
- ☐ 6 or more

End of Block: III. Past roles/experiences

Start of Block: IV. Information on current position

Q11 Are you currently working as a schoolteacher? Please select yes even if you are completing the statutory induction for NQT/ECTs.

- ☐ No
- ☐ Yes

Q12 Please select the geographical area in which you currently work as a teacher.

- ☐ London
 - ☐ East of England
 - ☐ South East
 - ☐ South West
 - ☐ East Midlands
 - ☐ West Midlands
 - ☐ Yorkshire and the Humber
 - ☐ North East
 - ☐ North West
 - ☐ Wales
 - ☐ Scotland
 - ☐ Northern Ireland
 - ☐ Republic of Ireland
 - ☐ Other (please specify)
-

Q13 The area of your school is:

- ☐ Urban
 - ☐ Rural
 - ☐ Other (please specify)
-

Q14 Which of the following best describes the school type you currently work at?

- ☐ Academy/Free School
 - ☐ Local Authority-Maintained School
 - ☐ Independent/Private School
 - ☐ Special School
 - ☐ UK-based International School
 - ☐ Other (please specify)
-

Q15 Which of the following best describe your role(s) at your school? Please select all that apply.

- ☐ Classroom Teacher
 - ☐ Subject Lead
 - ☐ Special Educational Needs Coordinator (SENCo)
 - ☐ Head of Year/Phase
 - ☐ Deputy or Assistant Head
 - ☐ Headteacher/Head of School or Acting Head
 - ☐ Executive Leader/MAT CEO
 - ☐ Other (please specify)
-

End of Block: IV. Information on current position

Start of Block: V. Special Educational Needs (SEN)

Q16 Have you completed any training (e.g., certificate, diploma, continuing professional development (CPD), degree) in Special Educational Needs (SEN)?

- ☐ No
- ☐ Yes
- ☐ In progress

Page Break

Q17 Please select the level of training in SEN. Please select all that apply.

- ☐ Postgraduate certificate or diploma
- ☐ Bachelor's degree
- ☐ Master's degree
- ☐ Doctorate
- ☐ CPD (Continuing Professional Development)

Q18

Do you have classroom teaching experience with children with SEN?

- ☐ No
- ☐ Yes
-

Q19 How many years of classroom teaching experience do you have with children with SEN?

- ☐ Less than a year
 - ☐ 1-2
 - ☐ 3-5
 - ☐ 6 or more
-

Q20 Of the children with SEN you have taught, which category would they fall under? Please select all that apply (even if you do not currently teach).

- ☐ Specific learning difficulties (e.g., dyslexia, dyspraxia, dyscalculia, dysgraphia)
 - ☐ General learning difficulties (e.g., moderate, severe, profound, and multiple)
 - ☐ Attention deficit hyperactivity disorder (ADHD)
 - ☐ Anxiety or depression
 - ☐ Self-harming, substance misuse
 - ☐ Eating disorders
 - ☐ Speech, Language and Communication Needs
 - ☐ Autism Spectrum Disorder (including Asperger's)
 - ☐ Visual impairment
 - ☐ Hearing impairment
 - ☐ Multi-sensory impairment
 - ☐ Physical disability
 - ☐ Medical needs
 - ☐ Other (please specify and use comma for multiple answers)
-

Q21 Do you feel you currently have the knowledge required to teach children with SEN (specific to your classroom)?

- ☐ No knowledge
 - ☐ Some knowledge
 - ☐ A lot of knowledge
 - ☐ Extensive knowledge
-

Q22 Considering your knowledge indicated in the previous question, how confident do you feel teaching children with SEN?

- ☐ Not confident
- ☐ Somewhat confident
- ☐ Very confident
- ☐ Completely confident

End of Block: V. Special Educational Needs (SEN)

Start of Block: Few Q left message

Few Q left message Only a few questions left!

End of Block: Few Q left message

Start of Block: VI. Neuroscience-based background questions

Q23 Have you completed any training (e.g., certificate, diploma, CPD, degree) in neuroscience/learning science?

- ☐ No
 - ☐ Yes
 - ☐ In progress
-

Q24 Please select the level of training in neuroscience/learning science. Please select all that apply.

☐

Postgraduate certificate or diploma

☐

Bachelor's degree

☐

Master's degree

☐

Doctorate

☐

CPD (Continuing Professional Development)

Q25 Do you use educational or professional materials (e.g., magazines, blogs, podcasts, videos, books, journals) related to neuroscience/learning science?

☐ No

☐ Yes

Q26 Which of the following educational or professional materials related to neuroscience/learning science do you use? Please select all that apply.

- ☐ Magazines
 - ☐ Blogs
 - ☐ Podcasts
 - ☐ Videos (e.g., TED/TEDx, YouTube)
 - ☐ Books
 - ☐ Scientific/academic journals
 - ☐ Other (please specify)
-

Q27 Do you think neuroscience/learning science is relevant to education?

- ☐ Not relevant
- ☐ Somewhat relevant
- ☐ Very relevant
- ☐ Completely relevant

End of Block: VI. Neuroscience-based background questions

Start of Block: VII. Your knowledge of neuroscience/learning science

Q28 To what extent do you agree or disagree with the following statements?

