The Development of Educational Neuroscience

Research and Practice in Ireland

UCD DUBLIN

QUEEN'S UNIVERSITY BELFAST

into
Irish National Teachers' Organisation
Cumann Múinteoirí Éireann

Shared Island Initiative

Taighde Éireann
Research Ireland

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1. An All-Island Consortium to Foster Educational Neuroscience Research and Practice (AIEN)

1.1 About the Project

This project aims to provide a foundation for a future all-island approach to inclusive education that is informed by neuroscientific evidence. Together we explore the development of the new interdisciplinary field of Educational Neuroscience on the island of Ireland.

Our project entitled, 'An All-Island Consortium to Foster Educational Neuroscience Research and Practice' (AIEN) is a co-creative project that invites the voices of researchers, parents, teachers, and policy-makers to contribute to the development of this field in Ireland.

Educational Neuroscience is a relatively new interdisciplinary field that addresses real life research questions that go beyond the separate research domains of neuroscience and education. Through the establishment of an all-island educational neuroscience research hub we aim to address our first collaborative research questions, form new collaborations, and disseminate co-creative findings on the current understanding and management of inattention in the early classroom settings. Finally, we aim to share ideas to improve practice and inclusion in classroom settings across the island of Ireland.

Our first collaborative research project, detailed in chapter 3, is focused on the foundational years of formal learning. This co-creative research aims to explore mind-wandering in the first two years of school and was chosen as an initial priority due to a lack of existing research on mind-wandering itself in addition to a lack of focus on inattention in the first two years of school. However, the AIEN project aims to develop further research initiatives with the expansion of the AIEN network in the longer term and input from stakeholders across different settings relevant to the broader domain of educational neuroscience.

The current project had three objectives:

1) To establish an all-island educational neuroscience hub of researchers and practitioners.
2) To engage with stakeholders to enhance classroom practice and make for a more inclusive start across the island's classrooms.
3) To establish teachers' and parents' understanding of mind-wandering in early classroom contexts.

The main deliverables we aimed to achieve through this initial project phase are:

- Qualitative paper targeted at education journal (in submission)
- White paper report for online dissemination (what you are reading now!)

- The establishment of an All-Island Educational Neuroscience network

1.1.1 Objective 1: To establish an all-island educational neuroscience hub of researchers and practitioners

This project aims to establish innovative research links and develop transdisciplinary collaboration between researchers and stakeholders North and South by developing research capabilities in the development of an educational neuroscience hub, an emerging transdisciplinary field. There is a well-established challenge in the translation of educational neuroscience research for educational policy and practice. A goal of this project was to improve the uptake of scientific knowledge in educational neuroscience to enhance pedagogy and the learning experience for all. We aim to achieve this by bringing together a national community of researchers, educators, and policy-makers and other relevant stakeholders to encourage knowledge exchange and collaboration.

1.1.2 Objective 2: To engage with stakeholders to enhance classroom practice and make for a more inclusive start across the island's classrooms

This project aims to contribute to the research, teaching, and learning continuum of the school community, particularly primary school teachers, by enhancing the understanding and management of neurocognitive skills behind observable learning behaviours and enhancing cross-border dialogue exchange around shared challenges. An all-island approach is crucial as teacher and parent stakeholders will inform the development of future tools that are universal in design. An engaged research approach is key to this project which aims to advance educational neuroscience research and practice in collaboration with community stakeholders.

1.1.3 Objective 3: To establish teachers' and parents' understanding of mind-wandering in early classroom contexts

This initial collaborative research focus aims to contribute to policy development relevant to the Shared Island initiative by benefiting communities, North and South through the promotion of inclusive equitable education in the early years of formal education.

1.2 About the Funder

This project is funded by a Taighde Éireann - Research Ireland New Foundations Grant in partnership with the Department of the Taoiseach as part of the Shared Island initiative.

Further information on Research Ireland is available at: https://www.researchireland.ie/ @Researchirel #LoveIrishResearch

1.3 About the Team

Meet the Collaborative Team

The project includes contributions from researchers from the School of Psychology and School of Education at University College Dublin (UCD) and Queen's University Belfast (QUB) (Olivia Wynne, Maisie Flynn, Associate Professor Michelle Downes, Dr Joyce Senior, Professor Teresa McCormack, Dr Agnieszka Graham, Dr John McMullen); policy-makers and practitioners (Patricia Davison, Educational Authority Northern Ireland; Thomas Maloney, Teaching Council Ireland; Máirín Ní Chéileachair; Irish National Teachers Organisation) as well as parent and teacher representatives (Celine Mackessy and Joelle Hendrick). See more details on researcher profiles below:

University College Dublin:

Associate Professor Michelle Downes: Principal Investigator and Associate Professor at UCD School of Psychology

Dr. Joyce Senior: Assistant Professor and Director of the Professional Doctorate in Educational Psychology at UCD School of Education

Maisie Flynn: Research Assistant Olivia Wynne: Research Assistant

Queen's University Belfast:

Professor Teresa McCormack: Professor at QUB School of Psychology

Dr Agnieszka Graham: Lecturer at QUB School of Psychology

Dr John McMullen: Director of the Professional Doctorate in Educational, Child, and Adolescent Psychology at QUB School of Psychology

2. What is 'Educational Neuroscience?'

2.1 Introduction to Educational Neuroscience

Educational neuroscience, sometimes referred to as 'neuroeducation' or 'mind, brain, and education' is a relatively new multidisciplinary field that aims to bridge the gap between research on brain development, cognitive processes, and real-life teaching and

learning experiences. As a research discipline it can involve researchers from neuroscience, psychology, education, and other related domains depending on the research question. Often the goal of research studies in this area is to better understand what is happening 'in the background' to inform teaching and learning strategies.

Traditionally, research in this domain is considered by many as the application of neuroscientific methodologies such as functional neuroimaging, eye-tracking (Appendix A), computerised tasks or measurements and coding of behaviour in relation to specific questions about how we learn. In this way, complex behaviours can be broken down into more specific mechanisms and researchers can measure different factors that contribute to learning both inside and outside the classroom. For example, using an eye tracker or event-related potential (Appendix A) measure, we can measure attentional focusing and distractor suppression when presented with interesting visual stimuli or auditory scenes and compare patterns in performance between a patient group and a control group (Appendix A). These very precise methods and explorations of group differences can contribute to the development of more focused research interventions and future support for children and adults with different learning needs. We can also track changes over time in longitudinal (Appendix A) studies to investigate developmental change or the impact of interventions and we can correlate (Appendix A) or explore links between cognitive constructs and other factors, such as screen exposure.

However, educational neuroscience is not just the use of neuroscientific methodologies to ask specific questions about cognitive processes. As Howard-Jones and colleagues (2016) succinctly put it – educational neuroscience '*does not espouse a direct link from neural measurement to classroom practice*.' As a field it considers the individual in their environment, and it is a two-way stream of dialogue between researchers and educators. Based on a review of the existing literature in the domain, Felier and Stabio (2018) recommended that we consider there to be three pillars of educational neuroscience – application, interdisciplinary, and translation of language (Feiler & Stabio, 2018). 'Application' refers to the consideration of research findings in this domain by educational policy-makers when exploring ways to improve the learning experience. Interdisciplinary collaboration relates to the non-hierarchical interaction between professionals in the fields of neuroscience, psychology, education, and other relevant areas. Translation of language applies to the bidirectional communication of jargon-free language between the domains of education and neuroscience. Weak communication channels between these fields can lead to 'neuromyths' - a term used to describe false and often over simplified interpretations of neuroscience research.