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
Information is stored in networks of cells distributed throughout the brain.	☐	☐	☐	☐	☐
There is a link between children's school performance and their preferred learning styles (visual, auditory or kinaesthetic learner).	☐	☐	☐	☐	☐
Some children are better suited to some tasks depending on whether they are 'left-brained' or 'right-brained'.	☐	☐	☐	☐	☐
The brain gets rid of neural connections it doesn't need.	☐	☐	☐	☐	☐
Children with dyslexia are likely to have difficulties with identifying rhyming sounds.	☐	☐	☐	☐	☐
Fish oil or Omega-3 supplements are beneficial for cognitive abilities specific to learning.	☐	☐	☐	☐	☐
Dehydration negatively impacts children's ability to pay attention in school.	☐	☐	☐	☐	☐
Specialised systems in the brain, such as the visual system and auditory system, work independently from other brain regions.	☐	☐	☐	☐	☐
When a brain region is damaged, other parts of the brain can take up its function.	☐	☐	☐	☐	☐
Aerobic fitness improves performance in lessons related to numeracy and literacy.	☐	☐	☐	☐	☐
"Brain Gym" exercises, that focus on cross body actions to balance the hemispheres of the brain and increase blood flow to the head, are effective in supporting learning.	☐	☐	☐	☐	☐

Children with dyslexia have similar IQ scores to those without dyslexia.	☐	☐	☐	☐	☐
Girls are better at reading and boys are better at maths.	☐	☐	☐	☐	☐
Sleep is important for consolidating knowledge.	☐	☐	☐	☐	☐
The processing of faces and of objects are situated in different parts of the brain.	☐	☐	☐	☐	☐
Children with autism are more prone to sensory overload than typically developing children.	☐	☐	☐	☐	☐
Children who speak more than one language have an advantage in school performance.	☐	☐	☐	☐	☐
Boys have bigger brains than girls, on average.	☐	☐	☐	☐	☐
Maths anxiety is real.	☐	☐	☐	☐	☐
Our brain stops developing by the time we reach our early teenage years.	☐	☐	☐	☐	☐
Deprivation over the first three years of life causes persistent cognitive deficits.	☐	☐	☐	☐	☐
Writing letters backwards is a common symptom of dyslexia.	☐	☐	☐	☐	☐
All children who are deaf and hard of hearing benefit from visual information.	☐	☐	☐	☐	☐
Broader cognitive difficulties related to dyslexia affect memory, attention, and executive functioning.	☐	☐	☐	☐	☐
Humans only use 10% of the brain at any one time.	☐	☐	☐	☐	☐

English speakers have higher literacy skills than those who are deaf and hard of hearing whose primary language is sign language (e.g., British Sign Language).	☐	☐	☐	☐	☐
Understanding depends very largely on verbal ability.	☐	☐	☐	☐	☐
Reducing dietary intake of sugar or food additives is effective in reducing the symptoms of ADHD.	☐	☐	☐	☐	☐
Symptoms of depression are found more frequently in children with ADHD than in children without ADHD.	☐	☐	☐	☐	☐
Children with ADHD have difficulties with focus and concentration.	☐	☐	☐	☐	☐
Children with autism are unable to notice social rejection.	☐	☐	☐	☐	☐
It is possible for an adult to be diagnosed with ADHD.	☐	☐	☐	☐	☐
Children with autism do not have empathy.	☐	☐	☐	☐	☐
Using a cochlear implant allows children, who are deaf and hard of hearing, to regain normal hearing and to learn to speak so well that they will achieve age-appropriate language skills.	☐	☐	☐	☐	☐
Children with dyslexia, who receive remediation for reading and spelling, are no longer affected by the developmental disorder in adulthood.	☐	☐	☐	☐	☐
Not everyone with autism has social impairment.	☐	☐	☐	☐	☐

End of Block: VII. Your knowledge of neuroscience/learning science

Start of Block: VIII. Future Participation

Q29 Would you be willing to participate in follow-up research and a workshop for teachers in the application of neuroscience in the classroom? (Your responses gathered in this questionnaire will remain anonymous; you will be able to provide your email address anonymously using an external link)

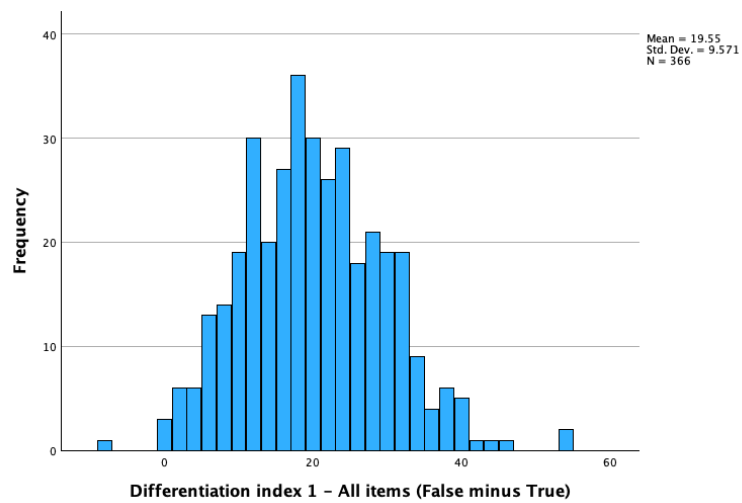
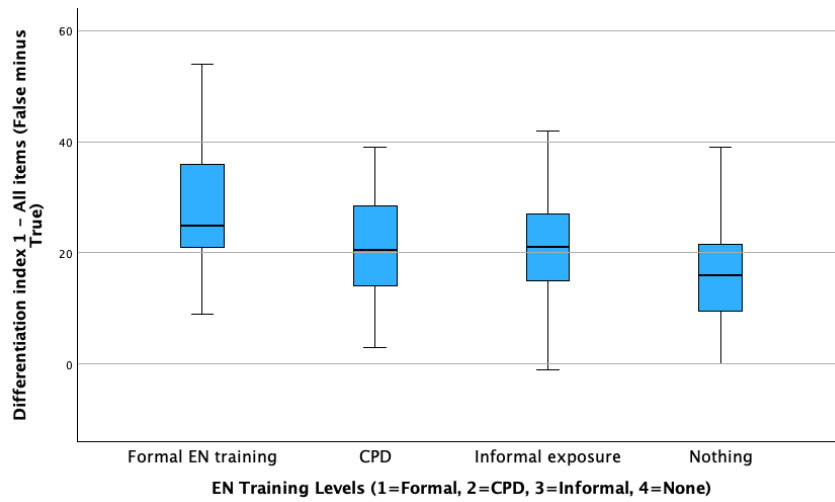
- ☐ No
- ☐ Yes (You can provide your email address at the end of the survey)

Q30 Would you like to add further comments or feedback that you didn't have a chance to express in the questionnaire?

- ☐ No
- ☐ Yes (please specify) _____

End of Block: VIII. Future Participation

Appendix E Study 1 Boxplot and Histogram



IOE, Faculty of Education and Society



UCL

'Neurocognitive mechanisms of learning: the role of educational neuroscience in teacher training in the UK'

Research Information Sheet

Dear teacher,

I am Yasin Arslan and I am a PhD candidate at UCL Institute of Education, a world-leading centre for research and teaching in education and social science, and it has been rated as the world number one for education for the 10th year in a row by the QS World University Rankings by Subject.

I extend a personal invitation for you to be a crucial part of my research project, 'Neurocognitive Mechanisms of Learning: The Role of Educational Neuroscience in Teacher Training in the UK'. Your insights are pivotal to unravelling the mysteries of effective teaching methods.

This research is not just a part of my doctoral studies; it is an opportunity for us to collaborate and make a lasting impact on education. Please take a moment to explore the details in this information sheet; it is crafted to address any questions you may have, but please do not hesitate to contact me if there is anything else you would like to know. If you would like to be involved after reading the following information, please complete a short consent form which can be accessed via a link at the end of this sheet (only takes 1-2 minutes to complete).

Who is carrying out the research?

Researcher:

Yasin Arslan, PhD Candidate & Postgraduate Teaching Assistant, Psychology and Human Development,

UCL Institute of Education, University College London, UK.

Email: y.arslan@ucl.ac.uk

Supervisors:

Prof Andy Tolmie, Chair of Psychology and Human Development,

UCL Institute of Education, University College London, UK.

Email: andrew.tolmie@ucl.ac.uk

Dr Rebecca Gordon, Associate Professor, Psychology and Human Development,

UCL Institute of Education, University College London, UK.

Email: rebecca.gordon@ucl.ac.uk

Why are we doing this research?

This study constitutes the second phase of a comprehensive PhD project. In the initial stage, our focus was on exploring common beliefs that teachers may hold about the brain and learning science, and factors influencing these beliefs. Building upon this groundwork, the current phase aims to delve into the processes through which teachers engage with educational neuroscience training and materials.

The insights gained from this research are intended to inform the design of targeted educational neuroscience training programmes and contribute to the development and dissemination of evidence-based resources in the future.

Why am I being invited to take part?

You are being invited because you are a teacher in the UK education system. We are interested in what you know about these topics, and we truly value your contributions.

What will happen if I choose to take part?

If you agree to participate in the study, we will conduct an online group discussion (focus group). During this session, we will explore topics related to training and materials in educational neuroscience, seeking your insights on exposure to such materials and training. We anticipate that three to five participants will join the session. However, we may make adjustments if fewer than three participants participate. If two participants join, the session will be conducted as a dyadic interview, where both participants interact in response to open-ended questions. If only one participant joins, the session will be conducted as a semi-structured interview. In any case, the session is expected to take approximately 1 hour.

What are the benefits of taking part?

There is no direct financial benefit of taking part. However, we would like to express our gratitude for your time and contribution. As a token of appreciation, you will receive a £15 Amazon e-Voucher as a thank-you gesture for your participation.

Will anyone know I have been involved?

All responses are anonymous and confidential. Only the research team will have access to the responses collected.

What are the risks if I take part?

We do not anticipate any risks related to taking part in this study. However, you are entitled to withdraw from the study at any point. You do not need to give a reason and there are no

consequences if you withdraw. We hope you would like to take part.

What will happen to the results of the research?

Once data collection is completed, results will be used in a PhD thesis and may be published in a journal article or presented. The anonymity of the participants will be assured. If the research is published, you will not be identifiable in any way. The data will not be made available to any commercial organisations.

Do I have to take part?

It is entirely up to you whether you choose to take part. We hope that if you do choose to be involved, you will find it a valuable experience.

If any of the discussion topics make you uncomfortable or you do not wish to proceed with the study, you have the right to stop at any time.

Data Protection Privacy Notice

The controller for this project will be University College London (UCL). The UCL Data Protection Office provides oversight of UCL activities involving the processing of personal data, and can be contacted at data-protection@ucl.ac.uk. This 'local' privacy notice sets out the information that applies to this study. Further information on how UCL uses participant information from research studies can be found in our 'general' privacy notice for participants in research studies [here](#). The information that is required to be provided to participants under data protection legislation (GDPR and DPA 2018) is provided across both the 'local' and 'general' privacy notices. The lawful basis that will be used to process any personal data is: 'Public task' for personal data. We will be collecting, with your consent, personal data such as email addresses. Your personal data will be processed so long as it is required for the research project. The data you provide will be anonymised and pseudonymised, and will endeavour to minimise the processing of personal data wherever possible. If you are concerned about how your personal data is being processed, or if you would like to contact us about your rights, please contact UCL in the first instance at dataprotection@ucl.ac.uk.

Contact for further information

If you have any further questions before you decide whether to take part, you can reach me at y.arслан@ucl.ac.uk (Yasin Arslan); or my supervisors, andrew.tolmie@ucl.ac.uk (Andy Tolmie); rebecca.gordon@ucl.ac.uk (Rebecca Gordon).

This project has been reviewed and approved by the UCL Institute of Education Research Ethics Committee. Data Protection Registration Number:

Z6364106/2021/07/137

Thank you very much for reading this information sheet.

Appendix G Study 2 Consent Form



Consent Form for Teachers in Research Studies

Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research.