The field of educational neuroscience is not just the application of neuroscientific methods to explore how we learn but the merging of research across subdomains in many meaningful ways to inform teaching and learning across the lifespan. For example, there is a growing body of educational neuroscience research that demonstrates the need to look at learning needs beyond specific diagnoses (transdiagnostic) and beyond just a focus on 'deficits' only (Holmes et al., 2019).

2.2 How Educational Neuroscience can contribute to a More Inclusive Classroom

The main goal of educational neuroscience is to bridge the gap between research in cognitive neuroscience and its practical application in educational settings. It is an interdisciplinary effort that integrates neuroscience, psychology, cognitive science, and education to understand how we learn and how this knowledge can be used to improve teaching methods and educational policy. We require both memory and attention during the learning process so by better understanding what promotes or inhibits these cognitive processes for individuals we can inform learning design. To achieve this, research must consider the impact of developmental stages on these processes. Different neural systems within the brain mature at different rates. Attention and memory ability changes with development. Cognitive skills relevant to specific educational topics also have different developmental trajectories, for example, number processing (maths) and language (literacy). Importantly, the development of other 'background skills' such as executive functions, social cognition, and emotion and how they are linked to learning are also studied in educational neuroscience research (Thomas et al., 2019).

To make the learning picture more complete, research also needs to better understand the influence of factors linked to prior and current lived experiences in the home environment and wider community (e.g. screentime, sleep, nutrition, trauma) on learning as well as internal experiences (e.g. stress, mood, motivation, fatigue). Research also needs to consider potential neurocognitive differences linked to a diagnosis of a neurodevelopmental disorder (e.g. ADHD), neurological condition (e.g. epilepsy), chronic health condition/genetic disorder (e.g. sickle cell disease, diabetes) or acquired brain injury (e.g. stroke, tumour). Every individual has a unique 'plastic' brain and educational neuroscience can help inform learning strategies that take this into consideration so that everyone can meet their learning potential.

The biggest challenge that this field currently faces involves the poor or sometimes 'premature' translation of research into policy and practice (Feiler & Stabio, 2018; Horvath et al., 2017; Thomas et al., 2019; Goswami et al., 2020; Jamaludin et al., 2019; Van Der Aar et al., 2019. Moving forward, evidence-based findings from educational neuroscience that are appropriately translated into policy and practice can inform learning design to cater to the diverse needs of learners from all backgrounds.

2.3 Spotlight on Irish Educational Neuroscience Research

2.3.1 Professor Victoria Simms, School of Psychology, Ulster University

Victoria Simms' research to date has focused on the development of mathematical cognition using multiple research methods. A particular focus of this research has been the contribution of domain-general and domain-specific skills to broader mathematical processing. Professor Simms and her research team have worked with different groups of children and young people, including those born very premature, or those with Down

Syndrome or William's Syndrome. Professor Simms and her colleagues have identified important factors that influence children and young people's performance in mathematics, even when they are struggling learners. These findings have informed recommendations for supporting learning in the classroom.

More recently, within the Centre for Early Mathematical Learning (CEML) Professor Simms has focused on development in the early years (2-5 years-old). This stage of development has been described as the "black box" of child development research. Professor Simms and her colleagues have worked hard to ensure that they create tasks that can really help them understand what toddlers and young children know about mathematics. This has been difficult, but rewarding! Professor Simms also has a particular interest in the environments in which young children learn about mathematics, specifically the home and early years settings. The next steps will aim to investigate how children's cognitive processes interact with their environments to develop these sophisticated mathematics skills.

Find out more here: https://pure.ulster.ac.uk/en/persons/victoria-simms

2.3.2 Dr Agnieszka Graham, School of Psychology, Queen's University Belfast

Dr Agnieszka Graham is interested in how executive functions develop, underpin school readiness, and how their development can be best supported. Her research has a strong translational perspective, using core principles of developmental and cognitive psychology to understand classroom learning and provide practitioners with research-based insights. The focus of Dr Graham's work is on cognitive skills with immense practical relevance for education. Currently, Dr Graham is leading a research program exploring mind-wandering in children, examining its nature, and considering its costs and benefits in the context of educational attainment. Her recent breakthroughs include establishing a robust link between mind-wandering and memory in children. Dr Graham also confirmed the feasibility of obtaining mind-wandering reports from young children by including a well-designed training phase that teaches children to report whether their thoughts are task-unrelated. Ongoing efforts focus on refining and scaling up methods for detecting mind-wandering in school settings, which will serve as a springboard for developing new interventions aimed at refocusing lapses of attention in authentic classroom environments. Additionally, Dr Graham's research explores the cognitive meta-awareness of mind-wandering in children and its relationship with mental wellbeing. Her work on children's mind-wandering has far-reaching implications, not only for education but also for children's mental health and the effectiveness of mindfulness-based interventions.

2.3.3 Dr Tim Fosker, School of Psychology, Queen's University Belfast

Collaborating with Speech and Langauge Therapists and Educational Psychologists, Dr Fosker and his colleagues have crossed the boundary of lab-based and classroom-based research, investigating the impacts of language and literacy outcomes to neurotypical and neurodiverse young people, and those from adversely impacted backgrounds (e.g. looked

after and adopted young people). Most recently, international funding has allowed Dr Fosker to look at differences in the perceived barriers and supports to the academic success of individuals with reading difficulties from the perspective of teachers, neurodiverse adults, and the children themselves. In the classroom, Dr Fosker has worked on refining methods of low-inference classroom observation to identify differences in language skills between children during classroom activities, without formal assessment. Using these measures, Dr Fosker and his research team have begun to look at how teachers change their language in the classroom for their neurodiverse pupils. In addition to examining the impacts of language and literacy difficulties, they have been investigating the potential causal mechanisms that may explain them, using measures of brain activity in infancy and adulthood. The findings have led to a focus on the processing of sounds relevant to speech and we have identified reliable methods for measuring these in preschool and school-age children with language and/or literacy difficulties. Dr Fosker's research has shown that these same sensitivities to sound are also predictive of second language learning skill in adults and Dr Fosker hopes that his research in the future will help establish what sensory abilities are most fundamental to the development of good language and literacy skills across languages.

Find out more here: https://go.qub.ac.uk/timfosker

2.3.4 Dr. Éadaoin Slattery, School of Psychology, Technological University of the Shannon Midwest

Dr. Éadaoin Slattery is a lecturer in Applied Psychology at the Technological University of the Shannon Midwest. Éadaoin's research explores the intersection of psychology, neuroscience, and education to enhance teaching and learning for children and adolescents. Her PhD research focused on the development and evaluation of a school-based attention training programme for improving children's attention spans. During this time, she also investigated the cognitive predictors of reading and attention in children. Recently, Éadaoin has shifted her focus to the use of educational technology to support cognition and STEM learning. This includes investigating the effectiveness of Minecraft Education as an educational tool. Her latest study, conducted during her post-doc at the Institute of Education at Dublin City University in collaboration with Microsoft Dream Space, evaluated a curriculum-based Minecraft Education intervention designed to improve spatial thinking in primary school children. This research highlights the potential of integrating innovative technologies into educational settings to foster essential cognitive functions and support learning. Éadaoin is interested in understanding how educational technology, informed by educational neuroscience, can make learning more engaging and effective. Additionally, she is interested in educational evaluation, aiming to assess and improve the effectiveness of educational interventions.