Title of Study: 'Neurocognitive mechanisms of learning: the role of educational neuroscience in teacher training in the UK'

Department: Psychology and Human Development

Name and Contact Details of the Researcher(s): Yasin Arslan, Department of Psychology and Human Development, UCL IOE, University College London, UK, y.arslan@ucl.ac.uk

Name and Contact Details of the Principal Researcher: Dr Rebecca Gordon, Psychology and Human Development, UCL IOE, University College London, UK, rebecca.gordon@ucl.ac.uk

Name and Contact Details of the UCL Data Protection Officer: Alex Potts, a.potts@ucl.ac.uk

This study has been approved by the UCL Research Ethics Committee. Data Protection Registration Number: Z6364106/2021/07/137

Thank you for considering taking part in this research. The person organising the research must explain the project to you before you agree to take part. If you have any questions arising from the Information Sheet or explanation already given to you, please ask the researcher before you decide whether to join in. If requested, a copy of this Consent Form can be given to keep and refer to at any time.

I confirm that I understand that by ticking/initialling each box below I am consenting to this element of the study. I understand that it will be assumed that unticked/initialled boxes mean that I DO NOT consent to that part of the study. I understand that by not giving consent to any one element, I may be deemed ineligible for the study.

Item number	Consent item	Tick Box
1.	I confirm that I have read and understood the Information Sheet for the above study. I have had an opportunity to consider the information and what will be expected of me. I have also had the opportunity to ask questions which have been answered to my satisfaction and would like to take part in this study.	
2.	I understand that all personal information will remain confidential and that all efforts will be made to ensure I cannot be identified. All my data gathered in this study will be stored anonymously and securely. It will not be possible to identify me in any publications.	
3.	I understand that my participation is voluntary and that I am free to withdraw at any time without giving a reason.	
4.	I understand that the risk of participating is minimal, but the support will be available to me should I become distressed during the course of the research.	
5.	I understand that the data will not be made available to any commercial organisations but is solely the responsibility of the researcher undertaking this study.	

Item number	Consent item	Tick Box
6.	I understand that I will not benefit financially from this study or from any possible outcome it may result in in the future. As an appreciation of my time, I will be offered a £15 Amazon Gift Card.	
7.	I understand that my anonymised research data may be used by other authenticated researchers for future research. [No one will be able to identify you when this data is shared.]	
8.	I am aware of who I should contact if I wish to lodge a complaint.	
9.	I voluntarily agree to take part in this study.	

If you would like your contact details to be retained so that you can be contacted in the future by UCL researchers who would like to invite you to participate in follow up studies to this project, or in future studies of a similar nature, please tick the appropriate box below.

Yes I would be happy to be contacted in this way ☐

No, I would not like to be contacted ☐

Name of participant

Date

Signature

Appendix H Study 3 Course Session 1: Introduction and "The Nature of the Evidence"

Session 1 Overview

Title: Introduction and "The Nature of the Evidence"

Duration: ~20 minutes

Presenter: Yasin Arslan

Content Summary

This session introduces participants to the foundational concept of evidence-based teaching and its significance in education. It includes real-life classroom scenarios, practical tips, and interactive questions designed to help teachers critically assess new strategies and their applicability in the classroom.

Learning Objectives

- Understand the concept of evidence and its role in informed decision-making.
- Develop critical evaluation skills to assess research evidence.
- Recognise and challenge common neuromyths in education.
- Explore tools and platforms for accessing reliable educational neuroscience resources.

Session Outline

1. What is Evidence?

- Evidence is information gathered from empirical, peer-reviewed research.
- Importance of peer review:
 - Ensures research quality.
 - Provides feedback and support for theories or hypotheses.
- Evidence helps with:
 - Informed decision-making.
 - Evidence-based practices.
 - Professional development.
 - Addressing diverse student needs.

2. Why is Evidence Important in Education?

- Encourages critical thinking and reflection.
- Engages teachers with the larger educational community.
- Guides professional development and practice.

Neuromyths

- **Definition:** Misconceptions or unscientific ideas about the brain that can harm educational practices.
- **Examples:**
 - "We use only 10% of our brains at any time."
 - "Students are either 'left-brained' or 'right-brained,' and this affects their learning."
 - "Writing letters backward is a key symptom of dyslexia."

Impact of Neuromyth Beliefs:

- Leads to ineffective teaching strategies and classroom practices.

- Results in inefficient use of technology and unnecessary focus on unproven methods (e.g., learning styles).

Evaluating Evidence

Key Questions to Consider:

1. Is this teaching strategy supported by robust evidence?
2. Can I assess its effectiveness in a classroom setting?
3. Is this assessment method valid and reliable?

Platforms and Tools for Teachers

- **Centre for Educational Neuroscience (CEN):** educationalneuroscience.org.uk
- **Learnus:** learnus.co.uk
- **Learning Scientists:** learningscientists.org
- **Tooled Up Education:** tooledupeducation.com

These platforms provide teachers with free, accessible, and research-backed resources for professional development.

Classroom-Based Scenario

Scenario:

Jack, a schoolteacher, adopted a learning styles-based teaching strategy based on a blog recommendation, believing it would improve student outcomes. However, he was unaware that this approach lacks empirical evidence and has no proven impact on educational outcomes.

Question:

What steps should Jack consider before adopting a new teaching strategy in the future?

Options:

- A) Rely solely on recommendations from blogs and colleagues.
- B) Base decisions on immediate feedback from a single classroom session.
- C) Seek out evidence supporting the strategy's effectiveness.
- D) Use strategies endorsed by popular blogs or magazines.

Correct Answer: C) Seek out evidence supporting the strategy's effectiveness.

Explanation:

- Teaching strategies should be based on empirical and validated research.
- Avoid reliance on unverified recommendations or singular experiences.