2.3.5 Dr. Flavia H. Santos, University College Dublin - Educational Neuroscience in Games for Mathematics

Dr Flavia H. Santos' research includes the ENIGMA Project which is led by the University College Dublin in partnership with Headstart Technology in Malta and funded

by the European Commission, Erasmus Plus. ENIGMA stands for Educational Neuroscience in Games for Mathematics. It includes a survey with maths teachers and interviews with game developers to inform a course design. The course will explore how games and gamification strategies can enhance engagement, motivation, and learning outcomes in maths education and empower educators to optimise pupils' learning experiences in the maths classroom. The Arithmós Project is a collaboration between University College Dublin and Technological University Dublin funded by the Irish Research Council. It engaged children, parents, teachers, and policy-makers through a multidimensional approach. Researchers conducted an RCT study of N=466 pupils from six primary schools (23 classrooms) in Ireland to test the efficacy of five sessions playing a maths digital game that could improve maths performance and reduce maths anxiety. Outcomes included scientific and policy papers, a cartoon video for children, and a teachers' workshop about maths anxiety. Furthermore, this project was presented at outreach events, conferences, and seminars abroad.

2.3.6 Associate Professor Michelle Downes, School of Psychology, University College Dublin

Research at the **UCD Babylab**, led by Associate Professor Michelle Downes, aims to better understand how the brain and behaviour of infants and young children develop in the first six years of life. Research in the lab primarily focuses on topics such as executive function, learning, play, sleep, family function and the influences of modern life on child development (such as digital technology and vaping). Through the **UCD Neuropsychology Lab** Assoc Prof Downes conducts research with patient groups (for example, children with ADHD, epilepsy, and Tourette syndrome) largely focused on executive function, sleep, and learning. This research often involves collaboration with clinicians, educators, and policy-makers. Research in both labs involve a variety of quantitative and qualitative approaches. Quantitative techniques include EEG (brain wave activity), eye tracking, actigraphy, and behavioural assessment. Executive functions (EF) is an umbrella term for a collection of cognitive skills that help control and manage behaviour and are crucial for successful learning. The overarching research goal across both labs is to establish a better understanding of executive functioning to enhance the learning experience for children who have poorer executive skills due to genetic or environmental factors.

Find out more here: https://www.ucdbabylab.com/

www.ucdneuropsychologylab.squarespace.com

2.3.7. Dr Katie Gilligan-Lee, School of Psychology, University College Dublin - Spatial Cognition and STEM

Dr. Katie Gilligan-Lee is Assistant Professor of Cognitive Development and Ad Astra Fellow at University College Dublin and an Affiliate member of the Centre for Educational Neuroscience, London. Her research investigates spatial cognition and its role in Science, Technology, Engineering and Mathematics (STEM) outcomes. This research

focuses on how an understanding of cognitive development and the brain can inform education, with a particular focus on Science, Technology, Engineering and Mathematics (STEM) achievement. The majority of Dr Gilligan-Lee's lab research investigates the role of spatial thinking, the cognitive ability to represent and manipulate space, for STEM. This includes cognitive predictors such as spatial thinking, memory and language; affective predictors like mathematics anxiety; and early home factors like mathematical play and spatial language exposure. By extension, they also investigate the cognitive and neural underpinnings of cognitive training and transfer of training gains between cognitive domains and educational outcomes.

Find out more here:

Links: https://people.ucd.ie/katie.gilligan-lee

https://www.gilliganleelab.com/

2.4 All-Island Educational Neuroscience Research Day 2024

The All-Island Consortium to Foster Educational Neuroscience Research and Practice initiative is a pioneering, co-creative project that invites the voices of researchers, parents, teachers and policy-makers in a collaborative effort to revolutionise this field in Ireland.

On the 4th of June 2024, the AIEN team hosted a Research Day at University College Dublin. The event brought together a range of speakers, highlighting exciting research in how educational neuroscience can be used to enhance classroom practice and the role of research in the classroom. This section will showcase some of the research presentations from the day.

The speakers on the day were (pictured L-R below) Professor Teresa McCormack, Olivia Wynne, Maisie Flynn, Dr. Lisa Keenan, Dr Joe Bathelt, Dr Flavia H. Santos, Professor Victoria Simms, Professor Joni Holmes, Dr Agnieszka Graham and Associate Professor Michelle Downes. The event was also an opportunity to showcase the art piece made by Shakira Browne during the AIEN World Cafe in February 2024. There was also a panel discussion on the role of educational neuroscience in the classroom, which included Dr Joe Bathelt, Dr Éadaoin Slattery, Dr Thomas Delahunty, Dr Tim Fosker, Máirín Ní Chéileachair and Associate Professor Michelle Downes.

Professor Joni Jolmes, University of East Anglia - Challenges of the Diagnostic Framework for Identifying and Supporting Children's Classroom Needs

Professor Joni Holmes spoke about the challenges in the current system, which assumes a 1-1 mapping of a child's diagnosis and their needs. Holmes et al. (2019) highlights the need for a transdiagnostic approach. In their cluster analyses of imaging and behavioural findings, children were placed in groups with similar cognitive or behavioural profiles, irrespective of their diagnosis, thus children with different diagnoses appeared in all clusters. This work stresses the need for a model to identify unmet classroom needs, that is time and resource efficient, while trusting that teachers are often experts on their own pupils.

Dr. Lisa Keenan, Dublin City University - The Need for Meaningful Consultation with Autistic Pupils to Inform Educational Policy and Practice

Dr. Lisa Keenan presented on the educational experience of autistic pupils, from their own perspective. Pupils could submit photos / free pictures about school and were also invited to interview. Interviews were designed to be as comfortable as possible for students with their individual needs considered and planned for. Indicative thematic analysis is underway but preliminary findings indicate a range of findings: liking school, disliking school and being traumatised by school. This study is part of a wider project funded by an IRC-COALESCE award 'The Autism-Friendly Schools Research Project'.

Dr. Joe Bathelt, University of Amsterdam - Diversity in the Classroom, Using Cognitive Neuroscience to Understand What Makes Each Child Unique

Dr. Joe Bathelt presented on the differing cognitive profiles of children with varying neurodevelopmental disorders. The importance of veering away from a one-size-fits all

approach was highlighted. The key findings of this presentation were as follows: Many autistic children and adolescents feel lonely at school, Young people's perspectives may differ from what you expect, Listening first and acting/prescribing later may be best, and it is paramount that we find out how individuals develop and adjust (Bathelt et al., 2021).

Dr. Flavia H. Santos, University College Dublin - Educational Neuroscience in Games for Mathematics: Insights from the Enigma Project

Dr Flavia H. Santos showcased two projects. The ENIGMA Project is led by University College Dublin in partnership with HeadStart in Malta and funded by the European Commission. ENIGMA stands for Educational Neuroscience in Games for Mathematics. The course will explore the use of games and gamification strategies to enhance engagement, motivation, and learning outcomes in maths education and empower educators to optimise pupils' learning experiences in the maths classroom. The Arithmós Project is a collaboration between University College Dublin and Technological University Dublin funded by the Irish Research Council. It engaged children, parents, teachers, and policy-makers through a multidimensional approach. Outcomes included scientific and policy papers, a cartoon video for children, and a teachers' workshop about maths anxiety.