Practical Tips

- Always prioritise evidence-based methods when selecting classroom strategies.
- Use peer-reviewed journals and reliable platforms to access robust evidence.
- Critically evaluate the validity of teaching strategies before implementation.

Conclusion

Key Takeaways:

- Recognise the importance of robust evidence in education.
- Develop critical evaluation skills to distinguish between validated practices and misconceptions.
- Utilise accessible tools and platforms for continuous professional development.

Appendix I Study 3 Course Session 2: Memory

Session 2 Overview

Title: Memory

Duration: ~15 minutes

Presenter: Yasin Arslan

Content Summary

This session explores memory as a foundational cognitive process essential for learning. It introduces the different types of memory, their roles in learning, and practical strategies for teachers to enhance students' memory retention. The session is designed to equip teachers with a deeper understanding of how memory functions and how to apply these insights to improve classroom teaching.

Learning Objectives

- Understand the process of memory and its role in learning.
- Identify the different types of memory and their functions.
- Apply practical strategies to enhance students' memory retention in the classroom.

Session Outline

1. What is Memory?

- Definition: The process of encoding, storing, and retrieving information.
- Types:
 - **Sensory Memory:** Immediate retention of sensory stimuli (e.g., touch, hearing, vision).
 - **Short-Term Memory (STM):** Temporary storage of attended information.
 - **Long-Term Memory (LTM):** Permanent storage of information, including knowledge and skills.

2. The Importance of Attention and Rehearsal

- Information that is not attended to does not transfer to memory.
- Rehearsal is key to moving information from STM to LTM.

3. Is Memory a Unitary Structure?

- Memory is not singular but comprises multiple systems:
 - **Short-Term Memory:**
 - Supports tasks like problem-solving and reasoning.
 - Tip: Provide information in smaller chunks or bind information into larger, meaningful chunks.
 - **Declarative Memory (LTM):**
 - **Episodic Memory:** Personal stories and specific events.
 - *Tip for Teachers:* Link new knowledge to existing knowledge using elaboration techniques.
 - **Semantic Memory:** General facts and knowledge (e.g., the capital of France).

- **Procedural Memory (LTM):**
 - Knowledge of "how-to" perform tasks (e.g., riding a bicycle).

4. Practical Applications

- Understanding these memory types helps tailor teaching strategies for different classroom activities.
- Examples include:
 - Breaking lessons into smaller sections to accommodate STM.
 - Using storytelling to enhance episodic memory.
 - Repetition and practice to strengthen procedural memory.

Classroom-Based Scenario

Scenario:

Mr. Patel, a primary school teacher, introduces a lesson on "Planets and their Moons." To aid recall, he associates Mars, the Red Planet, with the red Royal Mail postbox. This visual and narrative link helps students remember the planet's colour and presence in the solar system.

Question:

Which type of memory is Mr. Patel introducing to aid students in remembering the names of the planets?

Options:

- A) Semantic memory
- B) Procedural memory
- C) Episodic memory
- D) Working memory

Correct Answer: C) Episodic Memory

Explanation:

- Episodic memory allows students to recall specific events or experiences tied to particular times and places.
- By associating Mars with the red postbox, Mr. Patel creates a narrative that makes the information more relatable and memorable.

Key Practical Tips

1. **Short-Term Memory:**
 - Chunk information into smaller, manageable sections.
 - Bind related information to create larger, meaningful units.
2. **Declarative Memory:**
 - Use elaboration techniques to link new concepts to existing knowledge.
3. **Procedural Memory:**
 - Encourage practice and repetition to strengthen skills over time.

Conclusion

- **Key Takeaways:**
 - Memory is a multifaceted system, with different types playing distinct roles in learning.
 - Teachers can leverage these memory types to enhance retention and understanding.

- Practical strategies like storytelling and chunking information are effective tools for improving student outcomes.

Session 3 Overview

Title: Attention

Duration: ~15 minutes

Presenter: Yasin Arslan

Content Summary

This session examines attention as a critical cognitive function in education, detailing its types and the mechanisms underlying its operation. Practical strategies are provided to help teachers optimise attention in their classrooms by reducing distractions and effectively managing students' cognitive load.

Learning Objectives

- Understand the concept of attention and its significance in learning.
- Differentiate between types of attention (e.g., bottom-up and top-down).
- Apply strategies to help students focus, sustain, and effectively divide their attention during classroom activities.

Session Outline

1. What is Attention?

- **Definition:** A state of consciousness allowing individuals to respond to stimuli.
- **Two Main Types:**
 - **Bottom-Up Attention:** Automatic and involuntary; triggered by external stimuli.
 - **Top-Down Attention:** Effortful and voluntary; requires deliberate mental engagement.

2. Types of Top-Down Attention

- **Sustained Attention:**
 - Ability to focus over an extended period.
 - Example: Attending to a lecture or long-term task.
 - *Tip for Teachers:* Provide regular breaks and vary instructions to maintain students' attention.
 - **Selective Attention:**
 - Ability to focus on a specific task or stimulus while ignoring distractions.
 - Example: Listening to a teacher while tuning out background noise.
 - *Tip for Teachers:* Avoid overloading students with information at once, as they cannot focus on multiple elements simultaneously.
 - **Divided Attention:**
 - Ability to perform two tasks simultaneously.
 - Example: Listening to instructions while taking notes.
 - *Tip for Teachers:* Recognize that divided attention is limited, and some students may struggle to manage multiple tasks effectively.
-

3. Classroom Applications

- Strategies to optimise attention in the classroom include:
 - Breaking information into manageable chunks to support sustained attention.
 - Minimising distractions to aid selective attention.
 - Avoiding overly complex multi-tasking scenarios to reduce the cognitive load on divided attention.

Classroom-Based Scenario

Scenario:

Mrs. Thompson alternated between providing verbal instructions and having students engage in hands-on activities during a literature lesson. This method created moments of respite, helping students maintain focus throughout the session.