Dr. Agnieszka Graham, Queen's University Belfast - Educating Wandering Minds

Dr. Agnieszka Graham presented on mind-wandering in the classroom. Children may be off task 45% of the time during a listening task, 22% due to mind-wandering, and 23% due to distraction (Cherry et al., 2022). This may impact immediate recall of information but an impact on memory after a delay was not evident. Children experiencing negative effects may be more likely to mind-wander, specifically about the past and future. The needs to focus on helping children understand when mind-wandering is likely to occur and to understand the impacts of mind-wandering was expressed.

Maisie Flynn, University College Dublin - How Primary School Teachers Identify and Manage Mind-Wandering in Early Classroom Environments: Findings from Teacher Focus Groups

Maisie Flynn presented findings from teacher focus groups. A key finding was the lack of education teachers receive on cognitive processes such as mind-wandering. Teachers reported confusing mind-wandering from the similar, yet distinct, constructs of attention and distraction. Teachers reported frustration, gaps in pupil knowledge and the strain of resources created by mind-wandering. However, positives for the areas of problem solving, a protective factor against anxiety and better engagement with creative subjects was reported.

Olivia Wynne, University College Dublin - How Parents View and Manage Mind-Wandering in Early Classroom Environments: Findings from Parent Focus Groups

Olivia Wynne presented findings from focus groups conducted with parents of children in their first two years of school. The purpose of these focus groups was to explore how

parents view and manage their children's mind-wandering in relation to school tasks. Thematic analysis of the focus groups revealed that parents view mind-wandering as a normal and positive element of learning in children; it can even have unique benefits that enhance learning experiences such as promoting creativity and curiosity. Parents described how mind-wandering is more likely to occur in certain circumstances such as when their child is in a distracting environment, when a child has less agency over a task or when a child's needs are not met. Parents also highlighted that children usually vocalise their mind-wandering, this was seen as a positive element as it gives parents insights into their child's thought processes and experiences. Although parents are currently confident in managing their children's mind-wandering related to school tasks, parents expressed that they may need more support with this in the future, especially when homework becomes more challenging and when time pressures intensify.

Professor Victoria Simms, Ulster University - Building Mathematical Brains: What Counts for Early Mathematical Learning?

Professor Victoria Simms spoke about the formation of mathematical brains in young pupils. Executive function (EF) was mentioned as a key predictor of mathematics outcomes, yet it is not currently a target for mathematical intervention. It may limit the performance and learning of pupils. However, it can also be a factor for enhancing deep mathematical skills. The role of early learning and the importance of considering factors that influence executive function (such as social-economic background and premature birth) should be considered when reviewing a student's mathematical ability (Scerif et al., Under review).

3. AIEN Project 1: A Focus on Mind-wandering in Early Classroom Settings

3.1 Why a focus on mind-wandering?

People's conscious experiences often shift from their immediate surroundings and ongoing tasks to internally generated thoughts, a phenomenon known as mind-wandering (Murray et al., 2020; Smallwood & Schooler, 2006). Using thought-sampling techniques (Appendix A) where individuals intermittently report whether they are focused on a task or mind-wandering, research suggests that people spend up to 50% of their time mentally drifting away from the present moment (Killingsworth & Gilbert, 2010; Seli et al., 2018). Although not inherently problematic, mind-wandering can be particularly costly in educational contexts because learning relies on students extracting information from their learning environment and integrating it with existing knowledge, and mind-wandering disrupts this process (Sanchez & Naylor, 2018).

Over the past two decades, the link between mind-wandering and learning has been extensively studied in adult student populations, leading to the development of instructional strategies that can reduce mind-wandering in educational settings (Szpunar, 2017). However, despite its prevalence and educational significance, few developmental studies have examined mind-wandering in children before adolescence (see Section 3.3).

Studying the nature of mind-wandering in children provides a unique opportunity to explore how heterogeneity and individual differences affect learning, aligning with the 4th United Nations Sustainable Development Goal: Quality Education. Most research investigating attentional difficulties focuses on 'trait' attentional skills that vary across the population. Trait measures are typically based on judgments provided by parents or educational professionals, with research exploring the links between high trait inattention and academic achievement, and differences in educationally significant domains between individuals with attentional difficulties and 'typically' developing children. While this research has been fruitful, this project offers a new approach to the role of attention in children's learning. Here, the emphasis is on attention as a 'state' rather than a 'trait', consistent with the nature of attention itself, which is dynamic, context-specific, and malleable. Researching children's mind-wandering enables us to better understand the role of variability in learning and, ultimately, work towards fostering children's individual learning potential.

3. 2 Mind-wandering and learning in adults and adolescents: An overview of the literature

Much work in the field of mind-wandering has focused on understanding and quantifying the costs of mind-wandering in learning environments. Most educationally relevant research in adults and adolescents suggests that higher rates of mind-wandering are associated with poorer comprehension and less learning.

A significant portion of the existing research investigating the impact of mind-wandering on reading involves experimental studies where participants are provided with a passage of text to read. Periodically, they are asked to report if they had been mind-wandering in the preceding moments (e.g., Bixler & D'Mello, 2016; Faber et al., 2017; McVay & Kane, 2012; Naylor & Sanchez, 2018). These periodic queries, known as thought probes, indicate that adults experience mind-wandering approximately 30-44% of the time when silently reading text (e.g., Broadway et al., 2015; Unsworth & McMillan, 2013; Varao-Sousa et al., 2013). This estimate can rise to as much as 50% when participants are listening to an audio story (Kopp & D'Mello, 2016; Varao-Sousa et al., 2013). Crucially, these periods of inattention come at a cost: it is well-established that mind-wandering during reading exercises detrimentally affects reading comprehension (e.g., Al-Balushi & Al-Harthy, 2015; Feng et al., 2013; McVay & Kane, 2012; Sanders et al., 2017; Schooler et al., 2004; Smallwood et al., 2008; Soemer et al., 2019; Steindorf & Rummel, 2020).

Research also suggests that the impact of mind-wandering on reading goes beyond simply diverting attention from the text, affecting deeper cognitive processes (Schooler et al., 2004). Smallwood and colleagues (2008) found that participants who reported more mind-wandering when reading a Sherlock Holmes text were significantly less likely to correctly identify the story's villain. Similarly, Storm and Bui (2016) discovered that mind-wandering impaired participants' ability to perform analogical reasoning after reading a book passage. More recently, Zhang et al. (2020) found that participants who reported mind-wandering while reading jokes were less likely to reread the joke after the punchline, a crucial step for higher-level comprehension. These studies collectively suggest that mind-

wandering during reading not only affects surface-level understanding but also disrupts deeper semantic processing, such as inference model building, which is essential for successful learning by integrating external information with prior knowledge.

A growing body of evidence has identified key factors influencing mind-wandering during reading. Several studies emphasise the significance of interest in the reading material as a determinant for lower mind-wandering rates (Fulmer et al., 2015; Kahmann et al., 2022; Soemer et al., 2019; Unsworth & McMillan, 2013; Varao-Sousa et al., 2013). Participants tend to report more mind-wandering when they perceive the text as difficult (Feng et al., 2013; Kahmann et al., 2022; Mills et al., 2013; Soemer et al., 2019), and mind-wandering rates can increase as a function of time-on-task (Farley et al., 2013; Risko et al., 2012; Varao-Sousa & Kingstone, 2019).

In higher education, lectures serve as the primary mode of knowledge transfer. Research consistently shows that mind-wandering during lectures significantly impedes the retention of lecture material (e.g., Kane et al., 2017, 2021; Risko et al., 2012, 2013; Wammes et al., 2016; Varao-Sousa & Kingstone, 2015; Wammes & Smilek, 2017; Was et al., 2019). A pivotal study by Lindquist and McLean (2011) recruited undergraduate students attending a psychology lecture. During the lecture, an alarm sounded at several points, prompting students to mark if they had been experiencing task-unrelated thoughts (i.e., mind-wandering) on a response sheet. This procedure revealed that students experienced mind-wandering about 32% of the time, with higher rates of probe-caught mind-wandering negatively associated with course grades. Since this study, subsequent research has consistently reported similar estimates of mind-wandering during both live and recorded lectures, ranging from 25% to 46% (Kane et al., 2017, 2021; Loh et al., 2016; Varao-Sousa & Kingstone, 2019). There is also substantial evidence indicating that students who mind-wander more during lectures perform worse on memory tests immediately after the lecture (e.g., Risko et al., 2012, 2013; Varao-Sousa & Kingstone, 2015; Wammes et al., 2016; Wammes & Smilek, 2017; Was et al., 2019). Additionally, they tend to perform worse on end-of-term assessments (Lindquist & McLean, 2011; Kane et al., 2021; Wammes et al., 2016).

Mind-wandering research has revealed that attention wanes as lecture time progresses, with more task-unrelated thoughts reported in the second half of the lecture compared to the first half (e.g., Bianchi & Risko, 2022; Kane et al., 2021; Risko et al., 2012; Varao-Sousa & Kingstone, 2019). Higher mind-wandering rates are often accompanied by lower quantity and quality of note-taking (Dewey, 2020; Jing et al., 2016; Kane et al., 2017; Szpunar et al., 2013). Similar to mind-wandering during reading, the frequency of mind-wandering during lectures is closely related to interest and motivation (Kane et al., 2021; Seli et al., 2015; Varao-Sousa & Kingstone, 2015; Wammes & Smilek, 2017). Increased interest may foster motivation to learn, while uninterested students might choose to engage in mind-wandering (Fulmer et al., 2015; Kane et al., 2017, 2021; Soemer et al., 2019).

In summary, in adult populations, the link between mind-wandering and learning is supported by studies embedding intermittent thought-probes within lectures and other learning activities (e.g., discussions, problem-solving tasks, student presentations; Bunce et al., 2010; Cameron & Giuntoli, 1972; Locke & Jensen, 1974; Risko et al., 2012; Schoen,

1970; Shukor, 2005; Szpunar et al., 2013). Despite variations in lecture durations and topics, adult participants consistently report mind-wandering approximately 30-40% of the time. In line with the findings on reading comprehension, students who mind wander more tend to recall less lecture content (Hollis & Was, 2016; Kane et al., 2017; Wammes et al., 2016; Wammes & Smilek, 2017). The link between mind-wandering and learning has also been clearly demonstrated in studies with adolescents. Mrazek et al. (2013) showed that in both middle school and high school samples, levels of task-unrelated thoughts during reading were negatively associated with comprehension. Similarly, Soemer et al. (2019) reported that in 13- to 14-year-olds, greater mind-wandering was correlated with poorer reading comprehension. They also found that higher interest in the topic was associated with less mind-wandering during reading. These findings underscore the importance of maintaining student engagement and interest to minimise mind-wandering and enhance comprehension during learning activities.

3.3 Mind-wandering in Children

Strikingly, despite its obvious educational significance, only a relatively small number of studies have attempted to examine mind-wandering in children. Six published reports have investigated probe-caught mind-wandering in typically developing children (Cao et al., 2022; Hasan et al., 2024; Keulers & Jonkman, 2019; McCormack et al, 2019; Ye et al., 2014; Zhang et al., 2015). Additionally, two studies have focussed on children diagnosed with Attention Deficit Hyperactivity Disorder (ADHD; Merill et al., 2022; Van den Driessche et al, 2017), one study on children with dyslexia (Bonifacci et al., 2022), and two studies have linked mind-wandering with mood (Hoffmann et al., 2023; Jin et al., 2023). Jones (2019) explored whether lapses of attention would manifest as postural instability (i.e., increased movement) in a sample of 8- to 11-year-olds. Another study used experimental thought probes and questionnaires to assess how children's mind-wandering habits impact performance on a sustained attention task (Wilson et al., 2022). Finally, Frick et al. (2020) employed questionnaires to find associations between daily mind-wandering traits and ADHD symptomatology in children.

This report focuses specifically on studies of mind-wandering in children that have educational relevance. Massonnie et al. (2022) found that children who reported hearing and switching difficulties experienced higher levels of interference and annoyance from noise. Furthermore, children prone to mind-wandering experienced more interference from noise. However, their annoyance depended on the level of interference caused by the noise, unlike those with hearing and switching difficulties who experienced direct annoyance. This study emphasises the importance of distinguishing between annoyance and interference in educational research for theoretical, empirical, and practical applications.

To date, only Cherry et al. (2022, 2023) have specifically investigated the link between off-task thinking and learning in children. In their 2022 study, 6- to 11-year-olds listened to an experimenter read a story. Intermittently during the listening exercise, children were probed by a computer to report whether their thoughts were focused on the story or on something else. Immediately after the story ended, children completed a multiple-choice

memory test and indicated their situational interest in the story topic. Cherry et al. (2022) reported three key findings. First, children who reported more off-task episodes showed poorer immediate recall of the story information. Second, children self-reported being off-task around 25% of the time, a figure that did not change significantly with age, suggesting no age differences in levels of off-task thoughts in school-aged children. Third, situational interest had a significant indirect effect on memory recall via off-task thoughts.

In Cherry et al. (2023), the objective was to fine-tune the measure of mind-wandering to reflect only task-unrelated thoughts with no obvious external trigger. In this study, a group of 8–9-year-olds categorised their off-task thoughts as task-unrelated, task-related interference, or inattention due to distraction during two separate audio stories. While off-task thoughts (24%) were reported at similar rates to the previous experiment, the new fine-tuned measure of 'pure' mind-wandering (i.e., task-unrelated thoughts) suggested children are mind-wandering less than previously thought (9% of the time). Nevertheless, this more stringent index of mind-wandering was strongly associated with poorer memory recall of the audio stories. It also revealed that task-unrelated thoughts predicted how well children could recall components of the audio story after a one-week delay.

Previous experiments revealing the link between mind-wandering and memory recall performance in primary school-aged children highlighted the need for assessing how often children report mind-wandering in the classroom. In their most recent study, Cherry et al. (in preparation) scaled up their measurement methods and obtained mind-wandering reports from groups of children in authentic classroom settings. This method of data collection revealed that in the classroom environment, children were off-task 45% of the time – more often than expected, given the results of earlier experiments. Specifically, children reported mind-wandering frequently during the listening activity (22%). Regression analysis showed that mind-wandering predicted how much children could remember about the activity immediately after listening to it. However, mind-wandering was not associated with their ability to recall information from the audio story after a one-week delay.

Taken together, these findings suggest that mind-wandering is frequent among children engaging in learning activities, particularly in the classroom, and that it negatively impacts memory recall performance. While the longer-term consequences of mind-wandering in children remain unclear, educators should consider strategies to mitigate it in the classroom.