Question:

What was Mrs. Thompson primarily achieving by frequently switching between talking and asking students to use materials?

Options:

- A) Ensuring students always had something to do during the lesson.
- B) Emphasizing the importance of annotating literature for future reference.
- C) Keeping students on their toes by introducing unexpected tasks.
- D) Reducing the load on sustained attention through periodic engagement breaks.

Correct Answer: D) Reducing the load on sustained attention through periodic engagement breaks.

Explanation:

- Alternating between instruction and engagement prevents cognitive fatigue and maintains focus.
- Continuous listening and processing can strain cognitive resources, leading to reduced comprehension.

Key Practical Tips

1. Sustained Attention:

- Use regular breaks to allow students to reset their focus.
- Vary instructional methods to sustain engagement.

2. Selective Attention:

- Remove unnecessary distractions from the learning environment.
- Provide information incrementally rather than all at once.

3. Divided Attention:

- Avoid overloading students with simultaneous tasks.
- Be mindful of individual differences in managing divided attention.

Conclusion

• Key Takeaways:

- Attention is a deliberate, effortful, and limited resource.
- Different types of attention require tailored strategies to optimise learning.
- Teachers can significantly enhance focus and comprehension by managing cognitive loads effectively.

Appendix K Study 3 Course Session 4: Executive Function, Self-Regulation, and Metacognition

Session 4 Overview

Title: Executive Function, Self-Regulation, and Metacognition

Duration: ~15 minutes

Presenter: Yasin Arslan

Content Summary

This session explores the key components of executive function, self-regulation, and metacognition, highlighting their roles in learning and academic success. Practical strategies and classroom scenarios are provided to help teachers support students in developing these higher-order cognitive skills.

Learning Objectives

- Understand the components of executive function and their application in education.
 - Recognise the importance of self-regulation in managing emotions and behaviours.
 - Develop strategies to foster metacognition and support students' awareness of their own learning processes.
-

Session Outline

1. Executive Function

- **Definition:** Skills that help individuals control behaviour to achieve specific tasks.
 - **Components:**
 1. **Inhibitory Control:**
 - Ability to filter out irrelevant information and suppress inappropriate behaviours.
 - *Tip for Teachers:* Reduce distractions and provide clear, goal-oriented instructions.
 2. **Task Switching:**
 - Ability to adapt to changing conditions and switch between tasks or rules.
 - Example: Switching from a math problem to a reading task.
 - *Tip for Teachers:* Use verbal cues or structured routines to support smooth transitions.
 3. **Working Memory:**
 - Holding and processing information temporarily while completing a task.
 - Example: Mental math, following multi-step instructions.
 - *Tip for Teachers:* Break instructions into smaller, manageable steps to avoid cognitive overload.
-

2. Self-Regulation

- **Definition:** The ability to manage emotions, motivation, thoughts, and behaviours in different situations.
- **Application in Education:**

- Helps students focus on academic goals and manage challenges.
- Particularly challenging for students with SEN or those from suboptimal environments.
- **Practical Tip for Teachers:**
 - Scaffold self-regulation through activities like goal setting and self-monitoring.
 - Create a positive and inclusive classroom environment where students feel safe to express thoughts and emotions.

Classroom-Based Scenario:

Olivia, a student nervous about public speaking, uses deep breathing to calm herself, reminds herself of the importance of her presentation, and delivers her content effectively.

3. Metacognition

- **Definition:** Awareness and understanding of one's own thinking processes; "thinking about thinking."
- **Application in Education:**
 - Encourages students to reflect on their learning strategies and adjust them for better outcomes.
 - Example: A student planning memory strategies for an exam and monitoring their effectiveness.
- **Practical Tip for Teachers:**
 - Promote self-reflection by asking students to identify what they understood well and what they need to review.
 - Encourage students to plan, monitor, and adjust their learning strategies actively.

Classroom-Based Scenario:

Sophie, a student preparing for a history exam, reads her textbook and realises she needs to remember key points. She plans memory strategies, implements elaborative rehearsal, monitors her progress, and adjusts as necessary.

Key Practical Tips

1. **Inhibitory Control:**
 - Encourage focus by removing distractions.
2. **Task Switching:**
 - Use cues or routines to signal task transitions.
3. **Working Memory:**
 - Break tasks into smaller steps.
4. **Self-Regulation:**
 - Scaffold students' emotional regulation through activities like mindfulness.
5. **Metacognition:**
 - Foster self-reflection and strategy adjustment in learning.

Conclusion

- **Key Takeaways:**
 - Executive function, self-regulation, and metacognition are vital for academic and social success.
 - Teachers can play a crucial role in supporting these skills through structured strategies and inclusive classroom practices.

- Scenarios and activities help students apply these cognitive skills effectively in real-life academic settings.

Appendix L Study 3 Course Session 5: Neuroplasticity

Session 5 Overview

Title: Neuroplasticity and the Learning Brain

Duration: ~10 minutes

Presenter: Yasin Arslan

Content Summary

This session focuses on neuroplasticity—the brain’s capacity to adapt and change in response to experiences and learning. The session addresses misconceptions about the brain, explains how neuroplasticity underpins learning and provides strategies to leverage this concept in education to foster student growth and resilience.

Learning Objectives

- Understand the concept of neuroplasticity and its implications for learning.
 - Identify and challenge misconceptions about the brain's ability to change.
 - Explore strategies to create a growth-oriented learning environment that supports neuroplasticity.
-

Session Outline

1. What is Neuroplasticity?

- **Definition:** The capacity of neural networks to adapt in response to new information, sensory input, development, damage, or dysfunction.
 - **Key Mechanisms:**
 - Learning a new skill strengthens neural connections.
 - Practice further reinforces these connections, making recall easier.
 - **Biological Foundation:**
 - Approximately 86 billion neurons process and transmit information via electrical and chemical signals.
-

2. Challenging Misconceptions About the Brain

- **Common Myths:**
 - The brain is fixed and hardwired.
 - Neural capacities cannot change after early childhood.
 - **Reality:**
 - The brain is dynamic and can change with effort, dedication, and the right challenges.
 - Growth and adaptability are lifelong processes.
 - *Message for Teachers:* Challenges should be seen as opportunities to develop new skills and strengthen neural connections.
-

3. Neuroplasticity in Education

- **Relevance to SEN and General Education:**
 - Neuroplasticity is particularly significant in supporting students with SEN.