A separate but relevant line of research has explored the link between mind-wandering and mood in children. This is significant because studies with adults indicate that mind-wandering carries an emotional cost: frequent mind-wanderers often experience diminished psychological well-being (Deng et al., 2014; Killingsworth & Gilbert, 2010; Mason et al., 2013; Smallwood et al., 2009). The temporal orientation of thought also influences the emotional impact of mind-wandering. Mind-wandering toward the past is associated with depression and lower mood (McKay et al., 2017; Hoffmann et al., 2016), while future-oriented mind-wandering is linked to processing future personal goals and positive mood (Klinger, 2009; Stawarczyk et al., 2011).

The interplay between academic difficulties and psychopathology can create a vicious cycle. Academic struggles resulting from mind-wandering can lead to increased stress and anxiety, which in turn can exacerbate mind-wandering and further impair academic performance. To our knowledge, only two studies directly examine mind-wandering and mood in children. Jin et al. (2022) found that mind-wandering mediated the relationship between mindfulness and emotions. In this study, participants aged 9-14 years rated the frequency of mind-wandering and their affective state over ten days using Likert scales. Multi-level modelling of the data revealed that mindfulness predicted greater positive emotions and reduced negative emotions via lower levels of mind-wandering. Although this mediation effect was not observed at the six-month follow-up, the original finding nevertheless highlights the need for a greater understanding of mood and mind-wandering in children. A more recent study by Hoffmann et al. (2023) reinforces this point. It looked at self-generated thought patterns in children aged between 6-12 years, with and without a history of childhood maltreatment. Children with maltreatment exposure were found to have fewer future-oriented thoughts and increased past-oriented thoughts. Moreover, their thought patterns were related to elevated depressive symptoms.

Overall, the research on mind-wandering in children, particularly its impact on learning and mood, is still in its infancy but shows promising directions for future investigation. Further studies could provide crucial insights into how to support children's learning and well-being by addressing mind-wandering tendencies. Targeted strategies to reduce mind-wandering and support focused attention may have the potential to improve both academic achievement and psychological well-being.

3.3.1. Areas for Future research

Given the striking paucity of empirical evidence, children's mind-wandering is a fruitful area of research where advancements will be valuable and far-reaching — not only in education but also concerning children's mental health and the growing popularity of mindfulness-based interventions. Several specific areas warrant further investigation:

- **Children's understanding of mind-wandering**: Future research should explore young children's basic understanding of attentional states and mind-wandering. Given that metacognitive skills are still developing in young children, it is essential to establish what they understand about when and why mind-wandering occurs and its potential detrimental effects. This understanding is crucial as children's beliefs about mind-wandering could influence how effectively they regulate their learning.

- **Factors influencing mind-wandering**: The link between mind-wandering and learning in adults has been related to several factors, including working memory capacity, interest in the topic, prior experience, and motivation. These factors have not been thoroughly studied in children. Future research should investigate how these domain-general and domain-specific factors influence mind-wandering and subsequent performance on comprehension or recall tests in children.

- **Development of a digital thought-probe measure**: To advance research in this area, it is imperative to develop a digital thought-probe measure of mind-wandering suitable for classroom and home use. This tool should be versatile, available in a web browser and as an app, with a user-friendly interface. It should enable teachers to monitor engagement across activities and help children understand their attentional states. Such a measure could empower young learners to recognise when their attention has strayed and take remedial action.

- **Root causes of mind-wandering**: Identifying the root causes of mind-wandering in classroom settings is essential. Potential reasons for inattention include lack of sleep, low mood, lack of interest in the topic, and anxiety. Future work should assess the links between inattention levels (measured by a probe-caught method) and various relevant factors. These factors include classroom environment (e.g., layout, student-teacher relationships, peer relationships), cognitive skills (e.g., executive functions), and indicators of overall mental well-being (e.g., mood).

- **Mind-wandering, creativity, and problem solving**: Research in adults has explored the connections between mind-wandering, creativity, and problem-solving. However, there is a complete lack of research in these domains for children. Investigating these links could provide insights into how mind-wandering influences creative thinking and problem-solving abilities in young learners.

3.3.2 Perspectives from a World Café

As part of the AIEN project, researchers from UCD and QUB hosted a World Café for teachers, parents, researchers and policy-makers to come together to discuss the topic of mind-wandering. The aim of the World Café approach is to cultivate an informal, collaborative atmosphere where attendees develop unique insights that incorporate different perspectives, while also highlighting shared experiences and ideas (Prewitt, 2011). The World Café method involves attendees gathering together to discuss key questions while rotating between different discussion tables in a 'cafe style' environment (Schiele et al., 2021). During the World Café, attendees discussed four key questions: 1) Would you say mind-wandering is positive or negative for children? 2) How do you understand mind-wandering in relation to learning? 3) How does the home and educational environment influence mind-wandering in the Classroom? 4) Should tackling mind-wandering in the classroom be a priority for educators and, if so, why? Attendees answered these questions in small groups and wrote down key ideas on tablecloths provided. Once the event was finished, the research team analysed the handwritten notes and explored a number of central themes.

Firstly, attendees perceived mind-wandering to be both advantageous and disadvantageous in the classroom depending on the concurrent learning activity. For instance, teachers commented on how the Aistear program allowed for activities that facilitated and even benefitted from mind-wandering such as exploratory play and exploring topics through creative thinking and questioning. However, teachers also

highlighted that children who mind-wander when new topics are introduced in class can fall behind. In terms of environmental factors that contribute to mind-wandering, attendees reported that home factors such as sleep quality, video game usage and hunger levels may negatively impact children's mind-wandering in school. This question showed how the unique setting of a World Café can foster discussion between attendees from different perspectives in an informal environment, which may not have been easily achieved otherwise. For instance, parents and teachers could answer this question from different viewpoints, researchers could contribute their academic knowledge in this area and policy-makers could share their practical insights.

A key point that arose during the World Café was that it can be difficult to recognise mind-wandering in children, especially in this age group (first two years of formal learning), as children may not understand or be aware of their own mind-wandering. Moreover, the term 'mind-wandering' had not been familiar to the majority of attendees, especially the teachers and parents. This highlighted an important advantage of the World Café approach; its participatory nature (Löhr et al., 2020). During the World Café, attendees shared that the experience was insightful and how they had learned more about educational neuroscience, particularly the topic of mind-wandering. This demonstrates how the World Café can be used as a tool which allows for participants to share knowledge and learn from each other in a non-judgmental, flexible and fluid environment.

Overall, attendees agreed that mind-wandering is a normal and developmentally appropriate phenomenon in young children in the context of learning, and it can have both advantageous and disadvantageous outcomes. Attendees expressed an interest in learning more about the topic of mind-wandering, especially on how to encourage and discourage it appropriately in an educational setting. Attendees also conveyed that they are interested in learning more about educational neuroscience, especially in the areas of managing anxiety in the classroom and exploring children's own thoughts on mind-wandering.

3.3.3 Teacher's Understanding and Management of Mind-wandering in the Classroom

A series of online focus groups were conducted with primary school teachers, who had current or recent experience with children in the first two years of school across the island of Ireland. This meant that participants had worked with Junior / Senior Infants in the Republic of Ireland or Year 1 / 2 in Northern Ireland within the year prior to the focus group. Eight teachers participated, coming from a range of schools. The teachers varied in years of experience and educational background. Due to teacher industrial action in Northern Ireland at the time of focus groups, it was not possible to recruit from Northern Ireland, despite efforts to do so.

Reflexive thematic analysis (Braun & Clarke, 2006) of the focus group transcripts resulted in four main themes, each with distinct and relevant sub-themes. These themes are: 1) Teachers Conceptualisation of Mind-Wandering, 2) Positive Impacts of Mind-Wandering, 3) Negative Impact of Mind-Wandering and 4) Barriers in the Support of Mind-Wandering.

It was found that many teachers were initially unfamiliar with the term 'mind-wandering', often interpreting it as distraction which is a form of inattention that is caused by external factors. Through focus group discussions, teachers began to differentiate between these concepts and identified various situations where mind-wandering might occur, such as when children are bored, distracted, or do not understand the content. Teachers noted that mind-wandering could lead to distraction within the classroom and that their existing strategies to manage distraction, though not specifically designed for mind-wandering, were often used to address it. Additionally, children who struggle with language comprehension, such as those for whom English is an additional language, might mind-wander due to difficulty in understanding instructions, further disengaging from the lesson.

Despite its challenges, teachers acknowledged several positive impacts of mind-wandering. They observed that children who mind-wander might display higher creativity, enabling them to engage deeply with subjects like art and drama and to think innovatively about problems in mathematics. Teachers also suggested that mind-wandering might serve as a protective factor against anxiety, allowing children to process personal worries during class time. This reflective process can be beneficial for their emotional well-being, although it sometimes requires the teacher to balance between maintaining classroom focus and allowing such cognitive freedom. Furthermore, mind-wandering can prompt children to explore their interests, occasionally leading to rich, student-led discussions that enhance learning experiences, even though time constraints often limit these opportunities.

Conversely, mind-wandering can have negative impacts on children's learning. Teachers reported that it often results in students missing important information, leading to knowledge gaps that hinder their understanding of the curriculum. This challenge is exacerbated by limited resources, such as insufficient support from special education or learning support teachers, making it difficult to address these gaps effectively. Environmental factors like fatigue and hunger, as well as the increased use of technology, also contribute to mind-wandering, complicating its management. Teachers expressed a need for more formal training and resources to better support children and communicate with parents about mind-wandering, recognising its significant role in students' cognitive and emotional development.

3.3.4 Parent's Understanding of Mind-wandering in Relation to School Tasks

Focus groups were also conducted with parents of children in their first two years of school across the island of Ireland. Participants' children had completed at least 6 months of schooling by March 2024 and were aged between 4 and 6 years old with a balance of both male and female children. The purpose of these focus groups was to explore how parents view and manage their children's mind-wandering in relation to school tasks. Reflexive thematic analysis (Braun & Clarke, 2006) of the focus group transcripts resulted in five main themes: 1) Mind-wandering as a normal, positive element of learning in children, 2) Mind-wandering is more likely to occur in certain circumstances, 3) Children have a tendency to vocalise mind-wandering, 4) Parents approach mind-wandering through

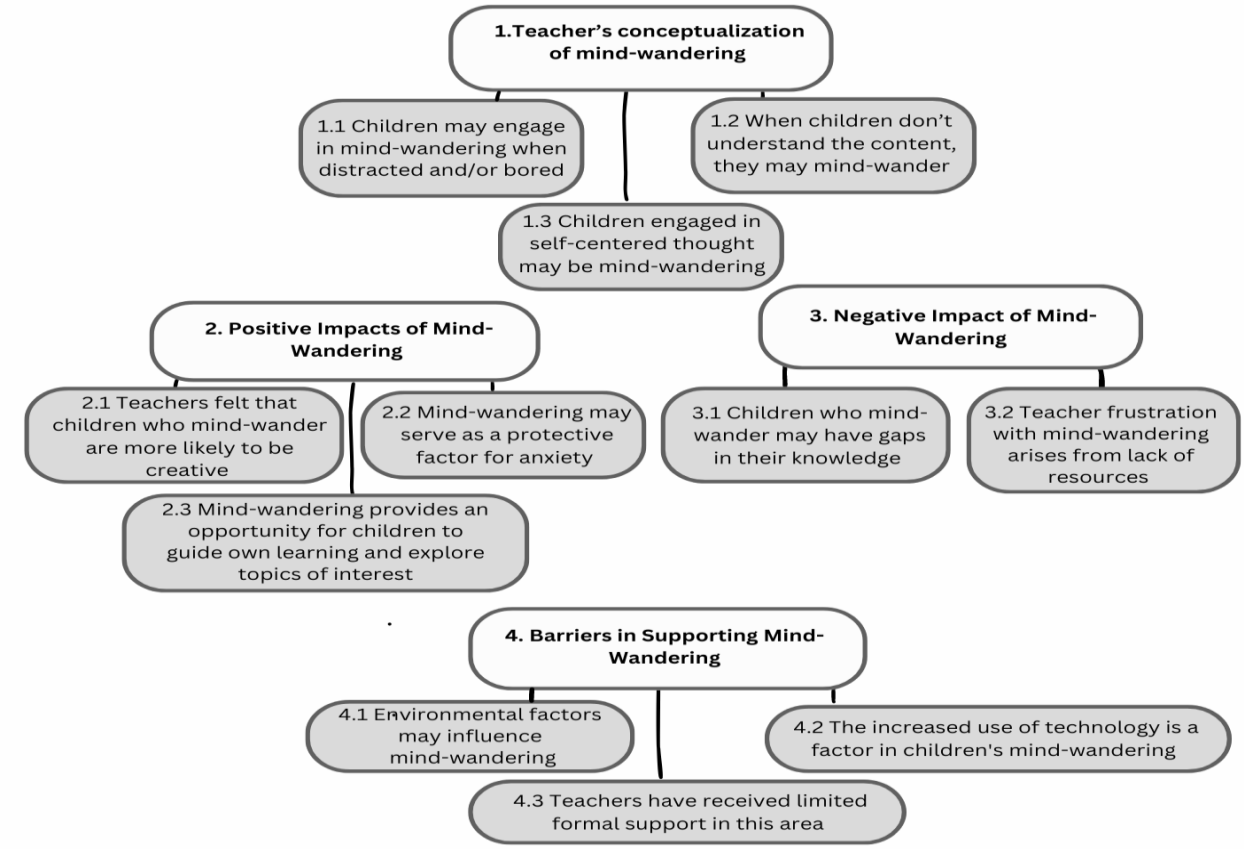
trial-and-error and 5) Parents' frustration with mind-wandering arises from time pressure (*Figure 1).*