- Understanding neuroplasticity helps create a positive learning environment that encourages effort, persistence, and resilience.
 - **Practical Tip for Teachers:**
 - Provide support and interventions that encourage brain development.
 - Emphasise the importance of effort and learning from mistakes.
 - Foster student engagement and create an atmosphere of growth and possibility.
-

Key Practical Tips

1. Emphasise effort and dedication as essential to growth.
 2. Use challenges as opportunities for learning and skill development.
 3. Encourage students to learn from mistakes and persist through difficulties.
 4. Create a supportive and engaging classroom environment that highlights the brain's ability to adapt and grow.
-

Conclusion

- **Key Takeaways:**
 - Neuroplasticity explains how learning shapes the brain and reinforces its adaptability.
 - Teachers play a critical role in fostering neuroplasticity by creating growth-oriented environments.
 - Understanding and applying the principles of neuroplasticity can empower students to see effort and learning as lifelong processes.

IOE, Faculty of Education and Society



'Neurocognitive mechanisms of learning: the role of educational neuroscience in teacher training in the UK'

Research Information Sheet

Dear teacher,

I am Yasin Arslan and I am a PhD candidate at UCL Institute of Education, a world-leading centre for research and teaching in education and social science, and it has been rated as the world number one for education for the 10th year in a row by the QS World University Rankings by Subject.

I extend a personal invitation for you to be a crucial part of my research project, 'Neurocognitive Mechanisms of Learning: The Role of Educational Neuroscience in Teacher Training in the UK'. Your insights are vital to unravelling the mysteries of effective teaching methods.

This research is not just a part of my doctoral studies; it is an opportunity for us to collaborate and make a lasting impact on education. Please take a moment to explore the details in this information sheet; it is crafted to address any questions you may have, but please do not hesitate to contact me if there is anything else you would like to know. If you would like to be involved after reading the following information and the consent form attached to the email you received, please click on the course enrollment link in the email. Please note that enrolling in the course implies consent to the consent form statements.

Who is carrying out the research?

Researcher:

Yasin Arslan, PhD Candidate & Postgraduate Teaching Assistant, Psychology and Human Development,

UCL Institute of Education, University College London, UK.

Email: y.arslan@ucl.ac.uk

Supervisors:

Dr Rebecca Gordon, Associate Professor, Psychology and Human Development,
UCL Institute of Education, University College London, UK.

Email: rebecca.gordon@ucl.ac.uk

Prof Andy Tolmie, Chair of Psychology and Human Development,
UCL Institute of Education, University College London, UK.
Email: andrew.tolmie@ucl.ac.uk

Why are we doing this research?

This study constitutes the third phase of a comprehensive PhD project. In the initial stage, our focus was on exploring common beliefs that teachers may hold about the brain and learning science, and factors influencing these beliefs. In the second study, we delved into the processes through which teachers engage with educational neuroscience training and materials. Building upon this work, the final phase aims to test the effectiveness of an educational neuroscience course.

Why am I being invited to take part?

You are being invited because you are a teacher in the UK education system. We are interested in your feedback about this course, and we truly value your contributions.

What will happen if I choose to take part?

If you agree to participate in the study, you will be asked to complete brief course tasks carefully designed to accommodate busy schedules.

At the end of the course, there is a brief questionnaire and a feedback form that we will ask you to complete. Completing this is crucial for the future developments of such courses.

What are the benefits of taking part?

There is no direct financial benefit of taking part. However, we would like to express our gratitude for your time and contribution. As a token of appreciation, you will receive a £15 Amazon e-Voucher as a thank-you gesture for your participation.

Will anyone know I have been involved?

All responses are anonymous and confidential. Only the research team will have access to the responses collected.

What are the risks if I take part?

We do not anticipate any risks related to taking part in this study. However, you are entitled to withdraw from the study at any point. You do not need to give a reason and there are no consequences if you withdraw. We hope you would like to take part.

What will happen to the results of the research?

Once data collection is completed, results will be used in a PhD thesis and may be published in a journal article or presented. The anonymity of the participants will be assured. If the research is published, you will not be identifiable in any way. The data will not be made available to any commercial organisations.

Do I have to take part?

It is entirely up to you whether you choose to take part. We hope that if you do choose to be involved, you will find it a valuable experience.

If you do not wish to proceed with the study, you have the right to stop at any time.

Data Protection Privacy Notice

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Contact for further information

If you have any further questions before you decide whether to take part, you can reach me at y.arslan@ucl.ac.uk (Yasin Arslan); or my supervisors, rebecca.gordon@ucl.ac.uk (Rebecca Gordon); andrew.tolmie@ucl.ac.uk (Andy Tolmie).

This project has been reviewed and approved by the UCL Institute of Education Research Ethics Committee. Data Protection Registration Number:
Z6364106/2021/07/137

Thank you very much for reading this information sheet.

Appendix N Study 3 Consent Form

IOE, Faculty of Education and Society



Consent Form for Teachers in Research Studies

Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research.

Title of Study: 'Neurocognitive mechanisms of learning: the role of educational neuroscience in teacher training in the UK'

Department: Psychology and Human Development

Name and Contact Details of the Researcher(s): Yasin Arslan, Department of Psychology and Human Development, UCL IOE, University College London, UK, y.arslan@ucl.ac.uk

Name and Contact Details of the Principal Researcher: Dr Rebecca Gordon, Psychology and Human Development, UCL IOE, University College London, UK, rebecca.gordon@ucl.ac.uk

Name and Contact Details of the UCL Data Protection Officer: Alex Potts, a.potts@ucl.ac.uk

This study has been approved by the UCL Research Ethics Committee. Data Protection Registration Number: Z6364106/2021/07/137

Thank you for considering taking part in this research. The person organising the research must explain the project to you before you agree to take part. If you have any questions arising from the Information Sheet or explanation already given to you, please ask the researcher before you decide whether to join in. If requested, a copy of this Consent Form can be given to keep and refer to at any time.

I confirm that I understand that by ticking/initialling each box below I am consenting to this element of the study. I understand that it will be assumed that unticked/initialled boxes mean that I DO NOT consent to that part of the study. I understand that by not giving consent to any one element, I may be deemed ineligible for the study.

Item number	Consent item	Tick Box
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If you would like your contact details to be retained so that you can be contacted in the future by UCL researchers who would like to invite you to participate in follow up studies to this project, or in future studies of a similar nature, please tick the appropriate box below.

Yes I would be happy to be contacted in this way ☐

No, I would not like to be contacted ☐

Name of participant

Date

Signature

IOE, Faculty of Education and Society



'Neurocognitive mechanisms of learning: the role of educational neuroscience in teacher training in the UK'

Research Information Sheet

Dear teacher,

I am Yasin Arslan and I am a PhD candidate at UCL Institute of Education, a world-leading centre for research and teaching in education and social science, and it has been rated as the world number one for education for the 10th year in a row by the QS World University Rankings by Subject.

I extend a personal invitation for you to be a crucial part of my research project, 'Neurocognitive Mechanisms of Learning: The Role of Educational Neuroscience in Teacher Training in the UK'. Your insights are vital to unravelling the mysteries of effective teaching methods.

This research is not just a part of my doctoral studies; it is an opportunity for us to collaborate and make a lasting impact on education. Please take a moment to explore the details in this information sheet; it is crafted to address any questions you may have, but please do not hesitate to contact me if there is anything else you would like to know. If you would like to be involved after reading the following information, please click on the questionnaire link attached to the email you received and complete the consent form.

Who is carrying out the research?

Researcher:

Yasin Arslan, PhD Candidate & Postgraduate Teaching Assistant, Psychology and Human Development,

UCL Institute of Education, University College London, UK.

Email: y.arslan@ucl.ac.uk

Supervisors:

Dr Rebecca Gordon, Associate Professor, Psychology and Human Development,
UCL Institute of Education, University College London, UK.

Email: rebecca.gordon@ucl.ac.uk

Prof Andy Tolmie, Chair of Psychology and Human Development,
UCL Institute of Education, University College London, UK.

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Why are we doing this research?

This study constitutes the third phase of a comprehensive PhD project. In the initial stage, our focus was on exploring common beliefs that teachers may hold about the brain and learning science, and factors influencing these beliefs. In the second study, we delved into the processes through which teachers engage with educational neuroscience training and materials. Building upon this work, the final phase aims to test the effectiveness of an online course.

Why am I being invited to take part?

You are being invited because you are a teacher in the UK education system. We are interested in learning about your beliefs regarding some statements in education. Your responses will contribute to evaluating the effectiveness of an online course.

What will happen if I choose to take part?

If you agree to participate in the study, you will be asked to complete a brief questionnaire.

What are the benefits of taking part?

There is no direct financial benefit of taking part. However, we would like to express our gratitude for your time and contribution. As a token of appreciation, you will receive a £15 Amazon e-Voucher as a thank-you gesture for your participation.

Will anyone know I have been involved?

All responses are anonymous and confidential. Only the research team will have access to the responses collected.

What are the risks if I take part?

We do not anticipate any risks related to taking part in this study. However, you are entitled to withdraw from the study at any point. You do not need to give a reason and there are no consequences if you withdraw. We hope you would like to take part.

What will happen to the results of the research?

Once data collection is completed, results will be used in a PhD thesis and may be published in a journal article or presented. The anonymity of the participants will be assured. If the research is published, you will not be identifiable in any way. The data will not be made available to any commercial organisations.

Do I have to take part?

It is entirely up to you whether you choose to take part. We hope that if you do choose to be involved, you will find it a valuable experience.

If you do not wish to proceed with the study, you have the right to stop at any time.

Data Protection Privacy Notice

The controller for this project will be University College London (UCL). The UCL Data Protection Office provides oversight of UCL activities involving the processing of personal data, and can be contacted at data-protection@ucl.ac.uk. This 'local' privacy notice sets out the information that applies to this study. Further information on how UCL uses participant information from research studies can be found in our 'general' privacy notice for participants in research studies [here](#). The information that is required to be provided to participants under data protection legislation (GDPR and DPA 2018) is provided across both the 'local' and 'general' privacy notices. The lawful basis that will be used to process any personal data is: 'Public task' for personal data. We will be collecting, with your consent, personal data such as email addresses. Your personal data will be processed so long as it is required for the research project. The data you provide will be anonymised and pseudonymised, and will endeavour to minimise the processing of personal data wherever possible. If you are concerned about how your personal data is being processed, or if you would like to contact us about your rights, please contact UCL in the first instance at dataprotection@ucl.ac.uk.

Contact for further information

If you have any further questions before you decide whether to take part, you can reach me at y.arslan@ucl.ac.uk (Yasin Arslan); or my supervisors, rebecca.gordon@ucl.ac.uk (Rebecca Gordon); andrew.tolmie@ucl.ac.uk (Andy Tolmie).

This project has been reviewed and approved by the UCL Institute of Education Research Ethics Committee. Data Protection Registration Number:
Z6364106/2021/07/137

Thank you very much for reading this information sheet.