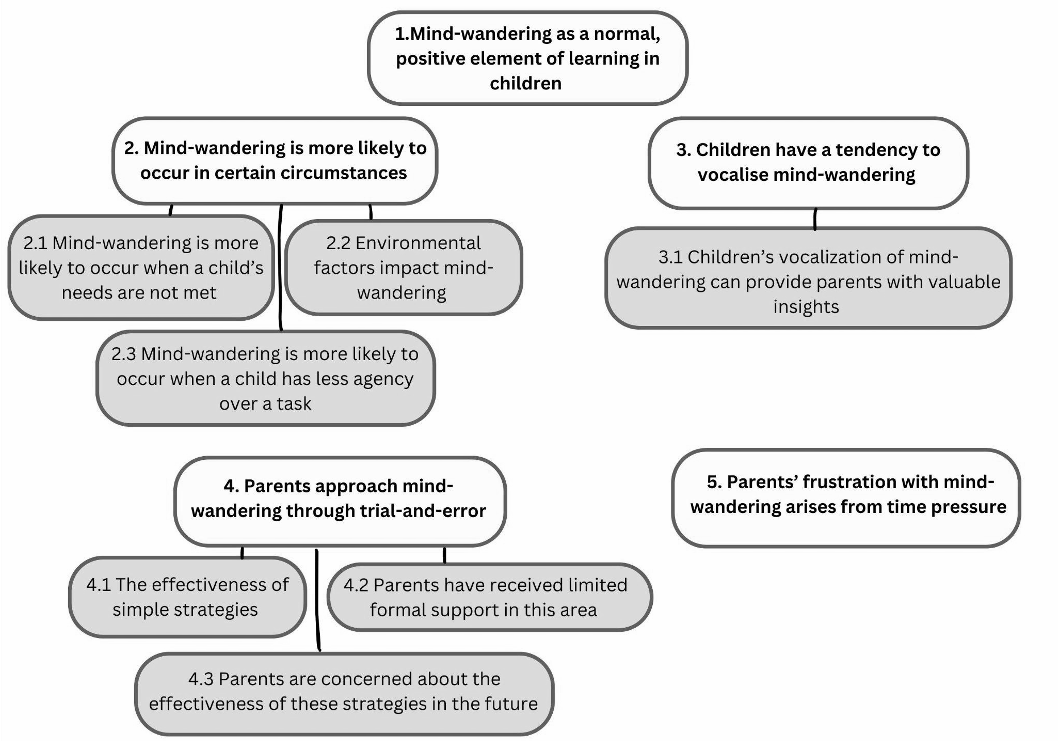
Overall, analysis of the focus groups revealed that parents view mind-wandering as a normal and positive element of learning in children; it can even have unique benefits that enhance learning experiences such as promoting creativity and curiosity. Parents described how mind-wandering is more likely to occur in certain circumstances such as when their child is in a distracting environment, when a child has less agency over a task, or when a child's needs are not met. For example, parents noted how their child mind-wandered more when they were hungry, tired, or over-stimulated after school. Similarly, parents mentioned that their child experienced less mind-wandering when they could choose what time they did their homework, as they felt 'ready' to do it. Parents highlighted that children usually vocalise their mind- wandering, this was seen as a positive element as it gives parents insights into their child's thought processes and experiences. Parents emphasised that their children continually spoke about what was on their mind, and that their child would not hesitate to share what they were thinking about with them - this may be a unique element of mind-wandering at this age.

Although parents have received very limited support in the management of mind-wandering, they have developed simple strategies that are effective in keeping their child on task. These strategies were developed through trial-and-error and advice from fellow parents, both in person and online. Although parents are currently confident in managing their children's mind-wandering related to school tasks, parents expressed that they may need more support with this as their child progresses through school, especially when homework becomes more challenging and when time pressures intensify.

The final theme showed how parents only become frustrated by mind-wandering when they are under time pressure, this in turn highlighted that there are many pressures on parents in our modern society. For instance, parents focused attention on how children have tight schedules these days with many time-tabled after school activities, and children must learn from a young age to "get with the program". The findings from this study show that more research is needed to further understand mind-wandering in this young age group to determine how best children and parents can be supported in the context of mind-wandering, such as understanding when it should be encouraged and when a child should be guided to stay on task.

Figure 1 - Thematic Map from Teacher (top) and Parent (bottom) Focus Groups





4. Educational neuroscience research and an inclusive Irish classroom

4.1 Priorities highlighted for further collaborative research

A number of priorities are highlighted for further collaborative research in the domain of educational neuroscience that aims to make the classroom more inclusive for all students in the Irish classroom. These priorities have emerged from stakeholder collaboration throughout the lifespan of the AIEN project. This includes a focus on early childhood, digital technology usage, and executive functions. At the research day, a series of presentations led to panel discussions which highlighted further emphasis on a transdiagnostic approach to learning needs which goes beyond specific diagnostic labels. Participants at the World Café completed an anonymous digital survey which showed that the mixed group of stakeholders (including seven practising teachers) felt that anxiety should be a future priority in this research domain. A specific priority that has emerged from our initial mind-wandering research studies is the necessity to explore young children's basic understanding of attentional states and mind-wandering.

4.2 Public policy and development of Shared Island Initiative

This project has allowed for researchers, educators, parents and policy-makers to collaborate together to promote educational neuroscience as an emerging area of interest in Ireland. This collaboration has forged new partnerships and links that aim to foster an evidence informed and equitable education on the island of Ireland beyond the lifespan of the current project. Articles based on our initial events such as the Knowledge Exchange Day and All-Island Research Day were featured in the Irish Psychologist (Psychological Society of Ireland) and the InTouch (INTO) magazine which directly targeted teachers and psychologists across the island of Ireland. The team will continue to grow the AIEN network through events and collaborative projects and aim to formalise the network as a Special Interest Group within an existing all-island society.

Teachers in our initial research expressed a need for more formal educational neuroscience training and resources. In particular, they voiced that better support is required to allow children to communicate with parents and teachers about constructs such as mind-wandering. The AIEN network will continue to directly engage with practising teachers through the Teachers' Research Exchange (T-REX) platform by embedding evidence-informed practice and research. Events such as webinars will be delivered through teacher training platforms including an INTO webinar series planned for Winter 2024. Examples of events that have been developed beyond the initial AIEN project include a planned webinar series on Mind-Wandering for the INTO educational platform in November 2024, an international educational neuroscience expert, Prof Michael Thomas, hosted at UCD October 2024, a Mind-Wandering Workshop in September 2024 co-chaired by members of the AIEN team, and planned public engagement events.

This project has also highlighted the scope to have more of an all-island approach to training and professional development in relevant fields including the education of teachers and educational psychologists. Regular meetings between the AIEN team emphasised existing differences in training and practice contexts between Northern Ireland and the Republic of Ireland. This included systemic barriers to change (for example not enough teachers, funding, training). Further cross-border projects and funding could help improve difficulties that the education systems Northern Ireland and the Republic of Ireland are facing.

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6. Appendix A: Key Definitions

Correlate: Where there is a relation or connection, in which one thing affects or depends upon another, for example "the study found that success in the educational system correlates highly with socioeconomic status".

Event-related Potential: The measured brain response that is the direct result of a specific sensory, cognitive, or motor event.

Eye-Tracking: The recording and study of the movements of the eyes in following a moving object, lines of printed text, or other visual stimulus, used as a diagnostic procedure or a means of evaluating and improving the visual presentation of information.

Functional Neuroimaging: Functional neuroimaging is the use of neuroimaging technology to measure an aspect of brain function, often with a view to understanding the relationship between activity in certain brain areas and specific mental functions.

Longitudinal: A longitudinal study is one which collects data at more than one point in time. For example, measuring a student's score on a maths test before and after receiving a maths intervention.

Patient group and Control group: A patient group or experimental group is the group that experiences the variable being tested in an experiment. The control group is the group in an experiment that does not receive the variable being tested. For example, in a study where researchers compare maths scores in a group who received a maths intervention and a group who did not, the group that received the intervention would be the patient/experimental group.

Thought-sampling Techniques: Thought sampling is a method where subjects are interrupted at unpredictable times and asked to report what they were thinking just prior to the interruption.